STATE RAILWAY OF THAILAND
MINISTRY OF TRANSPORT

THE HIGH-SPEED RAIL LINKING THREE AIRPORTS PROJECT

REQUEST FOR PROPOSAL

VOLUME 3 : OUTLINE SPECIFICATIONS

VOLUME 3/1 : THE RAIL-RELATED WORKS OF THE PROJECT

PART 3 : OUTLINE SPECIFICATIONS FOR RAILWAY SYSTEMS

Asian Engineering Consultants Corp., Ltd.
TEAM Consulting Engineering and Management Co., Ltd.
Sasin Graduate Institute of Business Administration of Chulalongkorn University

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SECTION 1 - OVERALL SYSTEM REQUIREMENTS

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SECTION 1
OVERALL SYSTEM REQUIREMENTS

1. OBJECTIVE

1.1 The Outline Specifications of the Electrical and Mechanical (E&M) Works aims at presenting the requirements that will be required in the design, manufacture, installation, and delivery of the rolling stock and other E&M systems to the High Speed Line between Don Mueang – Suvarnabhumi - Utapao, Thailand.

1.2 The Outline Specifications of the Electrical and Mechanical Works shall be read in conjunction with the SRT's Requirements and other documents forming part of the Contract.

1.3 The Outline Specifications of the Electrical and Mechanical Works includes the following Sections:

Section 1: Overall System Requirements

Section 2: Rolling Stock (RST)

Section 3: Substation and Power Supply System (PSY)

Section 4: Signaling System (SIG)

Section 5: Telecommunication System (COM) and SCADA

Section 6: Automatic Fare Collection System (AFC)

Section 7: Depot and Workshop Equipment (DWS)

Section 8: Platform Screen Door (PSD)

Section 9: Trackwork (TRW)

2. OVERALL SYSTEM REQUIREMENTS

2.1 Introduction

2.1.1 The Ridership Forecast shall serve as a guideline for the Private Party to have a common understanding of performances and provisions. The Private Party shall provide an actual Ridership Forecast, which shall result into Train Calculations, Timetables and Headways etc. All documents shall be submitted and approved by SRT before revenue service.

2.1.2 The HSR Line system shall run on the elevated guideway for two-direction operations.

2.1.3 The elevated guideway supporting structure can be either steel or concrete or both.

2.1.4 All guideway shall be in accordance with the operation plan, line alignment plan and profile both at mainline and depot area.

2.2 System Capacity

2.2.1 The system shall be designed to operate for maximum carrying capacity of 4,430 PPHPD for high-speed train and 9,350 PPHD for city line train as ultimate demand. The Passenger Flow Forecast is detailed in Appendix A for information.

2.2.2 The Private Party shall include all necessary design to cater for ultimate demand and identify the part of such design which shall be constructed for cater for the initial demand. The design to cater for future demand shall be materialized with the provision of capability increment without significant removal or modification of systems and facilities to be constructed and without expansion of the premise.

2.2.3 The Private Party shall provide evidence that the propose turnout installation plan meets possible future expansion of Depot and tracks.

2.3 System headway

Operation headway used for calculation of carrying capacity is of 3 min.

2.4 Dwell time

Dwell time shall be adjustable for individual platform to suit the ridership.

2.5 Train capacity

2.5.1 Seating occupancy rate of 10% of total train passenger carrying capacity shall be at minimum kept.

2.5.2 The Private Party shall demonstrate the calculation of passenger number in accordance with these criteria to verify its compliance with the service requirement.

2.6 Vehicle Fleet

2.6.1 The Private Party shall supply the details of its own proposal of vehicle fleet size (i.e. train configuration) to comply with the initial system carrying capacity and in case of ultimate capacity of 9,350 PPHPD for City Line Trains and 4,430 PPHPD for High Speed Trains under restraint conditions from civil and architectural plan such as station length and capacity of stabling yard in the Depot.

2.6.2 The Private Party will procure the number of train required for initial (the first 10 years) carrying capacity and additional trains in future to meet the ultimate capacity.

2.7 Operation hours

The system shall be designed to operate seven day a week.

- High Speed Services : 06:00 – 22:00 (16.00 hours operations)
- City Line Services : 05:00 – 24:00 (19.00 hours operations)

2.8 System Design Criteria and Requirements

In order to satisfy the operation service requirement designated by SRT, the Private Party is required to use the design criteria and requirements in the Table -1 as minimum to propose the rolling stock and E&M system.

Table 1: Design Criteria and Requirements

Line Length Total line length Don Mueang – U-Tapao **Extension :** Don Mueang – Suvarnbhumi Suvarnabhumi – U-Tapao	 app. 220 km. app. 49 km. app. 171 km.
Maximum possible gradient Maximum gradient applied	4.0 % 3.5 %
Track gauge (Standard Gauge)	1.435 m
Minimum track radius (Main Line)	1,700 m
Number of stations: High Speed Trains : Don Mueang, Bang Sue, Makkasan, Suvarnabhumi, Chachoengsao, Chon Buri, Sri Racha, Pattaya and U-Tapao City Line : Don Mueang, Bang Sue, Phayathai, Ratchaprarop, Makkasan, Ramkamhaeng, Hua Mak, Baan Thap Chang, Lat Krabang and Suvarnabhumi	15 9 10
Maximum speed: Main Line (Don Mueang –Phayathai - Suvarnabhumi) Main Line (Suvarnabhumi – U-Tapao) Depot Area	 160 km/h 250 km/h 25 km/h
Platform length: Bangsue Station Other Stations	 Not less than 420 m. Not less than 210 m
Daily Operation Times: High Speed Service Don Mueang -U-Tapao City Line	 6:00 –22:00 hours 5:00 – 23.:30 hours

Dwell times: at intermediate stations : City Line Trains at intermediate stations : High Speed Trains Reversing times, minimum (including dwell times): at direction reversal stations (City Line Trains) at direction reversal stations (High Speed Trains)	 30 sec 60 sec 180 sec (3 min) 300 sec (5 min)
Trip Times: City Line (Don Mueang – Suvarnabhumi) High Speed Trains Stop 3 airport : Don Muaeng – Suvarnabhumi - U-Tapao Stop every station : Don Muaeng – Si Racha Don Muaeng – Suvarnabhumi - U-Tapao	 45 min 70 min 75 min 110 min
Traction Power System	2 X 25 kV 50 Hz AC, OCS
Automatic Fare Collection (AFC)	Closed Ticketing System with the capability of upgrading for working with multiple operators and shall comply with Common Ticketing System by Ministry of Transport

2.9 System Interface

2.9.1 Interface Management

Interface Management is fast becoming a 'must have' discipline when managing major railway projects. Over the past decade, major railway projects have become substantially bigger and increasingly complicated, requiring numerous work packages distributed across multiple contractors.

The objective of interface management is to establish the overall interface structure, organization, roles and responsibilities, coordination process and procedures to manage , track and resolve all interface issues between all parties involved covering all phases of the project during design, manufacture, construction, installation, testing and commissioning and training.

2.9.2 Scope

The design, construction, installation, testing & commissioning of a railway project will require close coordination and communication between and within related subsystems, the SRT, Project Management Consultants, third parties and related government authorities.

The three key areas to the success of Interface Management are:

- Ensuring that each interface that interacts between and within the E&M Works sub-contractor package is fully identified, defined, correct and consistent.

  Where the E&M sub-ontractor is the lead interface party, he will define these interfaces in conjunction with all involved parties.
- Establishing a process for interface management through monitoring and interface change control.
- Full support and involvement from all disciplines concerned.

2.9.3 Interface Parties

The interfacing parties will include the

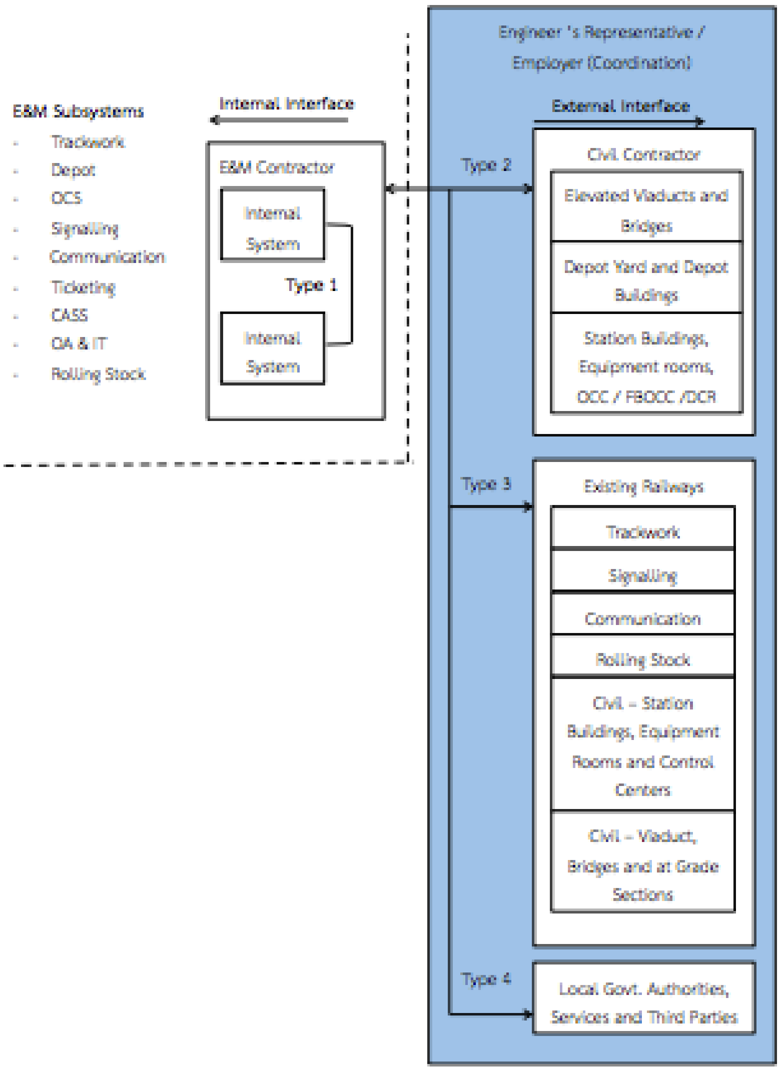
- E&M Works sub-contractors
- Civil Works sub-contractors
- SRT
- Third parties
- Government Authorities

The interface coordination procedure will include the management of external interfaces and internal interfaces to exhibit how these interface activities will be fully managed as a whole.

Most likely there will be four categories of interfaces to be identified in a railway project, where E&M Works sub-contractors will be involved in:

- Type 1: Interface Internal within E&M Works (Sub-sub systems)
- Type 2: Interface External between E&M Works sub-contractors and Civil works sub-contractors
- Type 3: Interface External between E&M Works sub-contractor and the SRT
- Type 4: Interfaces External between E&M Works sub-contractors and Local Government Authorities, Local Authority Services and Third Parties.

The following Figure shows the Interface Relationships



2.9.4 Interface Matrix

The Interface Matrix (External and Internal) facilities the preliminary interface identifications among all sub-contractors and interfacing parties during the preliminary design stage and is based on an evaluation of the interface requirements and initial design. The interface matrix is also used to facilitate and guide the Interface Control Register and the internal design coordinating interface document procedures for the E&M Subsystems.

An interface matrix is live document and will be updated throughout the project and when new interface relationships will be identified.

2.9.5 Interface Control Register

The system integration manager will create and maintain an interface control register with support from the subsystem design teams.

The propose of the register is to identify the individual external and internal interfaces based on the overall interface relationship identified in the interface matrix.

This will enable to track the interface definition and resolution process as it develops.

The Interface Control Register will also be a live document to constantly capture all the E&M Works related interfaces.

All internal interfaces (Type 1) and external interfaces (Type 2, 3 & 4) will be identified in the interface control register and defined in detail and reflected in the E&M Works subsystem design documentation as well as through formal design documentation (Preliminary, Detailed Design, Working Drawings) to ensure a clear demarcation of works of the Civil infrastructures.

The interface Control Register will be in a format and structure to enable filtering and reporting. The typical details will be a follows:

- Identification (Code, ID, leader and supporting party, date, type)
- Overall status (started, ongoing, pending, completed, critical, safety related)
- Stage (Prel. Design, Final design, manufacturing, construction/installation, testing and commissioning.

2.9.6 Subdivided into various columns.

All information exchanged between interfacing parties shall be recorded copies to the E&M Works where it will be associated with the interface control register to ensure that the latest status of the interface is maintained.

2.10 System Integration

System Integration and Engineering ensure the rail systems, trains and infrastructure, combined with operations and maintenance inputs, deliver a resilient operational railway meeting the customers' requirements.

2.10.1 System Integration

Modern rail technologies and systems are now becoming highly integrated. In revenue service these integrated systems must work effectively to support safe and efficient operations of trains, stations and other service infrastructure.

They also provide timely and accurate information to users, assist operators during any service disruption as well as provide ancillary services such as operational performance information.

Modern railway control systems are increasingly integrated to provide the following essential operational functions:

- <u>Signalling and train control</u> – ensures safe separation between trains and provides for efficient movement of trains.
- <u>Traction Power Control (SCADA)</u> – Monitors and controls traction power and high-voltage inputs to the railway and may even regulate the receptivity for regenerating power.
- <u>Passenger infrastructure and public address</u> – provides visual and audio information on train travels, departures and other details of services onboard.
- <u>Telephone and radio communications</u> – allow to transmit the information necessary to control railway operations.
- <u>Ventilation and environmental control</u> – provides monitoring and control of ventilation, air-conditioning, lighting, drainage and fire -fighting systems in railway tunnels, stations, control and equipment rooms.
- <u>Closed-circuit television (CCTV) and passenger assistance</u> – provides visual monitoring of railway premises and information to passengers, particularly for assistance and support.
- <u>Station- and building management system</u> – provides station/building monitoring and control, including lifts, escalators and equipment & central control rooms.
- <u>Fire and security</u> – monitors fire and security hazards.
- <u>Automatic fare collection (AFC)</u> – provides secure revenue collection and associated records.
- <u>Platform screen doors (PSD)</u> – prevent accidental falls off the platform, suicide attempts and homicides, improves security (access to tracks restricted). Improves climate control within stations (tunnel areas).
- <u>Remote condition monitoring</u> – provides data on the performance of major infrastructure, including static assets such as bridges and embankments.

Many of these integrated systems also impact safety- critical functions of the railway, particularly in the event of incidents. Therefore a carefully planned management approach to their implementation is required.

A dedicated and experienced system integration function will typically exhibit some of the following attributes:

- Highly competent integration engineers.
- Experienced integration team leaders.
- Early start on railway activities such as
    - requirement management
    - concept design
    - interface management
    - co-ordination
    - performance specification
    - contract packaging strategy etc.
- Integrated system – to – system structural architectural analysis.
- Careful system supplier's scope and interface definitions, selection and invasive management rights.
- Concurrent design and validation with Requirements and Operations concepts.
- Effective and consistent communication to everyone involved and impacted.

2.10.2 System Engineering

The Systems Engineering life-cycle typically comprises the following stages:

- Requirements management

  The need for requirements management is driven by two major factors; firstly, the increasing complexity of railway projects and equipment evolving technologies, and secondly, the need to address and show compliance to a multitude of stakeholders. Customers, users, and regulators.

- Concept development

  During the concept development phase of the project, a number of alternative options can be investigated. This exercise can be conducted for the project as a whole or for each component, on a system by system basis.

- Design

  During the design phase it is crucial for the leading technical staff to produce a fully coordinated design. The supervision of a rigorous interface management process is required to ensure that the design of all systems is integrated.

- Manufacture and Implementation

  During the manufacture of each system less direct supervision may be required. However, on large projects it is unlikely that this process can be done without the involvement of the Systems Engineer.

  The System Engineer coordinates the implementation phases of each system to avoid conflicts, as well as managing issues and changes identified.

- Integration

  It relies on the expertise of the involved system integration engineers and their empowerments to formulate an effective test, integration, and commissioning strategy which fully encompasses the railway system and its main interfaces, such as existing infrastructure, existing systems and operational and maintenance procedures and facilities.

- Testing

  The purpose of Testing is to expose subsystems and integrated systems to a range of investigations and trials to reveal their performance under controlled conditions against expected behaviour.

  Testing phases typically comprise:

  - Factory Acceptance Tests

  - Static Tests
  - Static Integration Tests
  - Dynamic Integration Tests
  - Trial Runs
  - Trial Operations

- <u>Commissioning</u>

  Through strategic planning and subsequent supervision the System Engineer has the opportunity at the commissioning stage to significantly de-risk the project, notably through phased opening of the railway and sequenced interface commissioning with existing operational assets and systems.

- <u>Operations and Maintenance</u>

  Once part of the railway have been commissioned , the key focus is to secure seamless handover from project staff to operators and maintainers. It requires verification that training has been provided for all staff at all levels, handover of assets and records have taken place and that ongoing support is provided before project staff are demobilized.

2.11 Train Simulator

To enable state of the art training for the new staff of the Railway system Driver Training Simulator shall support the training team to provide sufficient practical training for the future Train Divers and for refresher trainings after the start of revenue service.

A Driver training simulator shall be on real-time simulation system that covers instruction, training and examination. By the means of video, images, sound and computer generated images as well as analog simulation equipment, the system shall realize train control interfaces, operation displays, control logic and line scenarios.

The Training Simulator shall consist of:

- Simulated Cab
- Train Driving Simulation System
- View Simulation System
- Sound Simulation System
- Signal Simulation System
- Communication Simulation System
- Fault Simulation System
- Trainer Control System

APPENDIX A : PASSENGER FLOW FORECAST

ARL :

Station	2566		2576		2586		2596		2606		2616	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
ดอนเมือง	10,080	8,800	12,460	11,360	15,510	14,220	18,030	16,510	18,630	17,640	19,510	18,960
บางซื่อ	13,160	13,550	16,770	16,950	20,360	20,690	23,360	23,600	24,700	24,600	25,860	25,510
พญาไท	19,710	19,960	24,000	25,000	30,380	30,470	36,110	36,630	39,310	39,370	42,200	42,730
ราชปรารภ	7,970	8,010	9,880	10,070	11,770	12,320	14,350	14,010	15,160	15,210	16,530	15,990
มักกะสัน	11,780	11,740	14,950	15,040	18,150	18,230	21,330	21,580	22,620	22,910	22,960	23,150
รามคำแหง	8,110	8,810	10,630	11,090	12,470	12,640	14,980	15,200	16,040	16,330	16,890	16,880
หัวหมาก	9,260	9,250	11,890	11,720	13,990	13,960	17,080	16,430	18,270	17,720	20,050	19,880
บ้านทับช้าง	5,230	5,470	6,620	6,830	7,840	8,120	8,760	9,230	9,430	9,670	9,590	10,320
ลาดกระบัง	9,230	9,460	11,600	11,670	13,520	13,720	15,210	15,830	15,980	16,170	16,560	16,380
สุวรรณภูมิ	11,480	10,960	14,540	13,610	18,430	18,050	20,470	20,660	21,180	21,700	21,820	22,170
Total	106,010	106,010	133,340	133,340	162,420	162,420	189,680	189,680	201,320	201,320	211,970	211,970
Max Line Load (pphpd)	4,670		5,860		7,080		8,310		8,810		9,350	
Average Distance (km)	19.3		19.3		19.5		19.2		19.0		18.9	

HSR :

Station	2566		2576		2586		2596		2606		2616	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
ดอนเมือง	3,960	4,290	5,000	5,440	5,840	6,330	6,340	6,970	6,490	7,200	6,850	7,490
บางซื่อ	6,110	6,160	8,200	8,200	9,720	9,910	10,780	10,940	11,130	11,310	12,050	12,190
มักกะสัน	6,540	6,200	8,190	7,880	9,540	9,090	10,500	10,000	10,810	10,390	11,800	11,150
สุวรรณภูมิ	5,800	5,660	9,310	9,280	12,260	12,070	14,600	14,370	15,740	15,510	17,340	16,920
ฉะเชิงเทรา	6,100	6,190	9,360	9,450	11,450	11,650	14,000	14,180	15,120	15,290	16,990	17,210
ชลบุรี	3,540	3,590	4,610	4,700	5,490	5,630	6,030	6,150	6,240	6,310	6,810	6,940
ศรีราชา	3,800	3,870	4,950	4,970	5,820	5,870	6,400	6,550	6,720	6,760	7,280	7,410
พัทยา	3,420	3,470	4,590	4,610	5,370	5,430	5,920	5,980	6,110	6,180	6,620	6,770
อู่ตะเภา	1,920	1,760	4,320	3,990	6,570	6,080	8,390	7,820	9,260	8,670	10,100	9,760
ระยอง	-	-	-	10	-	-	-	-	-	-	-	-
Total	41,190	41,190	58,530	58,530	72,060	72,060	82,960	82,960	87,620	87,620	95,840	95,840
Max Line Load (pphpd)	1,840		2,670		3,300		3,820		4,050		4,430	
Average Distance (km)	109		112		114		114		114		114	

VOLUME 3 : OUTLINE SPECIFICATIONS

VOLUME 3/1 : THE RAIL-RELATED WORKS OF THE PROJECT

PART 3 – OUTLINE SPECIFICATIONS FOR RAILWAY SYSTEMS

SECTION 2 - ROLLING STOCK (HSR)

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SECTION 2

ROLLING STOCK (HSR)

1 EXECUTIVE SUMMARY

This Document provides a high-level performance-based Specification identifying the major requirements for a high-speed Train Set (HSR) only. The Specification of the Train Set for CITY LINE shall be referred to the TOR and Specification for Procurement of 7 additional Train Sets.

The Private Party shall provide a Train Set platform of a Service-Proven design, which is not limited to a narrow body train only. Necessary system modifications due to design changes for the existing Airport Link System are under the responsibility of the Private Party. The following key features being further defined:

a) High level of Safety,

b) High Reliability,

c) High Availability,

d) Excellent Maintainability,

e) High Energy efficiency,

f) Low life cycle costs,

g) Flexible high quality passenger and Train Crew environments,

h) High level of security.

The Private Party shall be required to perform the successful commissioning of the Train sets as further agreed.

Based on the SRT's experiences and future aspirations, below are several key issues that the Private Party shall address to ensure that the SRT's requirements are met:

a) Environments in which the Train Sets will have to operate,

b) High Reliability and Fault tolerance,

c) Passenger comfort,

d) Passenger and employee Safety and security,

e) Energy efficiency and conservation,

f) Environmental quality and impact,

g) Standardization of a product platform,

h) Optimization of whole life cost (Reliability, Availability, Maintainability and Safety),

i) Compliance with the SRT's individual infrastructure and System requirements.

2 GLOSSARY OF TERMS

2.1 Acronyms and Abbreviations

General usage acronyms and abbreviations are as follows:

Table 1 *:* Acronyms and Abbreviations

AC	Alternating Current
APS	Auxiliary Power Supply
ASC	Automatic Speed Control System
ATC	Automatic Train Control
ATLAS	Catering Equipment Standard
ATO	Automatic Train Operation
CCU	Central Control Unit
CDRL	Contract Deliverable Requirements List
CEM	Crash Energy Management
CEN	Comité Européen de Normalisation (European Committee for Standardization)
CIL	Certifiable Items List
CMA	Corrective Maintenance Analysis
CMF	Colors and Materials File
CPTED	Crime Prevention through Environmental Design
CS/SC	Cab Signal and Speed Control System
CT	Current Transformer
dB	Decibel
dBA	Decibel, "A"- Weighted Scale
DC	Direct Current (specifically traction current supplied by OHL)
DIN	Deutsches Institut für Normung
DMI	Driver-Machine Interface
ECM	Enterprise Content Management
EIR/S	Environmental Impact Report/Statement
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMU	Electric Multiple Unit
EN	European Norm
ERP	Enterprise Resource Planning
ETF	Engineering Task Force
EV-DO	Evolution Data Optimized
FAI	First Article Inspection
FEA	Finite Element Analysis
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes and Effects Criticality Analysis
FRACAS	Failure Reporting and Corrective Action System
FRP	Fiber-Reinforced Plastic
GFI	Ground Fault Interrupter

GPS	Global Positioning System
GUI	Graphical User Interface
HABD	Hot Axle Box Detection
HMI	Human-Machine Interface
HPMR	Historical Product Maintainability Report
hr	hour
HS	High speed
HSPA	High Speed Packet Access
HVAC	Heating, Ventilation, and Air Conditioning
Hz	Hertz
IBM	International Business Machines Corporation
IBS	Interface Breakdown Structure
IC	Intercom
ICD	Interface Control Document
ICE	Independent Checking Engineer
ICP	Integrated Control Panel
ICT	Interface Control Team
ICW	Interface Coordination Workshop
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronic Engineers
IM	Interface Management
IOS	Initial Operating Segment
ISO	International Organization for Standardization
ITE	Independent Testing Engineer
IV&V	Independent Verification and Verification
kph	Kilometers per Hour
kV	Kilovolts
LAN	Local Area Network
LCC	Life Cycle Cost
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LRU	Line Replaceable Unit
LSG	Laminated Safety Glass
LTE	Long Term Evolution
MAS	Maximum Authorized Speed
MCAT	Minimally Compliant Analytical Track
MCE	Maximum Considered Earthquake
MDT	Maintainability Demonstration Test

MDTP	Maintainability Demonstration Test Plan
MHz	Megahertz
MMS	Maintenance Management System
MPH	Miles Per Hour
MTBCF	Mean Time between Component Failure
MTBSI	Mean Time between Service Interruption
MTTRS	Mein Time to Restore Service
N/A	Not Applicable
NTP	Notice to Proceed
O&M	Operations and Maintenance
OCC	Operations Control Center
OCS	Overhead Contact System
PA	Public Address
PHA	Preliminary Hazard Analysis
PMA	Preventative Maintenance Analysis
POS	Point of Sale
PPM	Pulses per Minute
PRA	Preliminary Reliability Analysis
PRM	Persons with reduced mobility
PSP	Product Safety Plan
PTU	Portable Test Unit
QA	Quality Assurance
QC	Quality Control
RAMS	Reliability, Availability, Maintainability and Safety
RAR	RAM Allocation Report
RCM	Reliability Centered Maintenance
RDA	Remote Data Access
RDT	Reliability Demonstration Test
RDTP	Reliability Demonstration Test Plan
RF	Radio Frequency
RIC	Regolamento Internazionale delle Carrozze (International Coach Regulations)
RM	Requirements Management
RFR	Reliability Prediction Report
RST	Rolling Stock
RVTM	Requirements Verification Traceability Matrix
SCADA	Supervisory Control and Data Acquisition
SEMP	Systems Engineering Management Plan
SOS	Save Our Souls (emergency signal)

SRU	Smallest Replaceable Unit
TC	Traction Converter
TCN	Train Control Network
TDD	Technical and Diagnostic Display
TE	Energy Transmission
TFT	Thin-film transistor
TL	Light Transmission
TOP	Top Of Floor without floor coverings / carpet etc.
TOR	Top Of Rail
TPS	Traction Power Supply
TVA	Threat and Vulnerability Assessment
TSI	Technical Specifications for Interoperability
TSI CCS	Technical Specifications on Interoperability – Command, Control, Signaling
TSI ENE	Technical Specifications on Interoperability - Energy
TSI INF	Technical Specifications on Interoperability - Infrastructure
TSI LOC & PAS	Technical Specification on Interoperability – Locomotives & Passenger Coaches
TSI PRM	Technical Specifications on Interoperability – Accessibility to People with Reduced Mobility
TSI SRT	Technical Specifications on Interoperability – Safety in the Railway Tunnels
UIC	Union Internationale des Chemins de fer (International Union of Railways)
UL	Underwriters Laboratories, Inc.
UMTA	Urban Mass Transportation Administration
UMTS	Universal Mobile Telecommunications System
UTC	Universal Time Coordinated
V&V	Verification and Validation
VAC	Volts Alternating Current
VOC	Volatile Organic Compound
VPN	Virtual Private Network
WC	Water Closet (flush toilet)
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WSP	Wheel Slip/Slide Protection
WWAN	Wireless Wide Area Network
3D	Three-dimensional

2.2 Definitions

Terms used within this Specification shall have the following meanings:

Table 2 : Terms and Definitions

Analysis	A logical thought process which includes: clearly stated assumptions which can be justified, calculations with references for methods and equations stated, using data from simulation or, preferably, Full-Scale Test, and clearly-stated conclusions which logically follow from the supporting calculations and data.
Assembly	A group of components or subassemblies.
Availability	The ability of a product to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval assuming that the necessary external resources are provided.
Bogie	An Assembly that consists of a frame with axle(s)/wheelset(s) and braking Equipment that pivots under a carbody. It includes traction motors and gearboxes, if applicable.
Brake, Dynamic	A general term covering Regenerative Braking and the management of surplus braking energy via an onboard power management System.
Brake, Electric	A general term covering both Dynamic Braking and eddy current braking, if applicable.
Brake, Regenerative	Braking in which kinetic energy is converted to electrical energy in the traction motors, transferred by the control System through the DC link, and returned to the contact line or addressed by the onboard power management System.
Cab	The portion of the carbody of a Vehicle designed to be occupied by the Driver of the Train Set.
Cab, Controlling	The Cab from which the driver exercises control over the Train Set.
Collapse	Large deformations or buckling of structural members when their yield or buckling strength is exceeded.

Core Systems	Core Systems shall include the following aggregate of Systems, at a minimum, that form the SRT's railway System: Train Sets; Infrastructure (including trackwork, tunnels, viaducts); Supervisory control and data acquisition; Signaling (including Automatic Train Control); Overhead contact System; Traction power System; Communications (including public address, Wi-Fi, radio, closed-circuit television, etc.) System; Access control (including intrusion detection); Hazard detection and mitigation (including fire and seismic).
Corrective Maintenance	Maintenance that shall be performed to restore an Equipment component or System to a satisfactory condition after a malfunction or Failure has degraded that particular item below the Specified acceptable performance levels. The Maintenance shall be carried out after Fault recognition in accordance with prescribed criteria. The goal of Corrective Maintenance is the placement of the item back into a state where it could resume Normal Operations.
Coupler Adapter	The rescue/recovery interface unit that permits Train Set coupling with other rolling stock.
Data	Presentations, plans, reports, schedules, drawings, forms, plans, Programs, calculations, analyses, samples, photographs, video, etc. prepared by the Private Party and/or the Subcontractor in response to SRT requests and/or in accordance with the requirements identified in the Contract .
Design Review Process	The process by which the Train Set is designed to meet the requirements of this Specification and fulfills the requirements of the Contract. The Design Review Process will consist of 3 stages review levels (Preliminary, Detailed and Working Drawings) and necessitates close coordination between the Private Party, the SRT and the Engineer’s Representative via design review meetings.
Device	Can be used to describe a component, Equipment, Subsystem, or System and may be electrical, mechanical, pneumatic, and/or hydraulic in nature.
Diagnostic System	Centralized system that collects, advises, and displays detailed information relevant to the operational conditions of the Train Sets Systems and Subsystems

Double Traction	Two Train Sets operating in a coupled configuration.
Downtime	The time interval whereby any Device, component, or Equipment is not under Normal operation due to Maintenance requirements or Failures/Faults (inclusive of repair/reinstallation times and time needed to resume Normal functions).
Driver	Any qualified person who moves the Train Set or locomotive (if in the event of a rescue operation) regardless of whether or not it is coupled to other rolling stock.
EMU	Electrical Multiple Unit with distributed traction and passenger seating in every car.
Equipment	Any physical Device that is part of the Train Set and is the object of Maintenance actions. Equipment may also refer to the Train Set itself.
Failure	A deviation from the Specified performance of a System. A Failure is the consequence of a Fault or error in the System.
Failure Modes and Effects Criticality Analysis (FMECA)	Procedure that follows failure mode and effects analysis, and where each potential failure effect is classified according to its probability of occurrence and degree of severity. Requirements for FMECA are identified in EN 50126.
Fault	An abnormal condition that could lead to an error in a System. A Fault can be random or systematic.
Flammability	The ease, with which a material ignites and, once ignited, continues to burn.
Front End	The end of a Vehicle or Train Set unit facing the direction of travel.
Full-Scale Test	A test of a fully-assembled article.
General Provisions	Shall be understood as the document with the terms and conditions explicitly named as “General Provisions” in the Contract
Glazing Frame	The arrangement used to install the glazing into the structure of the Train Set.
Glazing, Interior	A glazing panel with no surface exposed to the outside environment and which is protected from projectiles by the structure of the Train Set.
Hazard	A physical situation with a potential for human injury, environmental impact, or service impact.
Interface	The physical or functional connection point between two Systems, Subsystems, components, etc.

Life of the Train Set	The service life of a Train Set being operated under the conditions set out in this Specification shall not be less than 30 years or 18,000,000 km, whichever is reached earlier. (see also Art. 4.3.1 below)
Mainline	Lines other than those within the Maintenance facilities/depots. They shall include both dedicated and shared portions of right-of-way or track.
Maintainability	The probability that a given Maintenance action, for an item under given conditions of use, can be carried out within a stated time interval when the Maintenance is performed under stated conditions and using stated procedures and resources.
Maintenance	The combination of technical and administrative actions intended to retain or restore a product to a state in which it could perform its intended functions.
Manufacturer	The builder/producer of Train Set materials or Equipment.
Mock-ups, Hard	Mock-ups used to convey final concepts and Equipment arrangements. All components shall be operable to the extent that their operating mechanisms, controls, and range of operation can be demonstrated.
Mock-ups, Soft	Mock-ups used to convey initial concepts and the general arrangement of Equipment in full size. Such Mock-ups are generally not "durable." Soft Mock-ups shall be neutral in color and shall not represent specific color schemes. Colors shall be used only to represent the range of motion of components. Soft Mock-ups shall include all appropriate simulated signage. The operating envelope of each moveable component shall be defined. All component deployment positions shall be demonstrated. Soft Mock-ups shall be made of inexpensive, easy-to-work materials such as plywood, wood battens, cardboard, foam core panels, and foam plastics. Alterations shall be simple through use of a saw or knife. Components shall be secured with nails, tape, or adhesive. 3D visualization tools for space planning and form, fit, and function would also be acceptable as a Soft Mock-up.
Normal	The condition in which the pertinent part, Equipment, Subsystem, or System is under proper Operations, as intended, and is not in a failed state.
Occupied Volume	The sections of a Vehicle which contain seating and are normally occupied by passengers or crew.

Operating Speed	The speeds that the Train Sets are expected to run during daily continuous Operations on appropriate sections.
Operations	The supervision, control, and operation of Train Sets, stations, depots, and control centre Operations during Normal, degraded, and emergency situations.
PPTA	3 Airports Seamless Connection by High-Speed Railway
Pitch	The distance between a point on one seat and the same point on the seat in front of it.
Preventative Maintenance	Maintenance that shall be performed to keep the Train Set in satisfactory, operational condition by timely/scheduled inspections, calibration, cleaning, etc. The Maintenance shall be carried out at predetermined intervals (based on days or distances or condition) in accordance with prescribed criteria. The goal of Preventative Maintenance shall be to reduce the probability of Equipment degradation/Failure that could affect Normal Train Set Operations.
Procurement	The furnishing of items, Equipment, Data, services, labor, management, etc. necessary for the design, manufacture, assembly, testing, and delivery of the Train Sets and Work under this Contract.
Product Safety Plan	A document that the SRT requires of the Private Party that gives the details of the techniques, procedures, and tests to be used as part of the Train Set design process to ensure that the Train Set meets all required Safety standards and SRT Safety design requirements.
Regulatory Agency	Entity responsible for regulatory approval.
Relevant Standard	An industry-recognized standard used in the design, production, and/or development of high speed rail deliverables identified in this Contract.
Reliability	The probability that an item can perform a required function under given conditions for a given time interval.
Revenue Service	The Normal operation of the Train Set on the railway System whereby passengers are transported and fares are collected.
Safety	The condition in which persons are free from unacceptable risk, unacceptable harm, unacceptable threat, or unacceptable danger.
Service-Proven	Refers to EMU Train Set Standard Platform based on TSI in use in commercial high speed passenger service at least 250 kph for a minimum of five years.

Shared Operations	Rail Operations conducted by more than one operator on the same alignment regardless of whether such Operations are the result of: • Contractual arrangement between operator; • Order of a governmental agency or a court of law; or • Any other legally binding directive
Software Safety Plan	A controlled orderly process to develop, produce, test, and verify safe and reliable computer programs for the Train Set.
Specification	The directions and provisions established in this document, in its entirety, that prescribes the manner of performing the Work, the requirements and criteria to be followed, and the deliverables to be submitted as part of this Contract.
Specified	As stated in this document.
Standard Platform	A Train Set or Train Sets from a "platform" family (e.g. either distributed or concentrated power, similar body construction/cross section, either conventional or articulated bogie architecture) that meets the requirements of Stage 1 of the Evaluation Process, for the SRT, with commonality of design and comparable manufacturing processes.
Subassembly	A grouping of components that are part of a larger System used to perform discrete functions in conjunction with other groupings.
Subsystem	A combination of components or Equipment that perform an operational function within a System.
System	A combination of Subsystems that performs a major operational function.
Train Crew	Onboard personnel who support the Train Manager and generally have and perform similar functions/responsibilities. Also called crew.
Train Manager	A person, who oversees the general welfare, Safety, and security of the passengers, manages the Train Sets assets, assists the Driver, and monitors and controls Train Set Subsystems, as appropriate, with applicable knowledge and qualifications. Also called a conductor.
Train Set	A fixed train formation consisting of Vehicles that can only be reconfigured within a workshop environment.
Vehicle	Passenger car forming part of a Train Set.
Vehicle, Bistro	The Vehicle in the Train Set which serves as the main food preparation and serving area.

Vehicle, Rescue	Fully functional Train Set or locomotive sent to aid a malfunctioning Train Set.
Vital	A subcomponent, component, or System that is Safety-critical, and therefore, must be designed to be failsafe and/or have a very low incidence of unsafe Failures.
Work	Refer to the General Provisions and relevant Contract Documents for definition.

3 REGULATIONS AND STANDARDS, UNITS, AND DESIGN APPROVAL

3.1 Regulations and Standards

The Private Party needs to comply with the referenced standards and regulations in this Specification. Furthermore the Private Party has to comply with the mandatory local laws of Thailand.

3.2 Units of Measure

As a general requirement, each Subsystem shall be designed and manufactured to a single standard of measurement, and there shall not be a mixture of standards in any enclosure or on any component or Subassembly for a Subsystem within the enclosure.

Subsystem and component designs and associated fasteners shall be metric standard.

Fractional measurements shall not be used on drawings but shall be expressed as decimal values.

3.3 Design Approval Process

The Private Party shall be subject to a formal Design Review Process in accordance with the SRT’s Requirements, Phase I, Design.

The Design Review Process shall be applied at the Train Set Subsystem level (e.g., traction, braking, air conditioning, seats, etc.), and shall include two staged gate review levels (preliminary and final).

The Design Review Process shall demonstrate that:

The Train Sets will meet the requirements of the Specification, including the provision of a high level of Safety (e.g., crashworthiness, occupant protection, etc.) in their design and construction. Any deviation from the criteria defined in this Specification shall be subject to the Engineer's Representative’s acceptance. Deviations shall be clearly presented by the Private Party, for the Engineer's Representative’s review and approval.

Compliance with applicable international standards can be verified through the submittal of previously conducted analyses and tests on an identical or similar item.

4 GENERAL CUSTOMER REQUIREMENTS

4.1 Minimum Technical Qualification Criteria

The following criteria shall be the minimum qualification criteria in order to be deemed a qualified Train Set:

- The Train Set shall be a single deck EMU capable of operating in revenue service at speeds up to 250 kph.
- The Train Set shall be based on a service-proven Train Set according to TSI 2008 or later which is operated at least with 250 kph in passenger service since at least five years (fleet size at least 10 Train Sets).
- Is compliant to applicable laws of Thailand, regulations and standards mentioned in this Specification.
- Meets the width and length requirements as specified Sub-Clause 4.3.6 and 5.3.
- Does not exceed the static axle loads of 16 tonnes in accordance to TSI INF 2015.
- Provides the combination of passenger seats incl. seat pitch, number of toilets and the required Bistro as specified in Clause 7.

4.2 Operating Routes

The Train Sets shall be able to operate on SRT's network as it is specified by the SRT to the Private Party in further detail in this Specification.

The segment from Don Mueang to U-Tapao is approximately 215 km. The majority of the track is dedicated to high speed rail; however, there will be sections of corridor and/or track that will involve operation at lower speeds and sharing tracks with other rail equipment and operators.

Train Sets shall operate satisfactorily over the entire PPTA network, inclusive of crossovers, sidings, station platforms, Maintenance facility ies, defined in this Specification.

The Train Set shall be capable of a continuous maximum Operating Speed of 250 kph under TSI full load conditions, and a testing speed according to EN 14363.

Train Sets for the SRT Train Set Procurement shall be able to operate on the planned high speed rail System as specified in this Specification on both dedicated and shared (blended) Operations.

4.3 Operational Requirements

4.3.1 Design Life

The Train Set shall have a service life of not less than 30 years or 20,000,000 km, whatever is reached earlier. The Train Set shall accommodate an estimated annual mileage of 650,000 km per Train Set while operating on SRT's network. A daily operational service time of 18 h shall be assumed.

4.3.2 Modes of Operation

The Train Sets shall support the following modes of operation as defined per the Grades of Automation (GoA) according to UITP: GoA 0 (on-sight train operation), GoA 1 (manual train operation under ATP where a train driver controls starting and stopping) and optional GoA 2 (Automatic driving and braking / Semi-automatic Train Operation (STO)).

4.3.3 Passenger Flow and Evacuation

The Train Set doorways and vestibules shall be sufficiently wide to meet or exceed TSI PRM 2015 requirements. The design of the Train Set including size and location of exterior doorways, vestibules, internal features, and seating areas shall be optimized to achieve TSI PRM 2015 compliance for maneuverability, and for allowance of passenger flows that achieve the required boarding, disembarkation, and evacuation times.

The Private Party shall submit a dwell time simulation considering a width of at least 720 mm per person.

The Private Party shall submit a Train Egress Report outlining the number and size of side entry doors that shall facilitate the complete evacuation of a Train Set to an adjacent platform according to TSI LOC&PAS 2015.

4.3.4 Journey Time

The Train Set shall provide performance required to achieve the shortest possible journey times consistent with the overall requirements of this technical Specification. SRT journey time requirements shall be met operating with an operational load under normal payload (Mass definition according to EN 15663 Tables 1 to 3) on the existing/planned infrastructure and are as specified in the Operations Concept.

Further conditions are specified in Art. 4.7 (Energy Consumption Efficiency).

The journey time shall be calculated by the Private Party with the latest run time simulation tools. The Private Party shall provide results including all relevant input parameters to allow re-simulation by the SRT.

The required inputs (track data, physical characteristics, maximum allowable speed information, etc.) can be found in Operations Concept.

4.3.5 Climatic and Environmental Conditions

The Train Sets shall be designed in accordance to TSI LOC&PAS 2015 Article 4.2.6 and shall be able to operate under environmental conditions as given in the table below:

Table 3 : Environmental Conditions

Environmental influence	**Requirement / class**
Temperature	According to EN 50125-1 class T3
Operation altitude	According to EN 50125-1 A1
Humidity	according to EN 50125-1 (§4.4 picture 2) for temperature class T3 Relative humidity of max. 100% possible within the range of temperature class T3
Wind	according to EN 50125-1
Rain	according to EN 50125-1 and class 5K3 according to EN 60721-3-5
Hail	according to EN 50125-1, grain diameter ≤ 15mm
Solar radiation	according to EN 50125-1 and class 5K3 according to EN 60721-3-5
Lightning strike	according to EN 50125-1
Chemically aggressive substances	according to EN 50125-1 and class 5C2 according to EN 60721-3-5
Contamination fluids	according to EN 50125-1 and class 5F2 according to EN 60721-3-5
Biologically aggressive substances	according to EN 50125-1 and class 5B2 according to EN 60721-3-5
Mechanically aggressive substances	according to EN 50125-1 and class 5S2 according to EN 60721-3-5
Stones	according to EN 50125-1, max. diameter ≤ 15mm

4.3.6 Infrastructure

The Train Sets shall be designed for a gauge of 1,435mm.

The Train Sets shall comply with kinematic gauge of the existing Suvarnabhumi Airport Rail Link System e.g. G1/GI2 according to EN 15273-2, compliance shall be established by the kinematic method as set out in EN 15273-2. The pantograph gauge shall comply with Annex A.3.12 of EN 15273-2. The completely assembled Bogies with motors, brakes and other Equipment shall not exceed the vehicle gauge as defined above. The maximum vertical and lateral deflection and maximum roll shall not exceed those values which will keep the complete Vehicle within the clearance outlines.

The Tunnels will be designed in a way to meet the requirements set forth in TSI SRT 2015.

Tunnels will be designed to allow for Train Set Operations at the maximum operating speed considering the respective requirements of the relevant TSI.

Train Sets shall be able to start, operate, and stop on the maximum gradients on all the lines for which they are designed and over which they are likely to operate. Max.

gradients and track centre spacing in accordance with TSI INF 2015.

4.3.7 Reliability

Reliability is a key requirement that the Train Set is reliable throughout the Life of the Train Set (also see Article 4.3.1). The Train Set shall meet or may exceed the RAM targets provided below. Reliability performance shall be achieved by the design, manufacture, testing, commissioning and then maintenance over the Life of the Train Set.

The Train Set shall be provided with the necessary redundancy or other means to recover from or mitigate for reasonably expected technical Failures of the Train Set.

The Private Party shall prepare and submit for the Engineer's Representative's review a Reliability Program Plan that describes how Reliability will be achieved and demonstrated throughout this Program. The Reliability Program Plan shall contain, as a minimum:

a) Program objectives,

b) Reliability Program schedule,

c) Methodology to be used in Reliability Analysis, such as FMECA or FTA,

d) Apportionment of Reliability target performance to each Subsystem,

e) Organization of personnel responsible for managing Reliability on the Program,

f) Control of Subcontractors and suppliers to ensure compliance with the Reliability Program plan,

g) Details for the Reliability demonstration Program, including procedures, and measurement criteria test parameters,

h) Reliability database, inclusive of Data drawn from current applications of the Standard Platform and technologies, including contact information for the Train Set operators.

The Reliability Program Plan shall be based on EN 50126.

As a minimum, a fleet consisting of at least 10 Train Sets ("FLEET") shall achieve the following Reliability metrics after a ramp-up time of at least 3 years:

Mean Time between Service Interruption (MTBSI) of 4,500 hr. MTBSI is the mean time in Train Set service hours between failures causing a Train Set service interruption (statistical value per year for the FLEET of Train Sets). Train service hours are the hours a Train Set is carrying passengers, i.e., running between terminals and boarding and de-boarding passengers at station stops. A Train Set service interruption is defined as a Failure that results in a Train Set in service being:

a) More than 10 minutes late arriving at or departing from at the first / the last (per time table) station solely due to the Failure;

b) Cancelled either at its originating point or en route due to failure reasons that need to be mutually agreed; or

c) Reduced in size or revenue capacity due to requiring a failed Train Set (under double traction configuration) to be removed.

The Private Party shall achieve and demonstrate RAM performance metric values for the SRT Train Set. In the bid documentation the Private Party shall break down the RAM performance metric values to relevant Train Set Systems as defined below for reference and comparison purpose.

The required RAM performance metrics are MTBSI and Mean Time between Component Failure (MTBCF). The Private Party shall implement the Maintenance Plan submitted by manufacturer/the Private Party to assure that the Train Set and Equipment achieve the MTBSI metrics.

MTBSI is the mean time in Train Set service hours between all Failures requiring a maintenance action.

Table 4 : Train Set RAM Metric Values

4.3.7.1

Train Set RAM Metric Values				
No.	Vehicle System	MTBSI (hr)	MTBCF (hr)	List each failure which immobilizes a Train Set and provide its MTBSI (hr)
1	Door Control System & Doors			
2	Communications Systems/Passenger Information Signs			
3	CCTV			
4	Event Recorder			
5	Monitoring and Diagnostic System			
6	HVAC System			
7	Primary Power Distribution and Auxiliary Power System, Low Voltage System, Trainlines and Train and Car Control, and Pantograph Current Collector			
8	Propulsion System and Adhesion Management			
9	Onboard Train Control			
10	Friction Brake System, Compressed Air System, Parking Brake System, Adhesion Management Dump Valves			
11	Carbody			
12	Interior Furnishing, Finishes, and Lighting			
13	Coupler			
14	Bogie			
15	Fire Protection Systems and Extinguishing			
16	Café Equipment			
17	Cab Controls			

Train Set RAM Metric Values				
No.	Vehicle System	MTBSI (hr)	MTBCF (hr)	List each failure which immobilizes a Train Set and provide its MTBSI (hr)
18	Water and Waste Water System			
19	Automatic Train Protection			
20	Remaining components			
Train-Level				

Table 5 : RAM Analysis Factors

RAM Analysis Factors		
No.	RAM Factor	SRT Value
1	Revenue hours per day	
2	Off-peak revenue hours per day	
3	Peak revenue hours per day	
4	Non-revenue Train Set operating hours per day	
5	Off-peak service headway minutes	
6	Peak service headway minutes	
7	Longest revenue service trip miles, one way	
8	Longest trip time, all station stops, one way	
9	Stations, per direction	
10	Average annual Train Set km	Min. 400,000 km
11	Maximum daily revenue Train Set km	
12	Average annual Train Set operating hours	Min. 4,500 hours
13	Average number of revenue service Train Set trips per day	
14	Average non-revenue service Train Set miles per day	
15	Average number of non-revenue service Train Set trips per day	

4.3.8 Availability

Operational Availability

The operational availability of the Train Sets (OA) is defined as the ratio between the sum of the days, where the Train Sets are already handed over for service and the sum of the days, where the Train Sets are actually received by the SRT (or operator of the

Train Sets) for operation.

Accordingly:

$$OA = \frac{\sum_{i=1}^{i=n} D_i}{\sum_{i=1}^{i=n} T_i} * 100$$

Being,

N = Number of trains of the series received before or during the period considered

Di = For each train, days of the period considered that this train has been available.

Ti = For each train, days of the period considered during which the train was already accepted and was planned for Operation as per the Operation plan in Operations Concept.

The operational availability will be measured on a daily basis at 7am in the morning and the average availability results will be considered of a moving window of 1 year. In the measurement the days do not count, where the Train Sets are immobilized by causes not attributable to the Private Party (e.g. accidents, vandalism).

The Private Party requires an average level of operational availability of at least 99.5% after a ramp-up time of at least 3 years calculated from the time the 5th train starts passenger operation.

Technical Availability

The unavailability of the Fleet shall be calculated as Maintenance hours per year (per definition under 4.3.9 below) divided by 8,760 hours (max. available hours per year). The required Technical Availability is therefore 95.4%.

The Technical Availability metrics shall be achieved after a ramp-up time of at least 3 years calculated from the time the 5th Train Set starts passenger operation.

4.3.9 Maintainability

General Requirements

The Train Set design shall be such that Maintenance, overhaul, and repair are minimized, and where possible Maintenance can be accommodated in times that are consistent with the Availability requirements.

The Private Party shall ensure that the Train Set design takes account of human factors in Maintenance, by ensuring that inherent design features reduce or mitigate the effects of human error during Maintenance processes.

The Train Set design shall consider Availability and quality of all spare parts and consumables as specified in this Specification within the Life of the Train Set.

The Train Set design process shall incorporate processes based on e.g. Reliability Centered Maintenance (RCM) in order to achieve good design and consider Maintenance requirements.

The Train Set shall generate minimum damage to the track, inclusive of rolling contact fatigue and wear. The track maintenance influence will be evaluated according to the Life Cycle Cost Analysis.

Maintenance Management System

The Private Party shall use an integrated, state-of-the-art Maintenance Management System (MMS) that facilitates rail-pertinent maintenance of all things rail: Rolling stock, signaling, central traffic control, power supply, catenary lines, communication and SCADA equipment, automatic fare collection, platform screen doors, trackwork, buildings, depots, workshop- and auxiliary equipment.

The MMS shall be based on a widely used standard software base (e.g. IBM Maximo) to benefit from continuous improvement and readily available expertise across the globe so the data can be easily exported and reused.

The MMS shall enable the maintenance organization to comply with laws and standards such as ISO 9001 and ECM.

The Private Party shall implement a customer portal to grant access to defined Vital performance indicators, data and reports. The customer portal provides access to a tracing and tracking system.

The MMS shall comprise of the following modules:

a) Configuration management: It is used to ensure consistency of a product's performance, functional and physical attributes with its requirements, design and operational information throughout its life. Another purpose of the configuration management module is to have current and historic records of all assets to be maintained. Configuration management will also be used as a basis for optimizing whole-life costs.

b) Maintenance planning system: The planning system shall support modern maintenance strategies like preventive, predictive and condition based as well as the classic processes of Corrective Maintenance, fleet modification campaigns and the like.

c) Material management module.

d) Work order management.

e) Interfacing abilities: Interface easily with Mobile Maintenance Tools, Train set diagnosis, SCADA, ERP systems, technical databases, document management systems and the like.

f) Reporting and analysis module: the data and analysis system shall be available to provide statistical information over different user-defined time frames.

The Vehicles shall be designed and constructed so that the time required to repair structural collision damage is minimized.

The Vehicles shall be designed and constructed so that times to repair vandalism and to replace damaged interior panels are minimized.

4.3.10 Safety

Requirements and Information

The Train sets shall be designed with consideration for the health and Safety of passengers, operational crew, emergency responders, and other third parties. The Private Party shall identify and mitigate Safety Hazards from the outset of the design process and report progress on Safety Work activities throughout the design and approval phases of the project.

Product Safety Plan

The Private Party shall develop a Product Safety Plan (PSP) for the vehicle and principles affecting the safety in accordance with EN 50126.

A first draft of the PSP shall be developed and submitted to the SRT for approval at the preliminary Design Review stage.

The Private Party shall identify Hazards and mitigations, which shall be subject to review and acceptance by the SRT. A final Safety certification report shall be submitted as part of the preliminary acceptance of the first Train set, verifying applications of mitigations, validating the effectiveness of the mitigations, and confirming the residual risk of all identified Hazards. Residual risk shall be assessed and approved by the SRT. The PSP shall include a software Safety section, which applies to any embedded or external software or firmware which controls or monitors Safety-critical functions. Software Safety requirements shall be treated as an integral part of a hardware/software System and shall comply with EN 50128 or equivalent. Functions accomplished through the use of software shall be considered Safety critical unless an independent redundant hardware means is also provided to accomplish the same function.

Features of the Software Safety Program shall include the following, as a minimum:

a) Definition,

b) Implementation and oversight of the software design and verification process,

c) Integrity of the documentation,

d) Software Hazard Analysis,

e) Software Safety reviews,

f) Software Hazard monitoring,

g) Reporting and tracking,

h) Software integration with hardware at each stage of the design and testing process for components, Systems, Vehicles, and Train Sets inclusive of software for Safety-critical functions.

4.4 Training

The Private Party shall offer a training program based on the concept of "train the trainer".

This training concept shall offer separate training sessions in theory and practice for train drivers and train staff.

The technical training program shall comprise of 4 weeks training for train.

The Private Party shall also provide one full-motion 3D driving simulator as an option. The SRT will be required to provide data and subsequent updates of the network route and characteristics.

4.5 Accident/Failure

The Private Party shall provide guidance within the technical documentation on how to re-rail and rescue (tow) the Train sets.

4.6 Documentation

The Private Party shall provide the technical documentation in accordance with the milestones (e.g. prior to technical training for train drivers) as mutually agreed between Private Party and the SRT.

The technical documentation shall include the following documents:

- Operational manual for Driver and Train Crew,
- Technical/Component Description of the Train set down to System Level (e.g.

drawings, part-lists).

Maintenance manuals and the respective work descriptions / instructions are not part of the technical documentation.

Both Parties shall jointly define the scope of technical documentation (incl. Service Software) in detail latest until NTP.

Handover of the technical documentation shall be realized with the help of a web based platform.

4.7 Energy Consumption and Efficiency

The Train set shall be designed to minimize the net energy drawn from the power supply Systems on SRT's System, consistent with the operational performance requirements for traction and auxiliary supplies defined in Sub-Clause 10.1.1.

The Train set shall recover a high proportion of kinetic energy during braking and facilitate its re-use both onboard the Train set and by return to receptive infrastructure.

The Train set shall have an intelligent stabling System, which limits energy consumption during out-of-use periods, but ensures that the Train set can re-enter service when required.

The Train set shall include Equipment to measure energy consumption that shall identify the net energy used over a settable time span and, separately, the energy regenerated into the PPTA network. It shall be possible to upload this information to a central data collection point while the Train Set is in motion. The information shall be provided in a form that will support billing requirements between the SRT and the System providers. Refer to Sub-Clause 12.5 for communications Interface requirements.

The Private Party shall calculate the consumed and regenerated energy by using the latest simulations tools under the following conditions:

- Simulated run on from Don Mueang to U-Tapao (one roundtrip) with the track data provided in Operations Concept,
- Driving Time in accordance with the Timetable as specified in the Operations Concept,
- Ambient temperature of 30°C,
- Altitude as provided by the track data, ISA conditions for atmospheric pressure,
- No wind, no rain, no fog,
- Tunnel effects shall not be considered,
- Operational load under normal payload according to the Mass as defined in EN

15663 Tables 1 to 3,

- Energy shall be measured in kWh per kilometer,
- Catenary fully receptive,
- Nominal OCS voltage,
- Neutral sections of the catenary system are not considered,
- Including actual rotating mass,
- Nominal wheel diameter,
- All comfort functions (e.g. HVAC, toilets, passenger sockets) are switched off.

Additionally, the Private Party shall declare the auxiliary power consumption for a Train set stabled at an ambient temperature of 30°C, wind speed 3 m/s, humidity 75 %, operational load under normal payload (radiation of 60 W/Person) and solar radiation of 200 W/m².

The Private Party shall provide a detailed narrative analysis of the model used for the energy and efficiency including the inputs assumed and the results achieved. The Private Party shall describe the model used and shall provide evidence that the model has been validated (and how). The Private Party shall allow the re-simulation by the SRT.

The SRT will evaluate the energy costs over 30 years based on the Life Cycle Cost Analysis.

4.8 Mock-ups

General

Full size cab and saloon Mock-ups shall be provided. The Mock-ups will be used by the SRT to evaluate the Train set interior against the agreed SRT's requirements and for acceptance with relevant stakeholders and user groups.

The Mock-ups shall be located in the Kingdom of Thailand and should be transportable.

The standard of construction shall be commensurate with the use of each Mock-up as a development and stakeholder review tool. It is not intended to use the Mock-ups for public display or storage/use outdoors.

Alternatively the SRT allows 3D simulations to replace Mock-ups. Precondition is 3D-laboratory to experience and judge decisions around 3D-space planning, form, function and aesthetics. As a second alternative, the Private Party is allowed to use existing Train Sets with identical / similar equipment for this case.

Cab Mock-Up

The interior Mock-up shall include representative examples of the cab seat and primary controls, for approval purposes. Primary controls in this context are those controls and indicators that the driver handles during normal driving operations of the Unit.

Passenger Compartment Mock-Up

Mock-ups are required which should be constructed in a timely manner to help develop the design concepts, and allow the SRT to give clear creative direction and make decisions throughout the design process and at stage gate reviews. The SRT expects the saloon Mock-ups to be used specifically to inform decisions around 3D-space planning, form, function and aesthetics.

For the SRT to make effective timely decisions the Mock-up should include at least:

- First class seating and environment,
- Standard class seating and environment,
- Standard and universal access (TSI PRM 2015 compliant) toilets,
- Vestibule,
- Bistro.

These Mock-ups should allow the SRT to make these decisions in context and should be created in a Mock-up Vehicle 'tube' at 1:1 size.

By final design review stage, the Mock-ups should reach the functionality of:

- Working seat Mock-ups (first and standard Class) with final color and material and finish proposed, in a real size model of the Vehicle tube, with final carpet and wall and ceiling paneling proposed. Working lighting effects in order to see the seats fully in context. Minimum quantity 1 seat mocked-up as above, combined with 3 other seats and a table in order to see spatially how they work. Seats to have moving parts and perform as the customer would expect, but need not necessarily have the final mechanisms to do this.
- A PRM toilet and standard toilet - full size model with real materials proposed to show space and situation of key functionality (toilet, sink, hand-dryer, baby change, flush etc), plus the Colors and Materials File (CMF) proposed for both first and standard class. The Mock-up should be sufficient to ascertain clean ability and general maintainability. It is not necessary to have a fully functioning toilet with working flush, hand-dryers etc.
- A full size model to show space and situation of key functionality (bar, seating, galley, partitions, etc.) plus the CMF proposed. The mock-up should be sufficient to ascertain the position of all key equipment (though this need not be functioning) and to assess cleanability and maintainability. The Mock-up should have working lighting effects in order to see the space in context.
- A full size model to show space and situation of key functionality (luggage, doors,

etc.) plus the CMF proposed for both first and standard class vestibules. The Mock-up should have working lighting effects in order to see the space in context.

The Mock-ups will be used by the SRT to assess and approve the final Vehicle interiors and schedule of finishes in combination with interior renderings.

5 TRAIN SET-WIDE REQUIREMENTS

The proposed Train sets shall be in compliance with the requirements of TSI LOC&PAS 2015.

5.1 Operational Speed

The Train set shall allow a maximum operational speed of 250 km/h.

The corresponding test speed shall be in compliance with EN 14363.

5.2 Certification

In any case the compliance with the operational safety level specified in TSI LOC&PAS 2015 shall be certified by an accredited notified body (No Bo) by means of risk evaluation analysis EC/352/2009 and EU/402/2013, and shall be submitted to the Engineer’s Representative before provisional acceptance of the Vehicle.

A certificate provided by the notified body (NoBo) shall be submitted to the Engineer’s Representative prior to the provisional acceptance of the vehicle, in order to prove the TSI-certification of the proposed Train Set. (EC Type Examination Certificate)

Approval for passenger operation shall be in the responsibility of the Engineer’s Representative and is to be granted by the State Railway of Thailand and Ministry of Transport.

5.3 Train set Length

The Train set length shall be a maximum of 200m +1% for single traction and 400m +1% for double traction in accordance with platform requirements as defined in TSI INF 2015.

5.4 Train set Mass and Axle Loads

Train set static axle loads shall be in accordance with TSI LOC & PAS 2015. A maximum nominal static axle load of 16t shall not be exceeded.

The maximum load per axle and load distribution shall be in compliance with the requirements listed in Article 4.2.3.2 of TSI LOC & PAS 2015 and EN 15663.

The Train sets shall be designed to achieve the lowest axle load and lowest unsprung mass compatible with the functional and technical requirements identified in order to minimize the track maintenance cost. The track maintenance influence will be evaluated according to the model of Life Cycle Cost Analysis.

The Private Party shall calculate the actual axle load and the actual unsprung mass for each axle using the load condition as defined in EN 15663 Tables 1 to 3 for operational mass and the calculation approach as per 13.

The Private Party shall confirm that the structural design of the proposed Service Proven platform can accommodate the payload. This information shall be submitted to the SRT for review.

The definition of the load conditions as per TSI LOC&PAS 2015 and EN 15663 Tab. 3 shall be applied. As design mass under exceptional payload 2P/m² shall be considered.

5.5 Aerodynamics

The Private Party shall demonstrate that the body profile, nose shape, and structural response of the Train sets have been designed to accommodate the relevant requirements of TSI LOC & PAS 2015. The influence of the running resistance will be considered as part of the energy consumption evaluation.

The driving resistance shall be provided for the following wind conditions:

1) 0 m/s wind
2) 2 m/s wind
3) 5 m/s wind
4) 10 m/s wind

The wind direction shall be considered at 90 ° of the driving direction.

5.6 Exterior Design

The Train set exterior, including front end and skirting, shall be painted in accordance with the color schemes to be proposed by the Private Party and agreed upon with the SRT. Exterior Vehicle finishes shall be compatible with the SRT's livery schemes. The Private Party shall propose cleaning agents compatible with the Train Set offered and the appropriate cleaning cycles.

5.7 Electromagnetic compatibility / interference (EMC / EMI)

The Train set shall conform to PPTA network in accordance with the network information provided by the SRT. These requirements cover emission and immunity limits, cabling, grounding, track circuit compatibility, human exposure, and adjacent railroads and airports.

The Private Party shall design, document, and test the Train Set to ensure tolerable protection against inductive and conducted interference with track circuits or other wayside Devices, and against Cab signal interference.

The Private Party shall submit for timely approval a report which demonstrates adequate Safety and dependability margins to protect all track circuits against worst-case Train emissions.

The Train Set Systems shall not have a negative impact on, nor be negatively impacted by:

- Operational electronics used by crewmembers, including radios, and wireless ticketing Devices,
- Consumer electronics used by passengers, including cellular phones, computers, and radios,
- Wayside Equipment,
- Vital control Systems and electronics,
- Third party Systems and Equipment.

Technical data of used/planned systems to be defined by the Private Party

The Train Set shall not cause unacceptable harmonic currents, voltages, or over voltages. The Private Party shall perform a compatibility assessment on the Train Set as a whole, including all power units which can generate harmonics into the traction power system, per EN 50388:2005 Section 10, and shall demonstrate that the Train Set does not generate harmonics beyond the defined limits.

All electrical and electronic Systems shall be capable of operating in the presence of external electromagnetic noise sources and shall not produce electrical noise that interferes with train line control and communications or with wayside signaling Systems.

All electrical devices of the Train Set and the Railway infrastructure shall have a sound electromagnetic compatibility as per related railway standards EN50121-3-1 and

EN 50121-3-2:

Effective measures shall be taken in order to avoid abnormal incidents. The following aspects are taken into consideration:

EN 50121-3-1:

- Radio interference emission,
- Interference immunity of the vehicle,
- Compatibility with signaling and communication systems,
- Interferences from communication systems (psophometric interference current).

EN 50121-3-2:

- EMC requirements for components built into the Vehicle

For people wearing a cardiac pacemaker protection measures shall be implemented that comply with the cardiac pacemaker limit values according to EN 50527-2-1.

6 CARBODY AND INTERIOR

6.1 Flexibility of Interior Layout

The Train Set shall be designed to account for flexible/modular internal layout, allowing refurbishment and/or relocation of interior furniture in the future.

Therefore, the passenger areas shall be kept clear of fixed installations (e.g. electrical cabinets, under seat Equipment) that could limit interior flexibility. Interior draft screens and other intermediate partitions shall not be structural.

6.2 Vehicle Floor

The Vehicle floor height above TOR shall not exceed 1200 mm with new wheels and under full loading condition and shall be compatible with the existing Suvarnabhumi Airport Rail Link's Platforms.

The structure of the floor shall be designed in order to enable the flexible mounting of interiors within lifetime of the Train Set.

Flooring in the passenger seating areas shall be covered with industrial grade carpeting that is hard-wearing, non-staining, and non-discoloring. Walls and ceilings' surfaces shall not be carpeted.

Flooring in toilets and food service areas shall be covered with service proven surface materials that are non-slip, even when wet, and colored so as to not accentuate the presence of stains. The floor shall be sealed to prevent moisture infiltration and shall either be integral with the walls or connected to them by a sealed joint, so as to prevent the leakage of water-based liquids into the Vehicle structure.

The floor of the drivers Cab shall have a smooth covering to support easy cleaning of the workplace.

6.3 Interior Height

The interior height shall be in compliance with TSI LOC & PAS 2015.

6.4 Interior Lining

The interior paneling of walls and ceilings shall be highly damage resistant and easy to clean. Therefore any openings where dirt could be collected have to be avoided.

The interior paneling shall be designed in a way to support air conditioning of the passenger compartment. Supply of cold air shall be provided through the ceiling, whereas supply of warm air shall be provided through the side panel. This guarantees a consistent supply of warm air in window and foot areas.

6.5 Noise

The Train Set will operate at high speeds, in tunnels and occasionally in close proximity to dwellings. The Train Sets shall comply with current noise regulations according to TSI NOI 2015 and EN ISO 3095:2013.

For the interior noise level the following values shall not be exceeded on open track:

Passenger saloon a 250 kph:	71 dB	at standstill:	63 dB
Restroom at 250 kph:	73 dB	at standstill:	66 dB
Vestibule at 250 kph:	81 dB	at standstill:	63 dB
Gangway at 250 kph:	83 dB	at standstill:	61 dB

The noise level inside the drivers Cab shall comply with TSI NOI 2015.

The verification of the noise levels shall be discussed and mutually agreed between SRT and Private Party.

6.6 Luggage

Overhead luggage storage shall be provided to accommodate a fully loaded Train Set.

Luggage stowed in overhead racks shall be visible from seated positions directly below and by crew walking through the Train Set. Additionally the overhead racks shall provide sufficient space to safely store suitcases with the following dimensions: 700mm length; 500mm height; 300mm width. Design of overhead racks shall comply with the requirements of EN 12663, UIC 562 and UIC 566.

In each Vehicle at least two luggage stacks shall be provided with a width of at least 650mm with shelves at a vertical distance between 600 and 700 mm with a depth of approx. 650 mm, with the lowest “shelf” being the floor.

6.7 Ballast projection

Ballast projection may be initiated either by underfloor aerodynamic drag, by obstacles in the track bed or by ice-drop.

Unless speed reductions are effective, impacts of ballast stones may occur. The underfloor equipment shall be designed to withstand a limited amount of stone impacts. The underfloor design shall avoid cavities in the underfloor area to reduce pressure drops.

The Train Set shall fulfill the following requirements:

- No initiation of stones by aerodynamic drag on run-in tracks, i.e. tracks passed approximately 100 times by same Train Set at vmax and operated in normal direction.
- Prove robust underfloor design against ballast stone impacts. Possible impacts shall not cause a loss of operational performance. Parts shall be protected and withstand

repeated impacts without corrective maintenance.

6.8 Vandalism Resistance

The Train Set shall be designed with consideration for the security of passengers, and crew. The Private Party shall provide measures that reduce the effect of vandalism to the lowest practicable level.

6.9 Crash worthiness

The Private Party shall comply with the technical criteria and procedures as set out in the TSI LOC & PAS 2015. The Private Party shall also adhere to the requirements of EN 12663 and EN 15227, unless otherwise noted in this Specification.

Each Train Set shall be provided with carbodies made of aluminum and a Crash Energy Management (CEM) System to dissipate kinetic energy during a collision. The System shall provide for controlled deformation and Collapse of designated sections within the unoccupied volumes to absorb collision energy and to reduce the decelerations on passengers and crewmembers resulting from dynamic forces transmitted to the Occupied Volume. The design of the CEM System and the end structure of the Train Set shall satisfy the requirements defined in TSI LOC & PAS 2015 and EN 15227.

Anti-climbing resistance shall be demonstrated at both the impacted Interface and at the coupled Interfaces in accordance with the criteria set out in the EN 15227 standard. In order to achieve this, the short couplers shall have means for stabilization and the whole System should absorb energy of at least 9 MJ.

6.10 Fire Protection

The Train Sets shall be designed to accommodate TSI LOC & PAS 2015 fire safety requirements according to category B as specified in Article 4.1.4 TSI LOC&PAS 2015. The requirements of EN 45545 shall be met.

The fire precautions on the Train Sets shall be in accordance with the standards applicable to a high speed rail operation, taking into account the operating conditions on the SRT's network, including tunnels, underground stations, extended-length viaducts, and trench sections.

6.10.1 Passive Fire Safety

The Train Sets shall be equipped with adequate fire barriers in specific areas according to the requirements of EN 45545-3 and TSI LOC & PAS 2015.

The Private Party shall select and use interior materials available to the transportation industry, taking full account of the toxicity and combustibility requirements.

Materials used for design of the Train Sets shall meet the fire safety requirements of

EN 45545-2 according to the required hazard level resp. Vehicle category.

The Train Set System design and operating procedures shall incorporate all practicable measures according to TSI LOC & PAS 2015 to ensure that a Train Set does not stop in a tunnel or is able to reach and stop at a fire fighting point or another safe area (definition see TSI LOC & PAS 2015).

Fire protection shall be achieved and demonstrated by passive fire safety measures rather than active measures (e.g. extinguishing system).

6.10.2 Smoke and Fire Detection

A System shall be provided for the automatic detection of fire in all Vehicles. The fire detection System shall interface with the event recorder and the Diagnostic System so as to provide a record and display the location of the detection and any automatic action taken.

The fire detection System shall comply with EN 54.

The detection System shall be able to accommodate simultaneous or sequential detection of fire at more than one location.

Areas to be monitored by automatic fire detection shall be identified in accordance with the requirements of EN 45545 and consideration of the respective Vehicle class. The defined areas shall be indicated in the offer by the Private Party.

Smoke detection devices in saloon areas shall not be visible for passengers.

6.10.3 Full Cross Section Fire Barriers

Adjacent cars shall be separated by a fire barrier with fire resistance properties as defined in TSI LOC&PAS 2015.

7 PASSENGER INTERFACE

This Clause defines the passenger interface for the Train Set Equipment. It encompasses all areas of the Train Set accommodating passengers and staff e.g. seating, toilet areas, HVAC, food service areas and passenger information. Criteria for vestibules and passageways through the Train Sets are addressed separately in this Specification, e.g. in Clause 8.

7.1 General Requirements

The interior of the Vehicle shall be designed and constructed with consideration for Safety, security, comfort, durability, convenience, and service to the passenger, while also ensuring the efficient use of space and maximum seating capacity.

There shall be First Class and Second Class Vehicle designs, both of which shall meet requirements Specified by TSI PRM 2015 and shall contain as many common elements as practicable. Vehicle interior configuration shall vary based on class of service. Interior colors, designs, patterns, and finishes of materials shall be developed by the Private Party as part of the conceptual design process to be reviewed by the Engineer's Representative.

The Train Set design shall strive for a balance between the needs of persons with disabilities and the needs of all passengers in general after meeting or exceeding TSI PRM 2015 regulations.

The Train Set design shall consider the capacity and passenger flow requirements of this Specification while also achieving full compliance with the requirements of TSI PRM 2015.

The Private Party shall work with the Engineer's Representative to ensure that the internal layout will meet or exceed the regulatory requirements and will meet the needs of people with disabilities.

7.2 Interior Graphics

Graphics shall be provided throughout the Train Set to provide passengers with information. The graphics shall not cover retro-reflective material for the purposes of emergency instructions and access identifications. Emergency exits shall be clearly identified to passengers and emergency responders by means of suitable signs. Emergency signage shall be implemented as described within TSI PRM 2015. Final configuration shall be established during design review.

7.3 Basic Features of all Vehicle Types

The Train Set shall be designed to account for the following:

a) Space for passengers to be able to move through the Train Set to access facilities during their journeys.

b) Evacuation under emergency conditions (e.g., no lighting, smoke, etc.).

c) The ability for Train Crew to efficiently service the needs of passengers, including catering of hot/cold meals and drinks from a trolley and the ability to maintain the temperature of such food via onboard food storage Equipment.

d) The design for table seating shall allow maximum legroom and minimal obstructions.

e) Interior materials, parts, and design elements shall contribute to decrease the overall noise level within the rail Vehicle.

f) The Vehicle interior shall be finished with high durability, low-Maintenance materials. With the exception of panel coating, all materials and visible surfaces shall be selected to retain their initial appearance for a period of not less than 15 years.

g) The interior furnishing shall present a clean, pleasing appearance, and facilitate easy cleaning using Normal railway and industrial cleaning methods and Equipment.

h) The interior design shall take into consideration compartmentalization for control of smoke/fire spread according to TSI LOC&PAS 2015.

i) Cabin lighting shall utilize LED (where practicable), or other equivalent long-lasting and environmentally-friendly sources of light.

j) Windows shall be provided with tinted glazing. All windows in the passenger seating areas shall be equipped with passenger operated blinds to provide protection against the glare of the sun.

k) The passenger seating and food service areas shall be separated from the vestibule and the restroom by doors.

l) Accessible seating shall be provided as per TSI PRM 2015 regulations, located in close proximity to exit doors and the accessible restroom. PRM seating areas shall not be located directly in front of the accessible restroom door.

m) Handholds shall be located in shared areas of the Train Set (i.e., vestibules and side aisles) for passengers and crew to grab to enable safe circulation throughout the Train Set, according to TSI PRM 2015 regulations.

In order to maximize space utilization and flexibility, the Private Party shall achieve a usable length accessible to passengers of at least 90% in relation to overall length of the Train Set.

Furthermore, the fastening concept shall be based on continuous channels for fastening the luggage compartments, luggage racks, seats, tables and mobile separating walls, etc. This design shall enable individual and variable positioning of interior furnishing components.

When considering Train Set communication (e.g., passenger information and associated interfaces), the Private Party shall ensure easy access to components (e.g., computer servers, network hubs, access points, and roof antennas) and provide reasonable provisions for future changes.

Train Set interior Systems shall be easily disassembled into recyclable or reusable components at the end of their useful lives

Passengers in wheelchairs shall be able to access the Galley area from their wheelchair location without crossing the gangway.

The Vehicle interior color scheme finishes and materials shall be proposed by the Private Party in accordance with the Design Review Process for review by the Engineer's Representative and approval by the SRT.

7.4 Guideline for Passenger Seating

The baseline interior layout shall provide at minimum 500 passenger seats (8 cars). A 2+2 transverse seating configuration in a mixture of both workstation table areas and unidirectional seating layouts is required.

a) Seats shall be rotatable or non-rotatable with a mix of forward-facing, rear-facing, workstation table areas, and accessible seating provided in accordance with the desired proportion of seats per class.

b) First Class seating shall be situated together in the Train Set in adjacent locations.

c) First Class seating shall be arranged in 2+1 rows and shall be provided in both workstation table and unidirectional seating layouts and shall include accommodations for TSI PRM 2015 compliant seating.

d) Second Class seating shall be arranged in 2+2 rows and shall be provided in both table and unidirectional seating layouts and shall include accommodations for TSI

PRM 2015 compliant seating.

e) The First Class areas of each Train Set shall be easily distinguishable to all passengers from the interior and exterior of the Train Set via the use of material, design considerations, and signage.

f) First Class seating shall be provided with a clearance at knee level (J-value) of at least 880 mm measured in accordance with UIC 660. The reclining angle of 21° in working position and 35° in reclining position.

g) Second Class seating shall be provided with a clearance at knee level (J-value) of at least 800 mm measured in accordance with UIC 660. The reclining angle of 21° in working position and 32° in reclining position.

h) First Class face-to-face-seating in workstation table areas shall be provided with a clearance at knee level (L-value) of at least 1580 mm measured in accordance with UIC 660.

i) Second Class face-to-face-seating in workstation table areas shall be provided with a clearance at knee level (L-value) of at least 1500 mm measured in accordance with UIC 660.

j) The center aisle in the First Class shall be minimum 600 mm (measured between the armrests including all tolerances).

k) The center aisle in the Second Class shall be minimum 500 mm (measured between the armrests including all tolerances).

l) Flip up seats in accessible areas shall not be counted as regular passenger seats.

7.4.1 First Class Seating:

a) Armrests shall be padded and comfortable and shall accommodate the 5th-percentile female and the 95-percentile male population in terms of length.

b) The seat width as measured from the inside faces of the armrests shall be at least 500 mm.

c) Each seat shall provide two armrests with a minimum width of 60 mm.

d) Seat backs shall be equipped with an integrated pillow-type adjustable headrest.

e) Seat backs shall be equipped with a folding and longitudinally sliding table with a width matching that of the seat back. Additionally, a seat back map pocket and coat hook shall be provided.

f) Seat backrests shall be adjustable.

g) Seat covers for the seat bottom, back, headrest, and armrests shall be made of genuine leather.

h) Each seat shall be provided with convenience outlets consisting of AC 230 V 50Hz Socket and USB-Port for charging purposes.

7.4.2 Second Class Seating

a) Armrests shall be padded and comfortable and shall accommodate the 5th-percentile female and the 95-percentile male population in terms of length.

b) The seat width as measured from the inside faces of the armrests shall be at least 450 mm.

c) Each single seat shall provide two armrests with a minimum width of 40 mm.

d) Each double-seat shall provide three armrests with a minimum width of 40 mm for the outer armrests and 60 mm for the shared armrest.

e) Seat backs shall be equipped with a folding and longitudinally sliding table with a width matching that of the seat back. Additionally, a seat back map pocket and coat hook shall be provided.

f) Seat backrests shall be adjustable.

g) Seat covers for the seat bottom, back, headrest, and armrests shall be made of velours.

h) Each Seat shall be provided with convenience outlets consisting of AC 230 V 50Hz Socket and USB-Port for charging purposes.

PRM-Seating:

TSI PRM 2015 defines requirements to enable persons of reduced mobility to use Train Sets freely. The following has to be equipped accordingly:

- Seats with enlarged seat spacing,
- Emergency call point at every wheelchair position,
- Attendant call buttons which annunciate to crew members shall be available at all designated wheelchair parking positions.

7.5 Drivers Cab

The Train Set design shall be such as to ensure that the driving Cab at each end provides a safe, comfortable, and ergonomically designed environment and comply with the respective requirements of TSI LOC & PAS 2015. Particular attention shall be given to the following:

- Architecture/ergonomics for Drivers ranging from the 5th-percentile female to 95th-percentile male,

- Comfort of the Driver,
- All edges and corners shall be rounded.
- Cab environment provided to the Driver, as necessary, to allow operation during all times of day and night,
- High efficiency Cab HVAC System (low noise, high Reliability),
- Cab lighting requirements.
- Surfaces in the Cab shall be easy to clean and avoid reflections.
- The drivers Cab shall provide a swiveling window, which can be used as emergency exit for the driver.
- A tip-up seat in the Cab for the drivers assistant with a separate reading light shall be provided.

The drivers seat shall be ergonomically designed, individually adjustable and based on an existing, proven design which reflects latest ergonomic findings and shall provide a pneumatic suspension system.

In combination with the Cab desk and the adjustable footrest, the ergonomic requirements of TSI LOC & PAS 2015 shall be fulfilled. It accommodates a range of Drivers from small (females in the 5th percentile) to large (males in the 95th percentile).

The seat geometry and position shall be individually modified using adjustment handles.

Drivers must be able to select the most ergonomic seating position to comfortably reach and operate the control elements on the desk and the foot pedals.

The footrest under the desk shall be continuously height adjustable.

Cab crew facilities shall be provided and shall be adequate to store crew's clothing and Equipment in or near the Driver's Cab. Additional Driver facilities/provisions shall include:

- A cup holder the driver’s desk, accessible in the normal seated position.
- A fixed coat hanger attached to the backrest of the driver’s seat. At least one coat hook is fitted to the rear cabinet wall next to the tip-up seat.
- A waste bin has to be installed in the cab.
- A thermo box for hot and cold storage shall be provided for the driver (Six-Pack

(6x0,33 l)).

- At least 2 USB ports shall be installed in the driver's desk.
- Two power sockets shall also be provided in the Cab area

The following pieces shall be arranged in the Cab:

- A 6 liter Fire extinguisher according to DIN EN 3-7 suitable for fire classes A and B (foam). The fire extinguishing capability is 13A/144B (4 LE) according to DIN EN 3.
- Safety Equipment for the Driver (e.g. jump suit, gloves)
- In storage boxes in the driver's desk or the Cab:
  - One flash light,
  - First aid kit,
  - RIC Square key,
  - Reflective vest,
  - Oxygen self-rescuer (type Dräger Oxy K 30 HS).
  - Emergency ladder,
  - Tool bag, containing:
    - Universal pliers,
    - Wrenches,
    - Screwdriver,
    - Ratchet handles with a set of socket wrenches.

In order to maintain operation in case of a failure of the Cab air-conditioning, the saloon HVAC shall air-condition both in an emergency situation. In this case the comfort values can differ from standard conditions. In case of a fire outside the Cab, it shall be possible to isolate the Cab.

The Driver shall be able to adjust manually the air supply by two air nozzles near the driver's seat. In normal operation both drivers Cabs shall be air conditioned according to EN 14813.

7.6 Waste Bins

According to UIC 560 each entry shall be equipped with a waste bin with a size of at least 16l.

7.7 Windows

The Train Sets shall be equipped with certified end-facing and Cab side-facing windows compliant to the requirements set forth in TSI LOC & PAS 2015 and UIC 651.

Each exterior window shall sustain air pressure differences caused by two passing high speed Train Sets travelling at maximum velocity in opposite directions, at the separation for two adjacent tracks, and by a Train Set entering a tunnel, on an infrastructure as defined in TSI INF 2015, Traffic Code P1.

The design of the window system shall permit the separate disassembly of each window of any type and without removing the interior lining if required.

The existing joints between the windows and the outer skin of the carbody are to be filled and sealed with a sealing compound.

7.7.1 Passenger Side Windows

The windowpanes of the Train Set shall be tinted and provide the following key characteristics:

Type:

Insulated glass pane made of a VSG/ESG combination glued into an aluminum frame (VSG=laminated safety glass/ESG=toughened safety glass). Each passenger window shall have the possibility of shading e.g. via manual blinds.

Technical data:

- Net transparent height of window of at least 550 mm,
- Net transparent width of window of at least 1700 mm (except for special compartments such as Lounges, Service compartments, etc., where windows with less width can be used),
- Light transmission (TL) at least 29 % acc. to EN 410,
- Energy transmission (TE) approx. 26 % acc. to EN 410,
- Sound insulation RW value ≥39 dB(A),
- Withstands aerodynamic pressure +/- 4500 Pa with peaks +/- 6000 Pa,
- Tinting: grey.

In each open compartment and each Vehicle area, (e.g. Lounge area), at least two emergency exit windows shall be provided with a height of at least 550 mm and a width of at least 700 mm. In each closed compartment at least one emergency exit window with the above mentioned dimensions shall be provided.

7.7.2 Cab Window

The end-facing window shall conform to TSI LOC & PAS 2015 and EN 15152.

The size of the field of vision shall exceed the definition of UIC 651. The windscreen system shall consist of the pane and the windscreen heater.

The window shall conform the following requirements:

- Laminated safety glass panel incl. spall shield,
- Withstands aerodynamic pressure +/- 6000 Pa
  (peaks +8000 Pa / -10000 Pa).

The windshield shall be replaceable from the exterior of the Vehicle and shall limit external glare and reflections from inside the Cab when the Train Set is operated at night with all interior illumination on.

The Cab shall be compliant with the signal sighting requirements as identified in TSI LOC & PAS 2015 Section 4.2.9.1.3 and EN 15152.

In case of light and energy transmission the window shall conform to TSI LOC&PAS 2015 und EN 15152. A light tint of the glass material to reduce the sun radiation and thus slowing the heating of the Cab shall be provided. It must not cause any falsification of signal colors.

To protect the glued section (against UV radiation) and to hide off the interior linings around the windscreen from the outside, a ceramic serigraphy of sufficient size shall be fitted around the edge.

A System for defogging/defrosting of the windshield and a manually adjustable front windshield visor shall be provided (This can be realized with a combination of the HVAC system and the windshield heating). They shall be effective at the environmental conditions encountered on the SRT’s network.

7.7.3 Windshield Washing- / Wiper-System

A single arm windshield wiper and washer assembly shall be provided for each Cab that covers the Driver's sight line area, when seated. The windshield wiper shall be effective in the environmental conditions encountered on the SRT’s network. When stopped, the windscreen wiper blade shall park in the rest position automatically and out of the Driver's sight line area. It shall maintain this position regardless of the speed of the Train Set. The capacity of the Train Set windshield wash System tank shall be at least 25 liters per Cab. A filling level indication is required.

7.8 Interior Lighting

The general and emergency lighting shall be based on LED technology. Lighting shall comply with the requirements of EN 13272. The light intensity shall be according to EN13272 and UIC555. The lighting fixtures shall complement the aesthetic design of the Train Set while meeting the regulatory requirements. Lighting fixtures shall be dust-proof and moisture-proof (at least IP34 according to EN60529). All lighting fixtures shall provide for easy installation, removal/replacement, adjustment, and cleaning (including diffusers, and lamps). Lighting levels shall be adjustable by crew members. Lighting equipment shall not deteriorate or discolor as a result of continuous exposures.

Optional feature: Day light controlled ambient lighting (RGB – LED technology) shall be proposed as an option. This optional feature shall have the ability to automatically adjust the interior lighting levels based on measurements from ambient light sensors placed throughout the Train Set.

7.8.1 Cab Lighting

The driver's Cab shall be equipped with ceiling mounted LED spot lights to illuminate the entire Cab including the driver's desk. The lighting fixtures shall be arranged to avoid reflections on the front windshield. The driver's desk shall have supplementary LED lighting that can be dimmed. One LED reading lamp shall be provided for the assistant driver.

7.8.2 Passenger Saloon Lighting

Interior lighting shall follow the requirements in EN 13272 and UIC 555. LED-modules within the passenger compartments shall be separately controlled as defined below:

- Basic lighting (= all LED-Modules lighted = 100%)
- Reduced lighting (= partial lighting + emergency lighting = 50%)

No single point failure of the lighting system or wiring and controls thereof shall result in total loss of lighting throughout a Vehicle.

7.8.3 Lighting in Common Usage Areas

Lighting in the toilets, gangways, galley and vestibule areas shall consist of LED ceiling mounting lights. LED-Modules shall be equipped with tamper proof covers to prevent unauthorized access.

7.8.4 Emergency Lighting

Emergency lighting shall fulfill the criteria of 1302/2014/EG – TSI LOC&PAS and of 1300/2014/EG – TSI PRM in the vestibule area. The operating period of emergency lighting shall be at least 180 minutes.

The emergency lighting shall be of LED technology. It shall be divided into two independent circuits per vehicle to provide redundancy.

Emergency lighting shall be provided in the following areas:

- Passenger seating areas:
    - The emergency lighting shall be independent of the general lighting. It shall be located above the central aisle of the cars. Lighting intensity of 5 Lux shall be

provided at floor level.

- Entrance/Vestibule:
  - All exterior side doors shall be equipped with LED door boarding lights designed to illuminate the side door threshold. Entrance lights shall remain lit during normal and emergency operating conditions.
  - The vestibule emergency lighting consists of light fixtures equipped with LEDs on the carbody end wall linings and in the inter-car gangway.
  - In the vestibule area adjacent to the toilets, the emergency lighting function shall be performed by an LED light fitting that is a part of the standard lighting situated between the toilet compartments.
- Toilets:
  - The normal lighting shall consist of two redundant LED-modules in the ceiling which are permanently lit, and hence also function as emergency lighting.
- Galley:
  - Two of the LED lights shall function as emergency lighting.

7.9 Heating, Ventilation and Air Conditioning (HVAC)

The HVAC units and the other HVAC equipment shall be of robust, heavy duty construction and shall be proven in high speed rail transit applications. Cooling circuits shall be designed to protect against lock-out due to temporary extremes such as tunnel operation and pull-down. Refrigerants such as R-134a and/or R-407C shall be used.

7.9.1 Saloon HVAC

General Requirements

The requirements of EN 13129 category B in Europe shall be achieved. Compliance with these requirements shall be verified by the testing methods as described in EN 13129. Train Sets and HVAC systems of existing and service proven design are expected to be fully adapted to achieve the required passenger comfort levels under the design environmental conditions specified.

Operating Modes

It shall be possible from the Cab to remotely start the HVAC System to pre-cool the Train Set to the interior temperatures Specified herein. A temperature control of up to +/-2K from the pre-set value shall be provided. This adjustment shall be made available to the Train Crew by control inputs via the HMI display.

The HVAC system shall be provided with a dehumidification mode, whereby the requirements for relative humidity control of the supply air according to EN 13129 shall be met, but the comfort criteria (e.g. temperature) might be exceeded to reflect the most energy-efficient HVAC design. The method of monitoring and dehumidification shall be submitted for review and approval.

Cooling modes shall be controlled by a microprocessor using solid state devices. The output of the microprocessor shall control electrical power to evaporator and condenser fan motors, and all control devices. The changeover between cooling shall be automatic and shall preclude the simultaneous operation of air conditioning.

A Portable Test Unit (PTU) shall be provided allowing service personnel full control of the HVAC microprocessor. The PTU shall also have the capability of changing any variable set points within the System.

The operating modes of the HVAC system shall consist of:

- Automatic:

  The air-conditioning control automatically controls the interior temperature in each car to the temperature set-point. Mixed air operation is only possible in the automatic mode. The pressure protection function is also functioning in this mode. Automatic mode is the normal revenue service operating mode for the HVAC system.

- Standby:

  The complete HVAC system is switched off. When the power supply is available, the air-conditioning control monitors the exterior ambient and passenger compartment interior temperatures. The air-conditioning control activates the frost protection function if the ambient temperature drops below 5 °C. The control system activates the high temperature protection function if the interior temperature exceeds 40 °C. Standby mode is intended for non-revenue yard storage of the Train Sets at a maintenance depot.

- Air conditioning emergency stop:

  The complete ventilation and air conditioning is switched off (e.g. in case of a fire detection).

- Emergency ventilation:

  If the auxiliary AC power supply should fail, emergency ventilation via the battery is initiated. In this case, the air-conditioning unit provides ventilation via one supply air fan with a reduced output.

- Waiting mode (e.g. in stabling operation):

  To save energy, the cars in which the air-conditioning unit is switched on are set to a lower stage. Depending on the outside temperature, the cars are cooled (kept cool, approximately + 30 ° C).

- Carwash mode:

  All pressure protection flaps are closed. In this mode the HVAC unit is switched off. No recirculation is provided.

RAM Requirements

A 50% redundancy with limited regulation shall be provided. In the redundancy case, comfort values don’t have to be maintained. This means that inside the HVAC unit for the saloon at least two separated cooling circuits with an individual compressor, two supply air fans etc. have to be installed. Therefore the loss of one component does not lead to the breakdown of the whole cooling, or ventilation system. The system continues to work, if necessary with reduced thermal comfort, whereby basic operations are maintained as long as possible. In order to limit maintenance efforts, the redundancy requirements shall be realized by one single saloon HVAC unit per car.

Mixed air filters in the HVAC unit for the saloon shall be provided. The minimal filter class is G4 according to DIN EN 779. Easy accessibility and easy replacement shall be ensured. The access for all climate devices takes place from outside. Exchange of the filter from the inside shall be avoided for reasons of hygiene.

Ventilation

The design of the fresh air supply shall be according EN 13129. Additionally the TSI LOC&PAS 2015 shall be met.

The fresh air supply shall be automatically modulated based on passenger occupancy level, via monitoring of the CO2 concentration inside each Vehicle.

Emergency ventilation shall be in accordance with TSI LOC&PAS 2015 and shall be maintained for at least 30 minutes. The HVAC unit shall be capable of providing at least 50% of the normal fresh air during emergency ventilation mode.

The ventilation System shall maintain a Vehicle internal positive static pressure at all Train Set speeds, and alignment conditions, including higher altitudes and within tunnels. Intake of filtered fresh air shall be provided to maintain positive pressurization. The exhaust air system shall be an integral part of the HVAC saloon unit.

Pressure Tightness

The Train Sets shall be appropriately configured to seal and/or automatically ventilate to ensure aural comfort for passengers when Train Sets are exposed to external pressure pulses e.g. when entering a tunnel or passing other Train Sets at high speed.

The pressure experienced by the Train Crew and passengers onboard the Train Set shall not exceed the limits Specified in UIC 660:2002 and UIC 779-11 Appendix F.4 (for sealed Train Sets).

In the design phase, a state of the art software program such as “DB Tunnel” which complies with UIC 779-11 Appendix F.5 shall be used to demonstrate compliance.

HVAC Controls

The integrated, microprocessor-controlled HVAC Equipment shall include separate temperature controls for the Driver's Cab and the passenger areas with continuous monitoring of exterior and interior temperatures to maintain the proper interior thermal comfort.

The exterior temperature shall be evaluated on a Train Set basis using arithmetic average of the all exterior temperature sensors. Each HVAC unit shall be equipped with two exterior temperature sensors.

The interior temperature shall be evaluated on a per vehicle basis. Each HVAC unit shall be equipped with two separately positioned temperature sensors, which will be arithmetically averaged to determine the interior temperature.

7.9.2 Cab HVAC

The design of the HVAC system of the driver Cabs shall consider EN 14813.

The Driver shall be able to control the fresh air flow rate supplied to the Cab. The pressure comfort in the driver’s Cab follows the same requirements as the pressure comfort in the passenger compartment.

7.10 Train Set Communication, Passenger Information and Interfaces

The Train Set communication and Passenger Information Systems shall be designed to allow both simple and logical uses to be made of these Systems under Normal operating conditions while ensuring that all its necessary communications and data transmissions can be made reliably when emergency situations arise.

The Private Party shall separate Passenger Network, Operator Network and Train Control Network (safety and certification relevant topics) from each other in order to allow easy upgradability of the Passenger Information System.

7.10.1 Public Address / Intercom System (PA/IC)

All passenger Vehicles shall be equipped with a public address (PA) System that provides a means for a Train Crew member to communicate by voice to the passengers and/or to the Driver. Means shall also be provided for the triggering of pre-recorded PA messages. Pre-recorded messages shall be synchronized with visual information presented on the displays.

In addition to the communication units in the Cabs at least one communications console shall be provided on the Train Set, preferably in the Train Set centre. The layout of this console shall be presented to the Engineer’s Representative for review.

7.10.2 Passenger Alarm System

A passenger alarm System accessible by all passengers (including persons with disabilities) shall be provided. The Private Party shall provide details of the proposed System for review by the Engineer’s Representative. Operating instructions, printed on photo-luminescent material and in Braille, of the emergency signal shall be posted adjacent to the respective Device. Back-up power for the passenger alarm System shall be available for a minimum period of three hours in case of an emergency

The "Call-for-Aid" signal shall be

- Compliant with TSI PRM 2015 regulations,
- Easily activated from any position mentioned in the TSI PRM 2015. Indication of the call shall be identified to the Train Crew by location,
- Accessible within the reach of a 5th-percentile female on the ground or seated on the toilet.

The Train Set shall have a general alarm to allow a Driver to alert all Train Sets within a radio ground station transmission area of major emergencies such as derailment, landslide, fire, or flood.

7.10.3 Passenger Information System (PIS)

The passenger information system (PIS) shall provide visual and audible information to passengers on the platform and on board. The PIS shall provide information about the final destination and intermediate stations to passengers on the platform via lateral displays. Optionally information about Train Set type, departure time and other information shall be shown. The PIS shall show the car number to passengers on the platform at each door.

The PIS shall provide information about the final destination, next stop and intermediate stations to passengers on board the Train Set. Optionally information about Train Set type, arrival/departure time, possible connections and other information shall be shown. The PIS shall show additional information such as current date/time, car number, etc. on internal displays.

The PIS shall support displaying arbitrary text messages entered by on-board Train Set staff or received via the wireless link from the wayside. The PIS shall interface with the on-board entertainment system. The PIS shall support synchronization of timetable, configuration and other data and with the wayside through wireless data links and data transfer using portable media (e.g. USB sticks).

Each seat shall have a designated seat number tag that is fitted to the top of the backrest. It shall also provide the seat number in Braille. An electronic seat reservation display (if required by the SRT) shall be provided on the sidewall cover below the luggage rack. The display shall have two rows, one for each seat.

The Private Party shall provide for dynamic signage through 19” ceiling mounted monitors, together with dynamic signage in vestibules, and bar/food service areas. The location, function, and appearance of all signage, graphics, and displays shall be submitted for Engineer’s Representative review.

Displays

Internal and external electronic displays meeting the TSI PRM 2015 requirement shall be provided. Interior displays shall be integrated with the Vehicle lighting System to control brightness under all lighting modes.

Displays and signs shall include:

- Passenger entry area display,
- General information display (ceiling mounted monitors),
- Toilet room sign,
- Exterior display (in entrance door panel).

The Travel Information network shall supply the following information, at a minimum:

- Travel status updates,
- Train destination,
- Current location or station,
- Next station and time to next station,
- Time and date,
- Service alert messages,
- Pre-recorded message,
- Visual graphics for inside displays (i.e., maps, advertisements, video, etc.).

7.10.4 Internet on board and Entertainment

Due to rapid development of IT-market, the Private Party should define requirements based on existing or planned landside infrastructure and on latest technologies. Example below:

The Internet on Board System shall provide:

- Internet access for passengers via WiFi,
- Cellular network access with use of following standards (GSM / GPRS / UMTS / HSPA+ / LTE),
- connection to WiFi Access Points on landside (2.4Ghz/5Ghz),
- An aggregation of bandwidth multiple wireless networks shall be possible.

The WiFi system for passengers shall provide:

- The security protocols according to market standard,
- 100% of the passengers shall have access to the Internet in parallel,
- Sufficient band width to ensure the multi user access inside the coaches for the known IEEE 802.11 (a / b / g / n) standards, for the services mentioned in these

requirements,

- Redirection of new client connections to a captive portal or landing page.

The broadband connection provider shall be identified by the SRT.

Passengers can use mobile devices like notebooks, Smartphone's or tablets for receiving information and to be entertained. In addition to the Internet on Board access via captive portal a web portal shall be provided as the central access point to all locally stored entertainment data. The web portal shall contain the following contents:

- Travel information (e.g. next stop, delays etc.),
- Route data / Moving Map,
- Location based tourist information,
- Entertainment (Audio, Video streaming),
- E-book,
- VoIP (Skype etc.).

Web portal data shall be stored locally and shall be independent from the status of the WWAN connection. Content of the web portal such as web pages and videos shall be created and edited easily with a land-sided web content management system. Synchronization of the web portal content and media files shall be possible via WWAN connection with the Network Operation Center. The web portal shall provide a passenger authentification. The web portal shall be optimized for different display sizes and resolutions (responsive web design). The Content and features shall be defined by the SRT and may be subject to additional technical development.

7.10.5 Mobile Phones

The Private Party shall ensure that mobile phones can operate reliably, inside all Vehicles within the Train Set, under all operating conditions and at all locations along the SRT's System, provided that the necessary wayside infrastructure has been installed.

7.10.6 CCTV

Video surveillance for passenger compartments and entrance areas shall be provided onsite the Train Set. Additionally video surveillance for exterior doors and exterior areas shall be provided onsite the Train Set. The train attendant shall be able to use the control unit of the unoccupied driver's Cab. The Train Set shall provide a CCTV data storage for at least seven days.

7.11 Sanitary Modules

7.11.1 Restrooms

The toilet facilities provided shall be of high quality and shall be chosen to reflect the needs of a prestige service. The design of the toilet facilities shall be identified by the Private Party for review by the Engineer's Representative.

The Private Party shall verify and prove the design of his restrooms with field data from its high speed operation. This particularly includes the amount of toilets per passenger. In case no data are available concerning this matter, the Private Party shall assume 40 persons/toilet in accordance to UIC 563.

The Train Sets shall be fitted with controlled emission toilets, capable of fully retaining all waste and odor between servicing on all routes and service patterns. Each Restroom shall be equipped with exhaust air inlet to separate odors from Restrooms from passenger areas.

Toilets shall be of the compact vacuum type.

All toilets shall incorporate a high level of resistance to becoming blocked due to misuse and overfilling. All toilets shall be designed to allow for efficient and effective cleaning.

All toilet modules shall be completely sealed and shall incorporate appropriate features to prevent fluid leakage into the passenger area outside the toilet cubicle and/or Vehicle underframe.

Electrical and plumbing connections shall be designed so that components can readily be installed, removed, and exchanged. The tanks and all piping shall be designed to prevent damage from freezing and corrosion. The waste System shall be designed to operate within the usual operating and environmental conditions outlined in this Specification.

In order to allow maximum special comfort the Restrooms shall be provided with manually driven sliding doors. All toilet doors shall incorporate a means for crew to lock the door out of service and clearly identify to passengers that the toilet is "locked out of service".

All toilets shall incorporate:

- Washstand with sink,
- Faucet for cold water supply (non-touch flow activation),
- Mirror cabinet above washstand,
- Compact vacuum toilet with toilet seat with damping mechanism,
- Toilet flush button,
- Toilet roll dispenser,
- Hand dryer, non-touch, or paper towel dispenser,
- Soap dispenser,
- Waste receptacle with lid,
- Coat hook,
- Indicator lights:
  - "Occupied" (outside cubicle),
  - "Out of Service" (outside cubicle),
- Loudspeaker,
- Electric fan,

At least one Vehicle shall be equipped with a universal toilet in accordance with TSI PRM 2015 that can be reached by wheelchair users without having to cross the gangway or other obstacles. Additionally the universal toilet shall include the following equipment:

- Fold-down baby changing table,
- Call-for-aid unit,
- Electric sliding door with TSI PRM 2015 compliant "assistant" mode,
- Push-buttons for door operation "Open & Close" (outside and inside cubicle).

7.11.2 Fresh and waste water tank

The Train Set toilet Systems shall provide sufficient clean water for flushing and hand washing for two days service and waste storage capacity for three days service, based on System drain and replenishment at service locations only. The Private Party shall propose the size of the fresh water and waste water tanks based on field data see Sub-

Clause 7.11.1.

A double-sided filling of the fresh water tank shall be provided. The interface shall be realized in accordance with TSI LOC & PAS 2015 (EN 16362). The fresh water tanks shall be equipped with overflow means. Fresh water tank shall identify ”full” and “empty” State. The wastewater tank shall identify “full” state. Extraction nozzles accessible from both sides (camlock) without a ball valve to the wastewater disposal shall be provided. The retention tanks shall be vented but nevertheless designed to be emptied by a vacuum System. Toilet waste retention tanks shall be capable of being 100% drained during normal servicing. Water containing parts (pipes, external tanks) shall be protected against freezing.

7.12 Catering Concept

Catering Concept to be defined to the individual service needs / planning (check impact on seating capacity)

The Galley shall be in accordance with national and international health and safety regulations and shall include and incorporate the following:

- 1 service and sales counter,
- 1 utility sink,
- 1 coffee specialties machine,
- 1 heated cup storage shelf,
- dispensers for paper towels, soap, disinfectant,
- 3 chilled trolley storages,
- 1 microwave oven,
- 2 ovens,
- 1 sub-zero freezer,
- 2 chilled beverage storage drawers,
- 1 chilled showcase,
- 1 drawer for two 45 liters trash bins,
- 1 service counter 45 liters trash bin with lid,
- 1 fire extinguisher,
- 1 illuminated working space,
- 2 power sockets AC 230 V 50 Hz,
- Different storage shelves.

The relevant national and international health and safety regulations are to be complied.

Point-of-sale (POS) Equipment shall be provided in the Restaurant/Bistro Cafe Vehicle/food storage and preparation area of each Train Set.

8 TRAIN SET ACCESS

This Clause 8 defines requirements with respect to ingress and egress from the Train Set as well as passageways through the Train Set. Interior design and configuration requirements for the Train Set Equipment are addressed separately in Clause 7.

8.1 Platform Height

The height of the floor of the Train Sets shall be compatible with the existing Suvarnabhumi Airport Rail Link System.

The nominal platform height will be according to the existing Suvarnabhumi Airport Rail Link System and TSI INF 2015.

As an alternative and in order to provide level access a nominal platform height of 1140 mm shall be provided.

8.2 Platform length

The nominal platform length will be according to the existing Suvarnabhumi Airport Rail Link System and TSI INF 2015 and the train length shall not exceed the platform length. The length of Train Sets shall be compatible with the existing Suvarnabhumi Airport Rail Link System.

8.3 Exterior Doors

The door system including the entry step and the gap filler shall be designed according to TSI LOC & PAS 2015, TSI PRM 2015 and EN 14752. TSI and EN supersede recommendations of UIC660. Additionally, an acoustic door finding signal on all exterior doors shall be provided. When closed, the doors shall be weather-tight and pressure-sealed under all Vehicle operating conditions.

Where vestibules areas are designated for wheelchair use, sufficient space for wheelchairs to easily move from or to the entrance doors shall be provided according to TSI PRM 2015. Separate doors for wheelchair use are preferred; those doors may also be used for further purposes such as loading/unloading of catering equipment.

Doors, doorways, and vestibules shall not have surfaces or edges capable of causing injury to passengers or of damaging or dirtying their clothes or baggage. Thresholds including the overhangs shall have an anti-slip surface with contrasting Safety markings that allows for the safe entry and exit of passengers in all weather conditions.

The side entry door System shall be designed and constructed such that no single point malfunction of door System components shall create an unsafe condition.

All door mechanisms requiring Maintenance or adjustment shall be easily accessible via access panels or other alternative means from inside the Vehicle. Access shall be provided from inside the Vehicle to all points necessary for inspection, service, installation, or removal.

Each doorway shall have minimum clear open width of 900 mm. Each doorway shall have minimum clear open height of 1950 mm. Electrically controlled and power operated swing-sliding Doors shall be provided. Each car accommodating more than 24 passenger seats shall have at least one entrance door per side.

The platform Screen Doors of the existing Suvarnabhumi Airport Rail Link System shall be considered in the design of the exterior doors of the Train Sets.

The Private Party shall provide audible and visual indicators at each passenger door prior to the opening and closing cycles. The audible and visual indications shall meet the requirements of TSI PRM 2015. Each PRM-entrance door shall provide a means of a call-for-assistance push-button inside and outside of the train.

8.3.1 Release of Doors/Lock of Doors

The driver's desk shall provide the following door system functions:

- "Release doors on left Train Set side",
- "Release doors on right Train Set side",
- "Close and lock all doors",
- "Lock gap filler".

Each door shall be equipped with a manual cutout/lockout mechanism. The cutout/lockout shall be provided on the door panel inside and outside the Train Set to enable the Train Crew to lock a defective door out-of-service in the closed and locked position. The manually locked door shall be bypassed from the trainline door control system.

The Train Set control and monitoring System/onboard computer shall indicate to the Train Set Driver and the Train Crew that all the doors (except for the door under local control of the Train Crew) are closed and locked. A subsequent indication shall inform the Train Set Driver that the door under local control of the Train Crew is closed and locked. An appropriate indication shall be provided to the Train Set Driver or the Train Crew of any Fault in the door closing operation.

8.3.2 Opening of Doors

After the doors are released the powered door operation shall be initiated by the Train Set Driver or via passenger enabled pushbuttons at each door location. Door operation signal shall be interlocked with a zero speed command and tied to the door summary circuit.

The step function needs to be implemented in the door control and realized selectively. During the opening process, the door opening shall only start after complete deployment of the step.

Each passenger Vehicle shall have pushbuttons provided on the exterior and the interior at each side door location so passengers can control the powered operation of local doors. Operating instructions shall be posted adjacent to the pushbutton.

Each passenger entryway shall be fitted with the following door control devices, which are arranged according to EN 14752:

- "Door open "pushbutton: inside and outside. The pushbutton is illuminated if the door has been released.
- A manual emergency release device fitted outside. It is operated by a flap-type handle. The handle is mechanically connected to the door locking system by a cable. The handle can be operated once the door de-energizes the drive unit. When the handle is operated, it unlocks the door, which can then be pushed open manually.
- A manual emergency release device fitted inside. It is operated by a pushbutton and a flap type handle.

8.3.3 Closing of Doors

The Train Set Driver shall be able to close/lock the passenger doors.

Each passenger entryway shall be fitted with the following door control devices, which are arranged according to EN 14752:

- RIC square key operated manual lock on the door panel operable from inside and outside. If manually locked, the door shall be bypassed from the trainline door control system.

During closing, the step shall retract after the door is closed.

Each passenger Vehicle shall have pushbuttons provided on the exterior and the interior at each side door location so passengers can control the powered operation of local doors. Operating instructions shall be posted adjacent to the pushbutton.

When the locking control is under the Train Crew control and activated from a door, it shall be permissible for this door to remain open when the other doors close. It shall be possible for the Train Crew to close and lock this door subsequently, and it shall be closed prior to the Train Set departing.

Each passenger entryway shall be fitted with the following door control devices, which are arranged according to EN 14752:

- “Door close “pushbutton: inside and outside. The pushbutton is illuminated if the door is open.
- RIC square key operated switch, which allows the Train Manager to close all doors of the related Train Set side.

The train manager door control elements shall provide the following functions:

- “door closing Train Set-wide“ (RIC square key switch),
- “cancel door closing Train Set-wide (operating the “door open pushbutton“).

Each side entry door shall be equipped with an obstruction detection System. The System shall include:

- Sensitive edge on the door panel leading edge,
- Motor current monitoring.

At the end of the close cycle, each door shall be fully closed and mechanically locked to prevent un-commanded door opening. Each door shall provide status to the door summary circuit indicating the door is closed and locked.

8.3.4 Door Lighting

All vestibule areas shall be equipped with LED door boarding lights designed to illuminate the side door threshold.

LED door indicator lights, if required by the SRT, shall be provided for each exterior door on the Train Set as agreed with the Private Party. The door open indicator light of each door shall be illuminated when the door is not closed and locked.

8.3.5 Emergency Door Handling

Each passenger entryway shall be fitted with the following door control devices, which are arranged according to EN 14752:

Emergency release of the exterior door from inside:

- To open the door in an emergency, the small window on the door operating panel shall first be broken in order to gain access to the emergency pushbutton. Pressing the emergency pushbutton shall cause the door drive to be switched off and activate the buzzer. At first, the door shall stay locked and blocked. The door shall not unlock until the mechanical door-release handle is operated (lifted). The door has to be pushed open by hand.

- The emergency pushbutton shall be activated at a speed of less than 5 km/h and deactivated at speeds greater than e.g. 10 km/h.
- Operating the door deactivation key switch (RIC square key) shall bypass the emergency pushbutton and provide the same effect as pressing the button. The door has to be pushed open manually after the emergency door release handle has been lifted.
- The retractable step shall deploy as long as electric power is available.
- The interior door release handle shall also function if no electric power is available.

Emergency release of the exterior door from outside:

- The exterior doors shall be able to be unlocked and opened from the outside by means of the exterior emergency door release mechanism independent of any auxiliary device or electric power supply.
- Exterior doors shall be prevented from unlocking from the outside for 5 minutes or until the Train Set has reached 10 kph after the "central doors close command from the Train Set manager" has been set. This is to prevent passengers from attempting to board the Train Set after the Train Set is ready to depart.

The Private Party shall provide onboard Devices that facilitate the escape of passengers to the trackside, through the access doors in situations where no platform is available when advised to do so by authorized crew. The Private Party shall submit, to the Engineer's Representative for review, drawings illustrating the emergency escape Devices' Interface functionality to the various civil configurations.

8.3.6 Gap Filler

A moving step with electric actuator shall provide for boarding or departing the Train Set at platforms in compliance with the requirements of TSI. It shall serve as a step when platform height is low. On high platforms, the folding step shall fill the gap between the vehicle and the platform edge.

8.3.7 Driving Cab Internal and External Access Doors

The Train Set design shall be such as to ensure that the driving Cab at each end provides a safe, comfortable, and ergonomically designed environment and comply with the respective requirements of TSI LOC & PAS 2015. Particular attention shall be given to Cab access and egress from ground level.

Passenger doors closest to the Cab shall have a safety key switch to allow access by authorized crew from the exterior. The safety key switch shall be accessible both from the track and at platform levels.

The exterior of each Cab car passenger entryway shall be provided with a driver's key switch for access to the stabled Train Set, in accordance to EN 14752.

The driving Cab shall be accessible from track-bed and platform level, from either side of the Train Set, by use of the nearest entrance door.

Exits from the driving Cab shall be equipped with hand rails and footsteps so that the Train Crew can get on and off the Vehicle safely. The hand rails and footsteps shall allow crew to enter or leave the driving Cab from or to track-bed level.

A manually operated hinged door shall be provided between saloon and cab. The door shall be capable of being locked from outside and inside the cab by means of a key operated security lock. Operation of the door panic bar inside the cab shall release the security lock to allow the Driver to escape in an emergency.

8.4 Interior Doors

Vestibules adjacent to seating areas shall be separated by electrically controlled and automatically operated interior doors. In order to facilitate movement on the Train Set, interior doors shall be highly transparent and shall have highly contrasting markings.

Interior doors that separate seating areas from vestibules shall automatically open on detection of an approaching person. Opened doors shall close automatically 5s after absence of an opening command. A specific mode for cleaning and maintenance purposes shall be provided which allows opening of power controlled interior doors by a central command. In this mode the affected interior doors will remain open until a manual closing command.

To support passenger flow and reduce dwell time, gangway doors which open on detection of an approaching person shall be avoided unless required to separate a passenger saloon from a gangway. However, the requirements defined in Sub-Clause 6.10 shall be met.

9 COUPLING AND GANGWAY

9.1 Coupling

Train Set coupling Devices (including leading and trailing end couplers, intermediate couplers, and Coupler Adapters) shall be of a Service-Proven design.

A coupling capability of two train-sets of the same type (double traction) shall be provided (the max. length of the two coupled Train Sets is 400 m +1% in compliance with the requirements of TSI INF 2015). End-coupler shall be designed with an automatic type with middle buffer coupling according to TSI LOC&PAS 2015 such as Type 10 of Scharfenberg System. Coupler height shall be nominal 1025 mm. The mechanical design of the couplings shall meet requirements defined in EN 16019 and EN 12663. A coupling capability with a different train-set shall be possible according to TSI LOC&PAS 2015

In order to prevent Vehicle overriding in case of an accident, the short couplers shall provide a means of stabilizing. The intermediate sections of the Train Set shall be semi-permanently coupled.

Emergency Coupling shall be designed according to TSI LOC&PAS 2015.

Couplers shall be designed for a maximum coupling speed of 5 kph (single traction) or 3 kph (double traction). Standard coupling speed is 2 kph. Front flaps shall open automatically.

9.1.1 Coupling Control

Coupling and decoupling of a Train Set consisting of two Train Sets shall be possible via automatic coupler units and coupler shrouds controlled by the train Driver from inside of the train cab without any assist of persons outside the train. The train Control system shall assist the train Driver during coupling and uncoupling by automatic control of train speed, automatically opening and closing the coupler shroud, automatically coupling of electric contacts, fiber optic wires and pneumatic pipes.

Intermediate short couplers between the single cars within the Train Set shall be coupled via manual couplers that can be divided for maintenance reasons.

Unintended decoupling of automatic train couplers shall be prevented by a highly reliable decoupling control system using redundant structures where a single fault may cause this.

In case of unintended decoupling e.g. train accident all remaining parts of the train shall be safely stopped by the friction brake system.

9.2 Gangway

Vehicle passageways shall provide access between all Vehicles allowing the free flow of passengers along the Train Set in normal and emergency conditions.

The interior throughway shall allow the passage of passengers in wheelchairs, passengers carrying luggage, and food service trolleys. It shall be of an aesthetically pleasing design with an appearance consistent with that of the vestibule. It shall also be free of any protrusions and shall not have any gaps that may be exposed during Train Set movements.

The design shall be done in a way to decrease or protect against surrounding impacts (water, dust, noise). The gangway shall be fully pressure-tight to meet the pressure requirements (see also 7.9.1).

The following clear passage widths shall be met on even and straight track:

- at shoulder level: min. 1100 mm
- at floor level: min 800 mm

The clear passage height measured from top of floor (TOP) shall be at last 1950 mm in all transition areas on even and straight track. The floor and all level transitions shall be compliant with TSI PRM 2015 requirements.

10 TRACTION AND AUXILIARY POWER EQUIPMENT

10.1 Traction system

The propulsion System shall be designed to meet the propulsion and braking performance targets of TSI LOC & PAS 2015. The traction System shall be designed to fulfill the specified targets for traction performance Reliability, Availability, Maintainability, and Safety (RAMS) of the Train Set.

Propulsion Technology and core components shall be of Service-Proven design and shall achieve at nominal traction power at least an overall energy efficiency from pantograph to wheel of 90% (without consideration of any auxiliary power). In case of implementation of newest traction technology with better efficiency levels compared to conventional traction technology the train builder shall validate all new features of the new technology in depth by traction system tests and train tests.

The Train Set shall meet or exceed all minimum acceleration rates described in TSI LOC & PAS 2015. Based on these rates, the Train Set shall be able to meet the level of performance required by the agreed SRT's Operating Plan (e.g., journey times).

The wheel/rail adhesion limits while meeting the performance requirements shall be according to TSI LOC & PAS 2015 Chapter 4.2.8.1.2.

The Train Set shall be able to operate on the SRT's network under OCS voltages and frequencies as defined in TSI ENE 2015 and in EN 50163:2004 Section 4.

The propulsion System shall regenerate into the Train Sets auxiliary power supply (APS) during Dynamic Braking. The remaining energy shall regenerate into the OCS. To maximize energy regeneration and minimize brake pad wear of the Train Set the electric brake system shall apply rheostatic brake whenever the catenary system is not receptive both in service brake and emergency brake.

The traction System shall allow a train operation in normal mode meeting the operators time table (not minimum journey time) without any brake pad wear when only service brake is applied, and all traction and brake system parts are operable. In any case, the Private Party shall assume that the SRT’s network is highly receptive and regenerative braking is the preferred braking option.

Propulsion performance shall be provided assuming a unity power factor at the pantograph. The Private Party shall implement a service proven energy measurement system.

Neutral sections

Train Sets shall be fitted with Systems able to receive information from control-command and signaling Devices that communicate the requirements of separation sections on a line to Train Sets. Subsequent actions shall be triggered automatically.

The Train Set shall be designed to operate with the design of the OCS phase breaks as detailed in TSI ENE 2015 / EN50367. The Train Set shall maintain the auxiliary power supply for comfort functions while running through phase break sections.

10.1.1 High voltage equipment

The Train Set shall be able to operate on the SRT's network under OCS voltages and frequencies as defined in TSI ENE 2015 and in EN 50163:2004 Section 4.

The traction System shall be compatible to AC catenary systems that comply with TSI ENE 2015. The Train Set and pantograph shall be designed to optimize for quality of current collection, mean contact force, and percentage of arc duration in coordination with the OCS.

The pantographs shall be compliant to TSI LOC & PAS 2015 and shall meet the defined test speed according to EN 14363.

The maximum spacing between the first and last pantograph for two coupled Train Sets shall be compatible with the requirements of TSI ENE 2015 Section 7.2.13 and EN 50367 for Phase Separation Sections. The pantograph shall have an operating range for wire heights as defined by TSI ENE 2015, Table 4.2.9.1.

For redundancy reasons two pantographs shall be provided per Train Set; however, current collection during Normal operation shall be performed by only 1 pantograph. Multiple pantographs if needed for compatibility reasons with OCS shall be electrically divided e.g. via isolation switches.

Train Sets shall be equipped with a Device to automatically drop the pantograph head if a contact strip becomes sufficiently damaged in any position along its length so as to not cause consequential damage to the OCS Equipment. The pantograph shall have means to allow the pantograph to lower and prevent excessive wire damage in the event of entanglement with the OCS. The pantograph mounting design shall decrease the chances of pantograph debris breaching the Train Set roof.

10.1.2 Propulsion Equipment

Propulsion System components shall be protected from damages due to water and dust ingestion into the cooling air supply. If forced air cooling is provided, all high voltage devices ((except of brake resistors, choke of the inverter resonant circuit if used) shall be isolated from the cooling air stream. Enclosure external surfaces shall be grounded to prevent passengers or operating staff from electric hazards.

In order to minimize noise and aerodynamic drag closed cooling cycles shall be used. Liquid cooling Systems shall be sealed and all components shall be rated for continuous exposure to the liquid. Environmentally friendly, non-toxic, biodegradable and non-conductive liquid compounds shall be used. The cooling liquid shall comply to class K (flash point ≥ 275°C) of ISO 2592 according to the requirements of TSI LOC&PAS 2015.

In order to minimize operational/maintenance impact of wheel diameter, the Private Party shall allow for at least 7 mm wheel diameter difference within a powered Bogie.

Abnormal operating conditions

In case of one inoperable traction unit the Train Set shall be able to complete its roundtrip compliant to TSI LOC&PAS 2015. The Train Set shall be capable of restarting on a 3.5% gradient under full load conditions with only 75% traction available.

The Train Set shall be capable of maintaining a speed level of 120 kph on a 2.5% gradient under full load conditions with one traction converter cut out.

A single Failure of power Equipment feeding the traction modules shall not deprive a Train Set of more than 50% of its traction power.

When operating the Train Set with one failed traction module (loss of 50% of its traction power), or Train Set (100% traction power available) pushing or towing a disabled Train Set under maximum load from any point of the route to the end of the line, making all station stops and observing all speed restrictions, there shall be:

- No Equipment damage,
- No heating above design limits,
- No reduction of the life of the traction motors below the Design Life of the Train Set.

Traction Motor

The design of traction motors shall be of robust capacity for the required Operational Speed, limit unsprung mass, and minimize use of consumables. They shall have sufficient capacity such that the Train Set under fully loaded conditions shall be able to continue operation with 25% of the rated power unavailable.

If air cooled traction motors are applied cooling air intakes and exhausts shall be protected against the admission of debris.

Motor cabling, e.g. temperature sensors, shall be protected against flying ballast.

A monitoring System shall be supplied to detect motor Failures at a minimum for bearing temperature and motor temperature.

10.2 Auxiliary power supply (APS)

The Train Set shall provide a highly redundant auxiliary power system supporting 4 supply voltage levels: 3AC480V/60Hz, 3AC400V50Hz, 1AC230V/50Hz, DC110V

Electrical Equipment shall be based on a Service-Proven architecture using newest state of the art semiconductors technology (e.g. SiC) to provide and proof an optimized power to weight ratio.

To limit the degree of lost auxiliary power in case of one failing auxiliary power unit to maximum 25% the Private Party shall provide and multi-unit consist of at least four auxiliary power units per Train Set.

10.2.1 Shop power supply receptacle

Maintenance tracks in Main workshop shall be energized by Power Supply and Power Distribution System with high safety standard for energizing or deenergizing including all safety aspects during maintenance of trains.

If necessary, to support efficient Maintenance the Train Set shall provide all necessary shop power receptacles in each end car:

a) One 3AC480V/50 Hz, 125 A auxiliary power receptacles on each side of each end car to supply the whole Train Set from one maintenance shop auxiliary power station. The on board auxiliary power System must be interlocked with the shop power supply to prevent double feed.

b) One DC 110 V external battery loading receptacle.

10.2.2 Batteries

Design of the battery System shall comply to EN 50547 using standard conditions.

Train Set shall include a load shedding scheme of Auxiliary Power System (APS) loads.

In the case that a Train Set lost OCS power, the battery ensures power supply of onboard units related to Safety of passengers and Train Set staff for up to 180 min.

Table 6 : Load Shutoff Times

APS loads	Load shutoff during battery sustained operation
Train Set control	180 min.
HVAC, Passenger 230V/50Hz receptacles	0 min.
Passenger infotainment system	5 min.
Interior comfort lighting	10 min.
Emergency ventilation of passenger coach	30 min.
Emergency lighting	180 min.
Toilet (control)	180 min.
Passenger announcement system	180 min.
Exterior lighting (front and rear)	180 min.
Doors	180 min.

11 BRAKE SYSTEM

11.1 General requirements

The brake Equipment shall be of a Service-Proven design and combine friction and electrical braking. It may consist of:

- Pneumatic brake
- Electrodynamic brake:
- The traction motors feed energy back into the power supply system. Purely electric and therefore wear-free braking shall be possible depending on the receptivity of the power supply system.
- Rheostatic brake (if provided):
- The energy from the traction motors is converted in the braking resistors.
- Spring applied parking brake actuators with the possibility of mechanical emergency release (integrated in the brake calipers of the trailer bogies) shall be used for the parking brake.

The friction braking system to be used shall be a pneumatic friction brake. The braking performance of the Train Set shall be compliant with TSI LOC & PAS 2015, relative to the maximum operating speed (refer to Article 5.1 above).

The brake System shall be capable of stopping a Train Set loaded according to the scenarios defined in TSI LOC & PAS 2015 Chapter 4.2.4.5.2 (6) –exceptional payload shall include 2 standees/m²- from its maximum Operating Speed within the signal spacing existing on the track over which the Train Set is operating, and/or within the given movement authority, under worst-case adhesion conditions.

The design of the brake Equipment shall:

- Comply with the performance requirements mentioned in this Specification in accordance with the SRT's Operating Plan,
- Comply with EN 15355, EN 15734-1, EN 16185-2, EN 50121-2, EN 50121-3-2, EN 50126, EN 50128, ISO 8573-1,
- Provide pneumatic brake control compatibility with rescue locomotives equipped with UIC 540 and UIC 541 brake systems,
- Provide wheel slip/slide protection (WSP) for all traction and braking cases,
- Provide and display System monitoring and Fault indications.

The Private Party shall demonstrate, through Analysis and testing, that the braking System does not exceed the thermal duty cycle of the brake components under any braking scenario mentioned in TSI LOC&PAS 2015.

It shall be possible to perform a test routine to test mechanical brakes from the driving Cab without support of a second person outside the train. It shall be possible to keep a Train Set with a full load stationary for an unlimited period of time under normal operating conditions, (i.e. air is available/ compressor is working) on the maximum gradient to be encountered with the maximum operational brake cylinder pressure applied and without assistance from the parking brakes. Spring applied parking brakes shall automatically substitute the pneumatic brakes in case of lost brake cylinder pressure.

The brake system shall provide a bogie-wise control and shutoff. The shutoff shall be initiated from inside the Vehicle. Loss of power or any kind of single Failure of the Brake System shall not result in exceeding the allowable stopping distance as defined in this Specification. The friction brake alone shall be adequate to safely stop the Train Set under all operating conditions defined in this Specification. The friction brakes shall be sized to permit the Train Sets to travel to its end destination with friction brakes alone after one emergency brake application at any location on the SRT's network.

An Interface between the brake system, Cab signal, alerter, ATP System, and Train Set diagnostic and monitoring Systems shall be provided.

The wheel/rail adhesion limits while meeting the performance requirements of this

Specification shall be according to TSI LOC & PAS 2015.

11.1.1 Wheel slip / slide protection

The design of the brake Equipment shall:,

- Provide wheel slip/slide protection (WSP) for all traction and braking cases according to TSI LOC & PAS 2015

A WSP shall be fitted to each Vehicle, having the role of reducing excessive wheel slide (resulting from brake applications) and wheel slip (resulting from traction applications) in situations where wheel/rail adhesion is temporarily impaired (e.g., inclement weather conditions, fouling of the rail), and of preventing wheels from locking. The Private Party shall outline the control philosophy for the WSP and act independently on all axles under its control.

The function shall operate with all wheel sizes and shall maintain performance with degraded rail conditions. The WSP shall be interfaced with the sanding trainlines, if provided.

11.1.2 Electro-dynamic braking

To reduce wear and tear the electrodynamic brake shall be used primary in both, service and emergency braking. Therefore it needs to be independent from the grid and shall meet high reliability standards. Proof shall be submitted according to CSM (common safety methods, EU guideline Nr.402/2013)

11.1.3 Parking brake system

The parking brake system shall be able to hold the Train Set with mass under exceptional payload as defined in EN 15663 Tables 1 to 3 for an unlimited period of time on the maximum gradient compliant to TSI LOC&PAS 2015.

The parking brake shall be able to be applied and released manually by the train Driver from the Driver's normal seated position in each Cab of the Train Set.

11.1.4 Passenger brake alarm

A passenger brake alarm shall be provided in the passenger compartment in line with TSI LOC & PAS 2015 that initiates a retrievable penalty brake application, which uses a brake rate consistent with prevailing adhesion, passenger Safety, and brake System thermal capacity. The Driver shall be capable of releasing the brakes to allow the Train Set to be stopped at a safe location.

11.1.5 Sanding

Manually operated sanding Devices shall be provided to improve the traction performance of the Train Set under adverse track conditions. The first and last driven axle of the Train Set shall be equipped accordingly. The sand tubes shall be heated to prevent from blocking due to wet sand.

11.1.6 Rescue operation

The brake System design shall allow a disabled Train Sets friction brakes to be controlled by a Rescue Vehicle, during a rescue operation. The Rescue Vehicle shall only be capable of supplying main reservoir pressure, and brake pipe pressure control.

12 CONTROL / COMMAND AND ONBOARD DATA SYSTEM

The control/command and onboard Data System is required to provide a high level of functionality and Reliability. The System shall be comprised of:

- A suite of functional Specifications,
- A diagnostics unit,
- A human-machine Interface (HMI) in the Cabs and the crew office composed of a display unit that shows the operational status (e.g. living icons/bars) of all of the Train Set Subsystems having diagnostics. Alarm messages shall be displayed on the diagnostic pages to the engineer (HMI located in the Cab) and the crew (HMI located in the crew office) depending on the information required.

It is envisioned that the System shall:

- Be based on an optimized architecture (operational independence of the Train Set functions, simplicity, standardization of components, etc.),
- Provide high Reliability levels,
- Permit management of modifications and their validation (reserve capacity for future updates in terms of memory capacity and intrinsic flexibility),
- Provide management of Data exchange (local diagnostics, event recording, Data transfer both onboard and import/export from the Train Set),
- Provide high performance Interfaces for both Operations and Maintenance.

The Train Set shall be Fault tolerant, with no conceivable Failure mechanism that could result in a "false departure" of the Train Set.

12.1 Cab

The Train Set shall have a fully-functional and identical driving Cab at each end. The layout of the driving Cab shall be arranged for operation by a seated, unaccompanied Driver and shall provide a tip-up seat for one additional occupant.

From his seat, the Driver shall have unobstructed forward visibility out the windshield complying with the TSI LOC & PAS 2015 and UIC 612 requirements and clear view of the displays, indicators and controls.

The Driver shall be able to control the head and signal lights from the normal driving position. The lights shall be controlled by a lever switch on the driver's desk.

All operating and indicating elements shall be marked with plain text or symbols according to UIC leaflet 612 or UIC leaflet 640.

A moisture-sealed Cab signal acknowledgement foot switch shall be integrated into the foot rest. Its dimensions and design provides for convenient operation by just a small movement of the Driver's feet.

12.2 On-Train Diagnostics System

The Private Party shall provide an On-Train Diagnostic System, integrated into the Train Set and the Train Sets Subsystems.

This Diagnostic System shall collect, advise, and display detailed information relevant to the operational conditions of the Train Sets Systems and Subsystems, and their respective Equipment. The Diagnostic System shall be fully integrated into the Train Set and the Train Sets Subsystems. The Diagnostic System shall collect status information relevant to the operational conditions of the Train Set from the onboard systems and subsystems. These systems and subsystems shall monitor the status and health of their respective equipment.

The Private Party shall provide a listing of Subsystems that will be monitored.

12.2.1 Diagnostics and Human Machine Interface (HMI)

Each Vehicle shall be provided with displays in both Cabs of the Train Set to display the diagnostic information for the Driver. The displays in the occupied Cab show the Drivers view (during maintenance also the maintenance view of the diagnostics), all other displays show the crew view.

At least the following views shall be provided:

- Driver view,
- Train Crew view,
- Maintenance view.

The HMI shall offer the following functionality:

- Visualize/provide mechanisms to identify and isolate failed subsystems,
- Monitors status, fault information and fault data from all intelligent subsystems, safety systems and service-critical subsystems,
- Generation and recording of status and fault information that assists the Driver or

maintenance staff during Maintenance and planning,

- Energy consumption data,
- Driving performance and timing data,
- Display relevant information in the driver's Cab and in the Train Set crew compartment,
- Monitoring of the Unit's status in the driver's Cab by maintenance personnel,
- Possibility of easily downloading diagnostic data without specialist software,
- Sending and displaying real time information to the control centre and the maintenance depot.

The Diagnostic System shall provide information prepared to various stakeholders. The contents of the information are optimized to the specific needs of the particular stakeholder:

- Driver,
- Train crew,
- Maintenance,
- Maintenance control centre.

The Diagnostic System shall be optimized to provide all stakeholders with detailed information they need and to suppress information they don`t need.

12.2.2 Diagnostics for the Driver

The information conveyed in the operational messages shall be aimed to improve availability. The Driver needs information about the operational status of various systems and in case of failure about instant remedy measures carried out by the Driver.

The “Train Set door group indicator” in the driver's HMI shall indicate the status of the exterior doors The operational status of the electric portion of the brake System, and all critical, Safety-related propulsion System Faults shall be displayed for the train Driver in the active control Cab. The display shall also depict the total tractive effort and wheel slip conditions.

12.2.3 Diagnostics for the Train Crew

The information conveyed in the operational messages shall be only aimed to improve availability and comfort.

The operational diagnostics system shall generate messages that can influence the actions of the Driver, the Train Manager or Train Set engineer. Messages to the Train Set Crew shall provide information on faults of operational functions. The diagnostics system shall display these messages in the driver's Cab or in the crew compartment.

The following information shall be displayed on the driver’s and crew compartment displays:

- Extended information about the availability/failure of important Systems,
- Recommendations/instructions for remedying malfunctions within the scope of the Train Set crew's possibilities,
- Availability/failure of important Systems.

12.2.4 Diagnostics for Maintenance

The maintenance diagnostics shall generate diagnostics messages, log messages, environment data and operating data. Their purpose shall be to support troubleshooting, fault detection, root cause analysis and Preventive Maintenance. Each diagnostics event is to be identified by a unique diagnostics event code. The diagnostics system shall save these messages together with additional information (occurrence/disappearance time stamp, installation location, diagnostics environment) in the non-volatile diagnostics memories of the subsystems and the higher-level diagnostics system.

The UTC time (= Universal Time, Coordinated) available on the vehicle bus shall be used as the time stamp base. It shall be converted to local time only when an output is made to a console.

The overview screen of the console shall show the following information on each diagnostics event:

- Vehicle number,
- Function,
- Short description.

This data is also to be reported to a stationary system by means of long-distance data transfer (Remote Data Access - RDA).

Information that is kept in the central diagnostics data memory of the higher-level diagnostics system:

- Higher-level diagnostics messages,
- Maintenance messages of all subsystems relevant to announcement,
- Log messages of all subsystems relevant to announcement.

Information that is kept in the distributed diagnostics data memories of the distributed control units:

- Maintenance messages of the subsystem relevant to announcement,
- Log messages of the subsystem relevant to announcement,
- Internal diagnostics messages,
- Operating data of the subsystem.

Besides saving the specific fault messages, the diagnostics data memories shall also save diagnostics environments. These shall be a compilation of characteristic quantities of the control process at the time when the diagnostics event was registered. The environment data shall primarily serve for root cause detection and analysis, not for deriving maintenance measures.

12.2.5 Diagnostic System Fault Log

Detected Faults shall be stored in the Diagnostic System Fault log. The information stored shall not be corrupted as a result of any technical malfunction. The Data in the Fault log shall include:

- Fault code and Fault text,
- Location where Fault occurred on the line,
- Location/source of the Fault within the Train Set,
- Fault status,
- Date and time when Fault occurred,
- Date and time when Fault disappeared / was remedied,
- Number of occurrences,
- Diagnostic environment showing the general status of the Train Set at the time the Fault was detected.

The System shall be equipped with a Data logger that shall diagnose and certain record performance information regarding

a) the propulsion and braking Systems in the Train Set, by date and time

b) the door System performance and Fault information

c) the performance and Fault information regarding the HVAC units

The Private Party shall identify the System status and Fault indications that will be provided, for review by the Engineer’s Representative.

12.2.6 Portable Test Unit (PTU)

It shall be possible to extract Data from the Diagnostic System memory. The Private Party shall provide a PTU (e.g. Service PC such as a Notebook, or Laptop) to view and analyze the retrieved Data. The PTU with service software shall be connected to a service interface. The information shall be downloaded to the PTU. It will also be possible to extract data from the TMDS. By using the same PTU it shall be possible to analyze and review the retrieved data. The information shall be downloaded to the PTU.

12.3 Operational Alarms

The Train Sets shall be provided with operational alarms. These alarms include those that may potentially affect passenger service.

There are two types of operational alarms:

- Alarms generated by actions of:
  - the Driver (e.g. emergency brake, horn, bell),
  - a Train Crew member (e.g. emergency brake, fire alarm), and/or
  - passengers (e.g. passenger emergency alarm).
- Alarms generated by the control system of the Train Set (e.g. fire alarm, alerter alarm, Help call, Diagnostic messages).

The Diagnostic System shall be configured to control, monitor, display, diagnose, and, if applicable, conduct performance tests on both types of operational alarms.

The Train Sets shall include operational alarms, which provide a warning to events that may potentially affect passenger service. These events shall be displayed on the crew-TDD (e.g. faults of comfort functions like HVAC, lighting, etc.). The Central Control Unit (CCU) shall control and monitor the activation of these alarms through distributed I/Os and report any faults of the voice module (automatic reading) to the Driver.

There shall be two ways to indicate alarm condition:

- Audible alarms,
- Visual alarms.

The audible voice alarms shall be prioritized, in case more than one event occurs at the same time, and be audible only in the manned cab.

Visual alarms shall be presented by indicator lights on the desk (e.g. fire alarm), icons on the TDD status bar (e.g. HVAC emergency off, fire alarm, passenger emergency alarm, communication failure with doors, alerter) and TMDS fault logs on the console.

The Private Party shall provide the list and types of alarm conditions for Engineer's Representative review.

12.4 Technical / Maintenance Alarms

The Train Sets shall be provided with technical/Maintenance alarms. These alarms are generated upon detection by Subsystems and/or sub-Subsystems Equipment and indicate the Failure status of such Equipment being monitored.

In addition in maintenance mode, they may be displayed in the Vehicle in a "maintenance fault overview".

Diagnostic messages for maintenance shall describe faults from the perspective of Maintenance. A definable maintenance task shall be connected to each of these messages. The aim of the maintenance tasks shall be to clear the cause of the fault.

Diagnostic messages for maintenance are not a direct request to locate the fault, but lead to the preparation of work tasks in Maintenance, via which it is possible to clear the fault, taking the relevant troubleshooting instructions into consideration, so that the vehicle can return to normal operation.

The maintenance database shall contain not only information about the troubleshooting but also the priority for the maintenance. The level of detail in diagnostic messages shall be determined on the basis of the principle of "as much as necessary". Ascertaining what is "necessary" shall be defined on the basis of requirements of maintenance when working on the Vehicle. The aim is to be able to perform the maintenance tasks on the Vehicle with the available tools, personnel and time. If the maintenance tasks involve the replacement of components, these should be referred to as the Smallest Replaceable Units (SRU), in economic terms. If more than one SRU is indicated as the cause of the error, the maintenance instructions shall clearly lead to the defective SRU.

12.5 Transfer of diagnostic and operational data

Diagnostic and operational Train Data, Video Data, Infotainment Data as far as Audio communication Data shall be collected and broadcasted by the Train Set Diagnostic System and exchanged with the wayside Train Operation and Maintenance Center via a redundant central point of RDA.

12.6 Start-Up and Change of Drivers Cab

The Train Set shall achieve a nominal start up time of maximum four minutes. This time shall be measured from the point when all electric energy and control Systems are off and de-energized, the compressed air system is at least at 90% nominal level, the system is not frozen, to when the Train Set is able to move with all Systems operational.

Furthermore the Train Set shall be equipped with an automatic start-up-mode, which causes the Train Set to be ready to operate at a predefined time.

The Train Set shall be capable of reversing (once stationary) in two minutes, nominal, excluding door open/close times and any walking time of train Drivers between ends.

Operational procedures e.g. extended brake tests or ATP tests, are considered to be performed during train preparation phase and not during train operation phase.

12.7 Propulsion and braking controllers

A manual mode of controlling propulsion and braking shall be accomplished through dedicated controllers provided in each Cab, located on the Driver's console. The design of the controllers shall match the overall aesthetic concept of the Cab and console and meet Safety and ergonomic requirements while utilizing robust components of traction power System quality in its construction. Emergency braking shall be initiated from the Cab by pulling the brake lever to the respective position.

The Train Sets shall also be provided with emergency brake Devices in each unmanned Cab that can be used to initiate an emergency brake application. The Driver shall in this case not be capable of releasing the brakes until the Train Set has come to a complete stop.

The traction handle and Electric Brake will be used to control the effort of the train in both cases. The use of the Electric Brake as holding brake to descend slopes at constant speed may be carried out with this handle.

Preferably, the shifters of traction and Electric Brake and brake conjugate, may be replaced by a single traction handle/brake.

12.8 Train Set Preparation/Pre-Departure Test

Basic departure tests (e.g. Brake-test, ATP-test) shall be carried out automatically upon each power up and their successful completion recorded as a timed event on the Diagnostic System. Pass/fail indications shall be incorporated to indicate the status of the System (e.g. indicators on ADU or output of diagnostic messages on console).

Test routines with impact on train operation shall be minimized as far as possible by performing these test during the train preparation phase e.g. in the train depot.

The Private Party shall submit the list of Train Set preparation/Train Set pre-departure checks proposed, together with details of the test functionality, for Engineer's Representative review. Such tests shall also include WSP System tests.

12.9 Event Recorders

Both car Cabs of the Train Set shall be equipped with a Train Set recorder system. Only the recorder system in the leading Cab car shall be activated.

System activation shall start as soon as the Cab is manned by the Driver.

The following Train Set recorder system shall be installed:

- Juridical recorder unit (JRU),
- Trainborne recorder unit (TRU).

Both recording systems are required to be integrated in one common unit.

The juridical recorder shall record all the information to be stored by the Train Control System .

The Train Set recorder system shall consist of a data recorder control unit including the crash-protected non-volatile electronic memory according IEEE Std 1482.1, and be provided with an interface to the vehicle Train Set bus.

Diagnostic information on the Train Set Recorder System as well as Train-wide date and time information shall be provided to the Train Set control system via the data bus interface.

The Train Set recorder system serial interfaces are required to be connected to the Train Set radios, driver's display and similar. It shall not have an isolation switch and be provided with its own Train Set data entry function.

The required software shall be available for set-up, configuration, Maintenance and analysis of the Train Set recorder system.

13 BOGIES AND RIDE COMFORT

The Private Party shall be responsible for providing smooth and safe performance of the Train Set, and of two Train Sets coupled together, at all speeds and track profiles experienced on the SRT's network as specified in Operations Concept. Private Party requirements for wheel/rail Interface criteria are entirely defined in the respective Chapters of the TSI LOC & PAS 2015 rules.

The proposed designs shall be demonstrated as being compliant with all Specification requirements through Vehicle dynamic simulation, and instrumented testing on the TSI compliant sections of the SRT's network.

As part of the proposal, the Private Party shall demonstrate that the Train Set design complies with the requirements for safe running behavior as stated in TSI LOC & PAS 2015.

The compliance shall be demonstrated by preliminary analytic simulations including documentation of the simulation’s boundary conditions and Vehicle design parameters, or by presenting TSI certification documents of equivalent vehicles in service.

In order to minimize LCC passive means of lateral suspension are preferred.

The Private Party shall ensure that as many components of the Train Set as possible are identical and interchangeable between the Bogie types as set out as follows:

- Each powered axle shall be identical and use identical Equipment.
- Each unpowered axle shall be identical.

Wheel re-profiling shall be possible with Bogies mounted on the Vehicle.

Adapters to the wheel truing equipment, if necessary, will have to be determined after the review of the Private Party's design and provided by the SRT.

The following table including the respective definition shall be used as basis for calculation of unsprung mass of each axle.

Table 7 : Unsprung Mass

Parts	Portion	Annotation / Comment	Examples
Wheelset and mounted equipment	100 %	All parts directly mounted on the wheelset and therefore not isolated from the track	wheelset, axle boxes including bearing, brake disks
Primary Suspension	50 %	Partially separated / isolated from the track	springs, dampers
Partially suspended links	50 %	Partially separated / isolated from the track	trailing arms, traction linkages
Gearbox / Drive			
- Axle-mounted Parts	100 %	directly mounted on axle	large gear wheel including its bearing
- Partially suspended parts	50 %	Partially separated / isolated from the track	gearbox housing, other gear wheel
- Links between partially and fully suspended parts	25 %	If the motor is fully suspended, only half of the coupling is partially suspended.	coupling between gear box and motor, torque bracket

13.1 Secondary suspension

Secondary suspension shall be realized by an air-spring system.

The secondary suspension shall incorporate automatic carbody-to-Bogie height adjustment, which shall be functional for all loading conditions, and shall include auxiliary spring units, to ensure safe wheel-rail performance at all speeds in the event of secondary suspension Failure. The air pressure of the air springs shall be monitored.

13.2 Bogie stability

Bogie stability in accordance with EN 14363 shall be achieved by passive means only. Bogie instability shall be monitored in accordance with TSI LOC&PAS 2015. An emergency brake request must be issued if a Hazard is detected.

13.3 Obstacle deflector

Vehicles with a driving Cab shall be fitted with an obstacle deflector at the Cab end to reduce the risk of derailment resulting from impacts with objects or animals lying at, or near, rail level. The Private Party shall demonstrate that the deflector complies with the requirements defined in EN 15227.

13.4 Wheel Flange Lubrication

An electro pneumatic wheel flange lubrication system shall be in accordance with the requirements of TSI LOC&PAS 2015.

13.5 Track Geometry

Track Geometry and its maintenance will be in accordance with TSI INF 2015 and EN 13848 (including measurement methods depending on accelerations, see EN 13848- 1 Annex A).

The SRT's System will utilize continuously welded rail for dedicated high speed tracks. The proposed Train Set wheel profile shall be fully compatible with the system rail profile. The Train Set shall be capable of satisfactory Operations on the system track under all conditions.

In regards to running safety the requirements of EN 14363 (2016) shall be applied. For calculation purposes of ride comfort, track parts with track qualities >qn2 (EN 14363 (2005)) shall be excluded.

The wheel/rail interface shall be compliant with the requirements of TSI LOC & PAS 2015.

Rail profile and rail inclination are described in E&M Specification for Trackwork.

The Train Sets shall be able to operate safely through curves with a horizontal radius of 150m and through curves with a vertical radius of 500m.

The single vehicles of the Train Set shall be able to operate safely through curves with a horizontal radius of 125m in depots.

The Train Sets shall be able to operate safely through S-curves with a horizontal radius of 190-6-190 m (Curve: 190 m, straight section: 6 m, curve: 190 m). In depot, it shall be possible for the Train Sets to pass S-curves with a horizontal radius of 190-0-190 m (Curve: 190 m, straight section: 0 m, curve: 190 m) at speeds below 5 kph.

13.6 Bogie monitoring

Means to monitor the axle box temperatures shall be provided in accordance with TSI LOC&PAS 2015. The data shall be signaled to the on-Train Set monitor and diagnostics system.

The Train Sets shall also be provided with rotation monitoring Equipment to detect locked axles and to indicate this condition in the operating Cab through a suitable audible and/or visual alarm.

13.7 Ride Quality

The requirements of section 4.2.3.4 of TSI LOC & PAS 2015 shall be fulfilled.

Train Sets shall be designed to be stable and free from hunting oscillations at all Operating Speeds up to 10% in excess of the maximum intended.

13.8 Ride Comfort

The ride comfort shall be evaluated for all speeds up to maximum operating speed according to the standard method for mean ride comfort defined in EN 12229 considering a track maintained in accordance with the requirements of TSI INF 2015 and EN 13848.

The ride comfort evaluation shall consider the guidelines of ISO 2631.

Any vibration that is caused by Equipment operation (e.g., compressors, blowers, electromagnetic Equipment, circuit breakers, motors, etc.) and emitted by the Train Set shall not be a source of greater discomfort to the passengers.

14 SIGNALING

14.1 Horn

Horns shall be installed at both ends of the Train Set and shall comply with TSI LOC & PAS 2015.

14.2 Exterior Lighting

The exterior lighting (headlights, signal lights and tail lights) shall meet the relevant requirements of TSI LOC & PAS 2015 (supersedes UIC recommendations). All lamps used for exterior lighting shall be long-life LEDs.

The lamps shall be arranged in a pressure resistant and humidity tight housing with a heated transparent cover to cope with pressure pulses encountered in tunnels.

14.3 Automatic Train Protection (ATP)

The ATP Onboard System shall comprise the following functionalities:,

14.3.1 ATP Onboard Systems

The on board system configuration to be installed shall comply with the Train Control specification version that is valid at the time of Contract signature of the equipment (e.g. SRS 3.4.0). Final selection of the version of the Train Control System shall be determined in consultation with and agreed by the SRT.

The ATP onboard equipment shall comprise in particular:

<u>Once per Cab car</u>

- EVC,
- GSM-R Data Radio System including roof antennas,
- Radar system(s),
- Speed sensor(s),
- Interface for brake access,
- National ATP system(s) if required,
- Speed sensor(s) for national ATP system(s) if required,
- Antenna(s) for national ATP system(s) if required,
- Trainborne Recorder Unit (including Juridical Recorder Unit).

14.3.2 Optional systems (if required)

The Private Party shall indicate in the offer, as an option, the national ATP system if required by the SRT.

This preparation includes as a minimum:

- The national ATP system,
- Defined and implemented interfaces for interaction with Train Control System

14.3.3 DMI

The texts on the DMI shall be applied in the language defined by the SRT and in English. The driver shall have the possibility to select the language of his choice.

14.3.4 ATP interfaces

The Private Party shall propose the interface specifications to be applied in the design of the Train Control onboard configuration i.e. for connecting the "European Vital Computer" (EVC) with other subsystems of the Train Control on board configuration (e.g. DMI, odometry, national ATP systems). Preference shall be given to interface specifications for which there are valid ERA approved FFFIS. The final interface specification shall be defined in consultation with and agreed by the Engineer's Representative.

14.3.5 Transitions between ATP systems

The Train Control onboard system shall be able to handle the system transitions between national ATP systems if required by the SRT and if technically feasible.

It is assumed generally that each dynamic (running) transition between ATP systems is controlled with balises.

A manual transition between the ATP systems shall be possible in standstill.

14.3.6 Track to Train Set Functions

Track to Train Set functionalities

14.3.7 Restricted Manual Mode Operations (ATP Isolated)

In the case of Failure of the ATP onboard Subsystem, the Train Set shall be able to continue operation under a restricted manual mode with a non-equipped configuration (i.e., ATP isolated). In this mode, the Train Set shall be under Driver control with a maximum permitted speed defined by the Engineer's Representative, limited by a speed governor function of the train control system. In the event of an over-speed condition, first a warning shall be send to the train driver and if he doesn´t react immediately an emergency brake application shall occur.

14.3.8 Automatic Train Operation (ATO)

The Train Set shall support Automatic Train Operation up to GoA Level 2.

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VOLUME 3/1 : THE RAIL-RELATED WORKS OF THE PROJECT

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1. INTRODUCTION

1.1 General

1.1.1 This Section of the Specification relates to the provision of a 2x25 kV AC electric traction system and the provision of all auxiliary supplies to stations and depots along the Bangkok - U-Tapao High Speed Railway Project (hereinafter referred to as "HSR").

1.1.2 The extent of the railway lines to be electrified and for the provision of auxiliary supplies is from Don Mueang station (km 20+200) to Beginning of ARL Extension (km 0+00) and from beginning of ARL Extension (km 0+00) up to U-Tapao (km 196+410) giving a total length of approximately 215 km.

1.1.3 The HSR line is basically double track. A large percentage of the line will be an elevated railway built on viaducts.

1.1.4 A railway Electrical Multiple Unit (EMU) and rolling stock maintenance and repair depot will also be located at Klongton.

1.1.5 The following table gives an overview about the main parameters of the stations.

Station	Chainage	Abbr.	Type of platform	Particularity
Don Mueang	- 20+672	DMU	Side Platforms	2 tracks
Bang Sue	- 6+281	BSG	1 Center Platform	Double Length
Beginning of ARL Extension	0+000			
Phaya Thai	0+179	PTH (E1)	side platforms, elevated	2 tracks; future extension to Bang Sue; interchange with BTS
Ratchaprarop	0+982	RPR (E2)	side platforms, elevated	2 tracks
(City Air Terminal) Makkasan	3+000 (SAE) 3+215 (SAC)	MAS (E3)	separated island platforms for High Speed and City Line, one side used, elevated	4 tracks, interchange with MRTA; interlocking
Ramkhamhaeng	7+399	RKH (E4)	side platforms, elevated	2 tracks
Hua Mak	12+305	HUM (E5)	island platforms, elevated	4 tracks; interlocking
Ban Thap Chang	17+267	BTC (E6)	side platforms,	2 tracks

Station	Chainage	Abbr.	Type of platform	Particularity
			elevated	
Lat Krabang	23+498	LKB (E7)	side platforms, elevated	2 tracks, interlocking
SA Terminal (Airport)	28+650	SVB (E8)	island platforms, underground	4 tracks, PSDs
Chachoengsao	64+839	CCS	Island platforms	4 tracks
Chon Buri	113+449	CHB	Side platforms	4 tacks
Si Racha	136+119	SRA	Island platforms	4 tracks
Pattaya	160+929	PAT	Island platforms	4 tracks
U-Tapao	196+410	UTP	Island platforms, underground	4 tracks, PSDs

1.1.6 The Private Party shall provide substations for railway electrical supplies from the Metropolitan Electricity Authority (MEA)/ Provincial Electricity Authority PEA (hereinafter referred to as Power supply Authority (PSA)) at 115kV and this will supply the power requirements for traction along the railway line and for both traction and auxiliary supplies to the Depots.

1.1.7 The substation facilities for HSR including 3 Sub Stations (hereinafter referred to as “SS”), 1 Sectioning Post (hereinafter referred to as “SP”) and 11 Sub Sectioning Posts (hereinafter referred to as “SSP”) and 2 Auto Transformer Posts (hereinafter referred to as “ATP”). Sub Stations are planned as follows:

Table 1 : Sub Stations Location

Name	Location (km)	Remarks
SS-1	Km. 86+900	
SS-2	Km. 185+000	
SS-3	Km. 57+000	In Depot
SP-1	Km. 143+000	
SSP-1	Km. 41+000	
SSP-2	Km. 55+000	

SSP-3	Km. 61+000	
SSP-4	Km. 74+000	
SSP-5	Km. 101+000	
SSP-6	Km. 115+000	
SSP-7	Km. 127+000	
SSP-8	Km. 157+000	
SSP-9	Km. 171+000	
SSP-10	Km. 197+000	
SSP-11	Km. 209+000	
ATP-1	Km. 26+700	Lat Krabang Station

1.1.8 Details of the layout of the railway alignment, location of stations, general station architectural arrangements, etc. are as shown in the general drawings provided to the prospective bidders. All the lines including depots are to be electrified.

1.1.9 Overall operations and electrical control shall be undertaken from a new Operational Control Centre (OCC) to be located at the HSR depot at Chachoengsao.

Table 2 : Depot Location

Depot	**Location(km)**
Depot	Km. 53+000

1.2 SRT's Requirements

1.2.1 Earthing and bonding system provided shall comply with EN50122-1 Railway Applications - Fixed Installations - Part 1: Protective provisions relating to electrical safety and earthing and the Engineering Institute of Thailand (EIT) EIT2001-45 Standard.

1.2.2 The Electric Power System, including electric power load to be connected to the Power Supply Authorities (PSA's), shall comply with the PSA's regulations "instructions for the preparation electrical equipment of the user" issued by MEA 2544. Other relevant International Standards, e.g. IEC, IEEE, etc., shall be also complied wherever necessary.

1.2.3 The proposed capacities, ratings and number of equipment as a result of the engineering development shall be demonstrated by a proper engineering and simulation study and subject to review by the Engineer's Representative. Where practical, the main components of the equipment provided shall be sized to operate the HSR Line railway train services under normal and congested situations for the forecast patronage for the year 2073.

1.2.4 The system provided shall be demonstrated to be reliable, available, maintainable and safe.

1.2.5 The current collection system for rolling stock shall be overhead equipment providing electric power at 25kV 50Hz.

1.2.6 The cost for PSA electrical connections to the HSR Line railway, shall be the responsibility of the Private Party.

1.2.7 Standards indicated in this Specification are provided solely for the guidance of the Private Party, standards shall be EN, IEC standards or other equivalent standards proposed by the Private Party and approved by the Engineer's Representative.

1.3 System Overview

1.3.1 The SRT's preliminary system design shown in the attached drawings is for reference only. The Private Party shall improve on the SRT's preliminary design.

1.3.2 Power supplies for the traction power system shall be availed from PSA's for the sub stations. PSA's grid sources to ensure a collective availability of HV power for 99.98% of time. Sub-Station (SS) shall include two sets of traction system transformers and associated equipment, appropriate to meet the technical requirements of PSA, each capable of supporting the load and the system configured for load sharing or full redundant operation. Traction power to be provided to trains at a nominal 25kV 50Hz single phase by an Overhead Catenary System (OCS) shall be in accordance with UIC796 standard or equivalent International Standard as approved by the Engineer's Representative.

1.3.3 Centralized 22 kV 3-phase, electric power shall also be supplied from the Sub-Station in the depots, through dual redundant feeders to ensure reliability and availability of power supplies.

1.3.4 For the event of extended PSA power outages, a back-up diesel generator set shall be provided by the Private Party to support the "essential" equipment at each and every station and depot.

1.3.5 Availability of the power supply at the OCC, stations and depots is important during the management of emergency situations. The OCC, stations and depots power supplies shall include redundant power supply paths, Uninterruptible Power Supply (UPS) systems with 4-hour battery support and the PSA supply backed up by a dedicated diesel generator set. Reconfiguration of the OCC power supply system during any failure of the system equipment shall be transparent to the OCC operation.

1.3.6 The Electric Power System shall normally be supervised by a SCADA system work station at the OCC at Chachoengsao. The Private Party shall provide the control system, which shall provide automatic and manual management of the entire HSR line power system. Normal mode of supervision shall be for automatic operation where reconfiguration of the system during failure vents ensures transparency of the failure to the transit system operation.

1.3.7 The Private Party shall provide built-in diagnostics and remote monitoring function for each microprocessor-based equipment and module of the systems, such that the performance requirements can be demonstrated. Protection equipment shall be provided to avoid damage to equipment during failure situations and protect people from harm.

1.3.8 The Private Party shall provide earthing and bonding of all E&M equipment's and these arrangements shall comply with EN50122-1 Railway Applications - Fixed Installations - Part 1: Protective provisions relating to electrical safety and earthing and the Engineering Institute of Thailand EIT2001-45 standard and MEA's regulations.

2. SCOPE OF WORK

The scope of work relating to this Section shall cover the following:

1) Interface with other external parties associated with this Contract (e.g. MEA/PEA, public or private telecommunication companies, regulatory bodies, etc.) to resolve any interface issues with these parties arising from the provision of both the 2 x 25kV AC traction or 22/0.4kV auxiliary supply system.
2) Undertake a number of theoretical studies on which the Private Party's design will be based.
3) The design and provision of substations building and equipment at various locations to be able to meet the power quality connection regulations (unbalance, harmonics, voltage flicker and power factor) specified by PSA.
4) The design and provision of Auto-Transformer (AT) locations and/or track sectioning facilities along the railway alignments, including buildings, platforms etc.
5) The design and provision of all 2x25 kV overhead catenary equipment to provide electrical power to the EMU's that will operate the HSR services on the lines.
6) The design of all OCS pole and gantry bases.
7) The design of all station OCS supports.
8) The design of all depot OCS supports.
9) The design of the earthing and bonding system necessary to protect the E&M Systems, the staff and the passengers.
10) The provision, installation and testing of all earthing and bonding systems and equipment.
11) The provision of suitable screening segregation within the civil guideway and at grade cable troughs between any HV cable and signaling and communication cables.
12) The design and provision of all HV switchgear, transformers, a LV switchboard and UPS equipment at each station/depot.

13) The design and provision of a standby emergency diesel generator(s) at each station and depot along the track.

14) The design and provision of an overall earthing arrangement for both traction and auxiliary supplies.

15) The design and provision of a SCADA system to control and monitor the whole network from the OCC. An emergency control and monitoring facility shall also be available at alternative location as proposed by the Private Party and approved by SRT.

16) The design and provision for the monitoring and possible control by PSA of certain items of equipment within the bulk supply point. This provision to be incorporated within the PSA’s SCADA system and PSA’s PQMS (Power Quality Monitoring System), Line Transfer Function (LTF) and Line Differential Protection.

17) The provision of all documentation required throughout the period of Phase I for approval purposes and the provision of all design criteria, studies, "as fitted" documentation, maintenance manuals, etc. at the end of the Phase I.

18) The provision and installation of all necessary screening and the provision and installation of all safety notices to warn both railway staff and members of the public regarding the dangers of the HV equipment (both for traction and auxiliary supplies) and provision of all energization notices.

19) The provision and installation of all screens necessary for signals on gantries and in "At Grade" track areas to protect maintenance staff from the OCC conductor wire potential.

20) The training and where necessary certification of subsequent maintenance and electrical control personnel.

21) The provision of all maintenance instructions for the equipment being provided.

22) The provision of all "working instructions" (safety rules and regulations applying to all railway staff) and "electrical control operator’s instructions" for the safe operation and isolation (isolation procedures, permit requirements, etc.) associated with the HV supplies (both traction and auxiliary supplies). It should be noted that the Private Party will be required to employ an individual or individuals from a 2x25kV operational railway who has knowledge of these requirements as they are associated with the train operational aspects of a railway system. These instructions, etc. are to be provided in both the English and Thai language.

23) The provision of all spares associated with the equipment being provided for both maintenance and repair activities. The level of spares to be provided will be the subject of discussion between the Private Party and the SRT.

24) All testing and commissioning aspects.

25) The possible provision of all necessary capital plant and equipment (OCS wiring trains, OCS inspection vehicles. rail cranes. rail augers. road/rail etc.) and any special tools and equipment necessary to maintain and/or repair the system being provided under this Contract.

26) The provision and installation of all concrete power cable toughing and cable ways, cable ladders, cable gantries etc. in the depots.

27) The installations of power cable in suitable sized plastic ducts and covered in concrete and buried in main line "At Grade" track areas. The cables shall be buried minimum 1 meter below normal ground surface and shall have a concrete cable marker warning block every 50 metres to identify to location and warn of buried HV Cables.

28) The provision of HV Cable Termination Cases in "At Grade" track areas to allow for fault finding purposes during failures of the HV cabling. The case bases shall be concrete and piled to SRT Design Standards and include suitably secure cases such as supplied in the Signaling PS and the bases shall have handrails and steps. The Private Party shall also supply padlocks to SRT Standards and submit all designs to the Engineer's Representative for approval.

3. POWER SUPPLY ARRANGEMENTS

The supply to the bulk supply point from power supply authority network:

1) Each supplying bay will be connected to possibly two transformers of power supply authority. Transmission lines constructed to supply the bulk supply point will be connected to the existing network.

2) The Private Party shall select the optimum alternative in conjunction with power supply authority to supply the substation point by considering power quality according to the PSA's criteria or regulations and power supply reliability. Furthermore, the Private Party shall consider the timing of the substation supply point construction and PSA's transmission system construction of the alternative selected.

4. POWER SUPPLY AUTHORITIES CONNECTION COSTS

All incidental costs for providing power supply connection including engineering, designing and installing facilities, interface, installation of any asset from PSA's substation to HSR's substation will be borne by the Private Party.

5. OVERALL CONCEPT

5.1 Sub Station Supply

5.1.1 General

1) An area of land will be made available for the construction of substations. The Private Party shall provide part of the total area for locating the HV switchgear, traction and auxiliary power transformer, MV switchgear and other special equipment i.e. phase balancing equipment, harmonic filtering equipment, and/or power factor correction equipment. Anyway, the area allocation has to follow the PSA's regulations.

2) Two independent 115kV supplies (or as recommended by the Private Party to the Engineer's Representative for approval) will be provided by PSA at the substations so that the loss of either one will not result in loss of all supplies to the railway. From these supplies, all traction supplies for the HSR line will be derived.

3) There shall be two 115/2x25kV traction transformers. One traction transformer will be connected to each incoming 115kV incoming supply, however facilities will be provided to supply both the transformers off of either one or the other of the incoming supplies. All necessary isolators shall be provided such that only one transformer can be taken off line for maintenance or isolated under fault conditions.

4) A conceptual layout of the arrangement is shown in the Conceptual Drawings. The Private Party may however suggest improvements to this conceptual, layout either on the basis of cost, operational flexibility or operational reliability. The Private Party on basing his Tender submission shall if he alters this conceptual design fully explain any alterations that he may propose and the effects of these changes on the operational flexibility, maintainability or reliability.

5) All 115kV switchgear shall be of the GIS indoor or outdoor type depending on the Private Party's recommendation for the Engineer's Representative's approval.

6) All 2x25kV, 25 kV single-phase and 22 kV 3-phase switchgear shall be of the indoor type. Depending on the type of 115 kV switchgear being provided within the railway compound both the traction transformers and the auxiliary supply transformers shall therefore have either HV cable and LV cable termination boxes. Rather than cable termination boxes on either the HV or LV sides of the transformers however the preferred arrangement will be to have the cables connected to outdoor sealing ends which are then connected to the HV and LV bushings on the transformers.

7) Buildings shall be provided to house the indoor switchgear (both at 25 kV and 22 kV), all control and protection equipment and all ancillary equipment (batteries and battery chargers, LV distribution panels, SCADA equipment, etc.). The layout of the equipment within this building or buildings and/or the building design shall be such to meet the RAMS requirement detailed in Clause 7 of this Section such that the

catastrophic failure of any one piece of equipment does not affect any other equipment. The Private Party shall determine the requirement or otherwise the need for the inclusion of fire suppression systems for this building(s) in accordance with Thai law and local practice.

8) The buildings, in so far as their functionality will allow, shall be to the same specification and architectural design of the buildings being provided on the rest of the railway.

9) The Private Party shall build an independent and powerful electricity grid so that its power supply will not be affected by other electric power users of the power supply authority. The Private Party shall also maintain and operate its own electric facilities.

The diagram of power supply from power supply authority to trains is shown in **Figure 1 and Figure 2**.

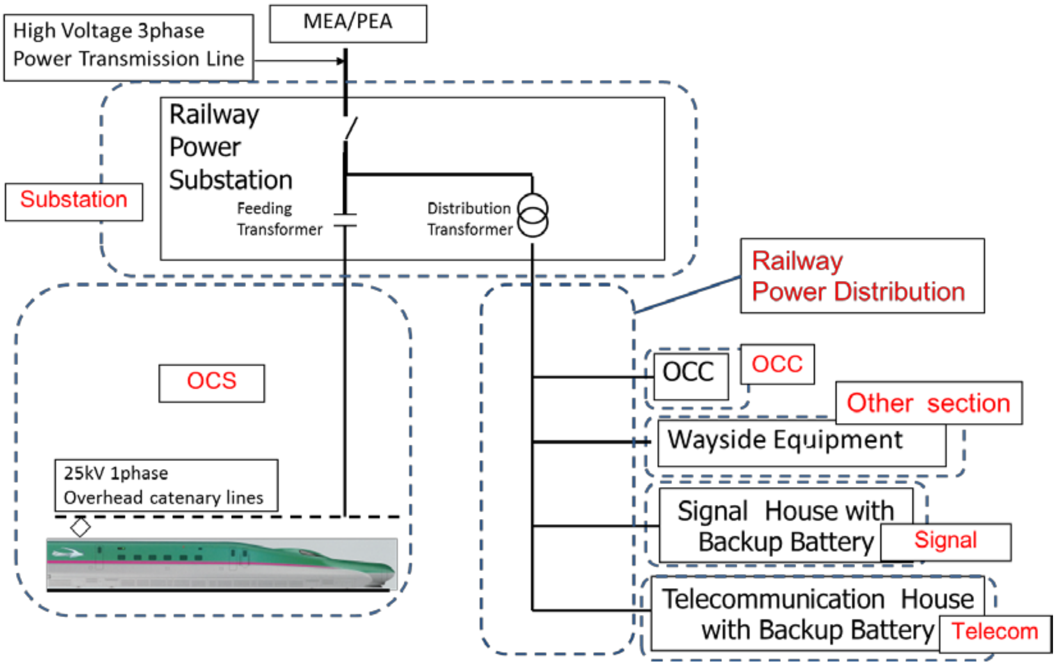


Figure 1 : Scope of Power Supply in the Main Line

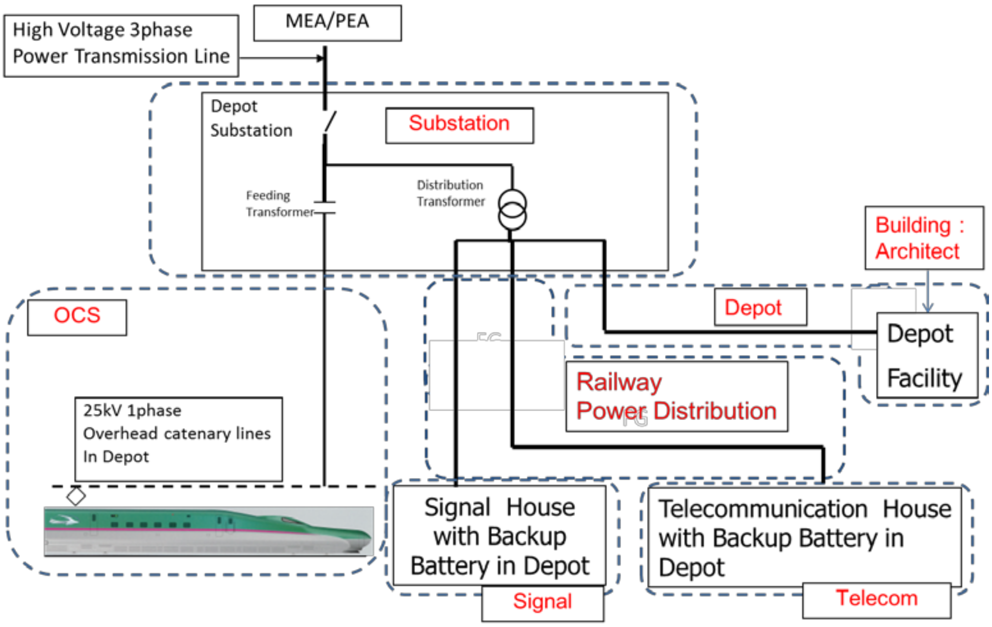


Figure 2 : Scope of Power Supply in the Depot

The scope of power substation is from the primary side of receiving DS to the secondary side of feeding/power distribution CB in substation.

5.1.2 Function of Power Substation System

At HSR substation, 3 phase commercial frequency AC power will be transformed into 2x25 kV AC single phase traction supply by traction transformer, and at Depot substation AC power will be transformed into 2x25 kV AC single phase traction supply by traction transformer as well as 3 phase medium voltage power by distribution transformer.

For the construction of High speed railway from Bangkok to U-Tapao, there are necessary to put new substations for traction of trains. Based on the train operation plan for the year 2050, the location and capacity of the SS, SP, SSP, ATP are determined and the following tasks are performed.

- Composition and configuration of the SS, SP, SSP and ATP (hereinafter referred as “SSs”) equipment.
- Determination of areas required for the SSs plants and buildings.
- Locations selection appropriate for the SSs plants with taking into consideration the availability of land, land acquisition, and the transmission power line route, etc.
- Centralized SS control system, etc.

And more, power distribution transformer which is necessary for train operation such as signaling, train radio, platform screen doors and auxiliary power source of SSs.

5.2 Auto-Transformer (AT) Locations

5.2.1 AT locations shall be provided along the length of the railway to maintain the required voltage profile and to provide suppression at source to EMI from the 25 kV traction system.

5.2.2 The spacing between AT locations shall be chosen by the Private Party to meet the above criteria of voltage and EMI suppression. For the sake of this Specification a spacing of 13 km approx. along the routes has been assumed. This spacing however is required to be confirmed or altered by the Private Party. AT's location should be able to take over the duties of an out of service AT.

5.2.3 On viaduct railways, it is envisaged that the AT's will be located in the space under the railway in the arches (to keep the AT compounds within the railway right of way) and where the railway is at grade if an AT location is required the AT compound shall be located on some suitable railway land.

5.2.4 Each AT will be fed through a load making/ load breaking switch or isolator.

5.3 Auxiliary Supplies

5.3.1 The Private Party shall build an independent and powerful electricity grid so that its power supply will not be affected by other electric power users of the power supply authority. The Private Party shall also maintain and operate its own electric facilities.

5.3.2 The railway facilities that are essential for train operations, such as the signaling system, telecommunication system, and systems of the OCC, shall have dual system configuration. PSDs are not envisaged to be installed at first but will be planned in the future and to be considered as the same. The redundancy can ensure that there will not be any power outages during maintenance inspection or failure of one system.

5.3.3 The power distribution system shall be able to supply power to essential facilities using a standby generator in the case that both of the dual distribution lines fail.

5.3.4 The PDS for E&M is designed to provide power to the various electrical loads for train operation such as signaling, telecommunication, PSD, OCC and trackside services along the railway track. Auxiliary control power of SS, SP, SSP, ATP is also supplied. The power distribution system for depots, workshops and maintenance center is designed to provide power to areas of the depots, workshops and maintenance centers.

5.3.5 The HSR power distribution system for E&M (hereinafter referred to as "power distribution system") transmits power to the train operation equipment at the power room and to the OCC by means of the secondary terminal of the AC circuit breakers for the power distribution transformers installed at SS. The HSR has standby generators to backup the essential loads for each station and the OCC.

5.3.6 The characteristics of the power distribution system at are as follows:

- The power of distribution system will obtain power via dual dedicated lines from SS.

- If one of the power distribution lines fails, another line will supply power to the whole railway facility.
- The standby generator will supply power to back up the essential loads in the case that both of the dual distribution lines fail.
- The power distribution system consists mainly of power distribution lines, transformers, switchgears, AC circuit breakers, switchboards, and standby generators.

5.3.7 The electric power at the railway power substation will be transformed from HV power to 22 kV power by the transformers at the railway substation. The 22 kV power will be transmitted from SS to the loads, (see **Figure 3 and 4**). It will be transformed to three-phase 400V and single phase 220V at each of the power room near the load.

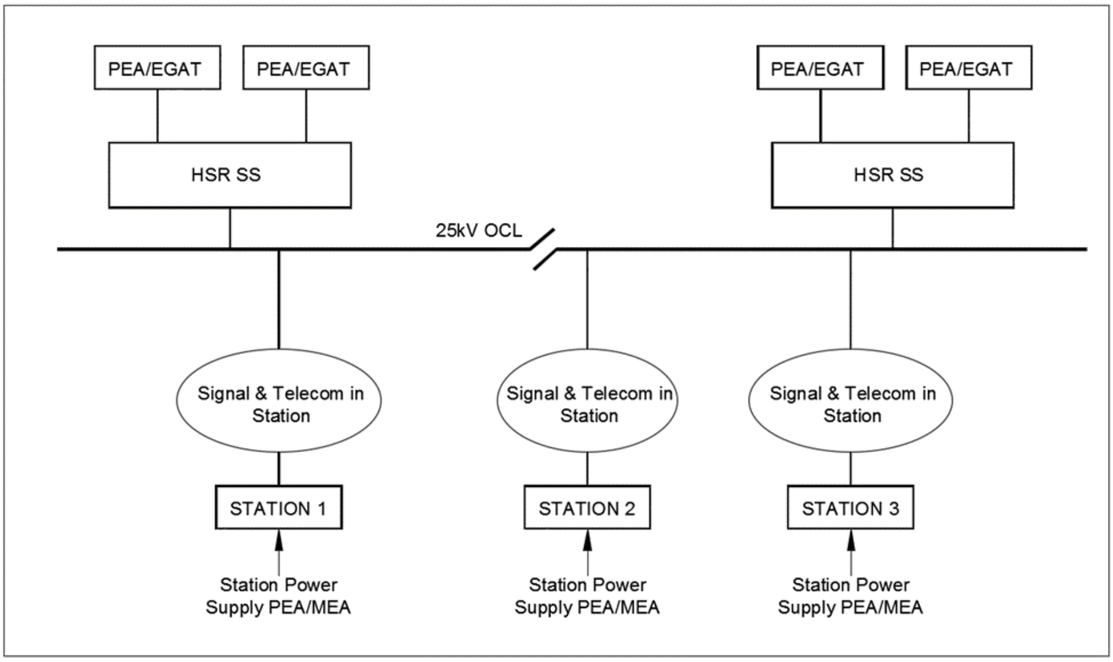


Figure 3 : Outline of Power Distribution System for Main Line

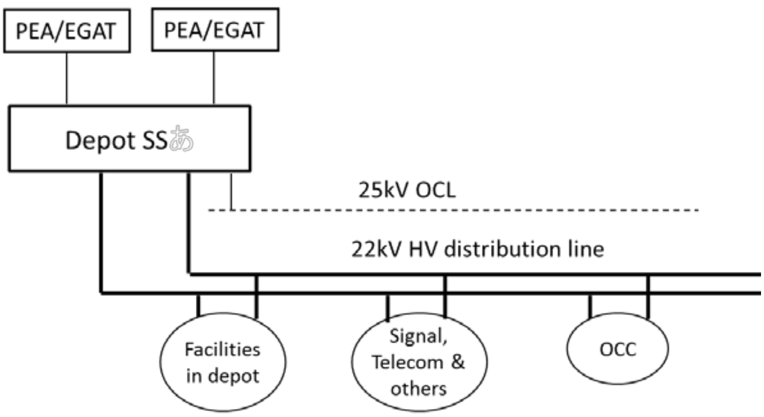


Figure 4 : Outline of Power Distribution System for Depot

The 22 kV power will be transmitted from the railway power substation to the switch room nearby each load. The power will then be transformed from 22 kV to three- phase 400V and single-phase 220V by the transformers at the power room.

5.3.8 The 22 kV 3-phase cables shall be laid in the cable troughs. As these cable troughs may also have to carry signaling and telecommunications cables, the Private Party shall provide suitable separation within these cable troughs to provide both mechanical separation so that a fault on a 22kV cable does not damage the signaling or communication cables and separation for Electro-Magnetic Interference (EMI) effects being transferred from the 22kV cables to the signaling and communication cables.

5.4 Supplies at Stations, Depot, etc.

5.4.1 At each station and the depots and at a number of other strategic wayside locations along the routes a 400 V 3-phase supply is required. This supply is to be fed from the networks of PSA except for Depot. The supply to depot will be from the SS bulk supply point. At the depot two 22/0.4kV transformers, all associated HV and LV switchboards and control and protection equipment shall be provided but at wayside locations unless these can be fed from either a station or depot supply, only one transformer may be provided taking into account the operational requirements of the equipment to be fed from the supply. UPS equipment shall also be provided at stations to ensure continuity of supplies even under the total loss of the 22 kV supplies for some essential operational equipment. A suitably rated (taking into account the total loading at each station/depot) standby diesel generator set complete with switchboard and control panel and all fixtures shall also be provided at all locations where there is a 22kV/0.4kV sub-station.

5.5 Overhead Catenary System (OCS)

5.5.1 As stated above the OCS on the mainlines shall be a 2x25kV system and shall therefore consist of a messenger wire, contact wire, and negative feeder wire together with all support arrangements, insulation, droppers between messenger wire and contact wire, fittings, jumpers, section insulators, etc.

5.5.2 In the rolling stock maintenance complex, simple tramway consisting of a single contact wire can be provided on sidings and entrance to sheds, etc. however the entrances and exits lines to this complex shall be provided with full OCS equipment (messenger and contact wire) as a shall any loop lines.

5.5.3 All OCS equipment shall be auto-tensioned.

5.5.4 The concept for OCS support is totally independent support arrangements (i.e. cantilever arrangement) for each line. Single track cantilevers or portal structures giving independent support and registration (dependent on track spacing) shall therefore be provided where the railway is at grade. On viaducts where there are three tracks, portal structures shall be utilized and on two track viaducts either portal structures or single-track cantilevers shall be provided.

5.5.5 Overhead Contact Line (hereinafter referred to as "OCL") is an important equipment for power supply in direct contact with the current collector of an electric rolling stock. The mechanism of the OCL is decided by the operating conditions (collected current, driving speed, train density, train formation) of the electric rolling stock.

5.5.6 The intended OCS shall support a maximum speed of 250 km/h. as such the System for OCL needs to be a Stitched catenary system. A flexible, regulated polygonal Overhead Equipment (OHE) shall be provided. The Private Party can propose any other proven OCL capable of supporting 250 kmph for approval by Engineer's Representative.

5.5.7 The configuration of typical Stitched catenary overhead contact line systems is shown in **Fig 5.**

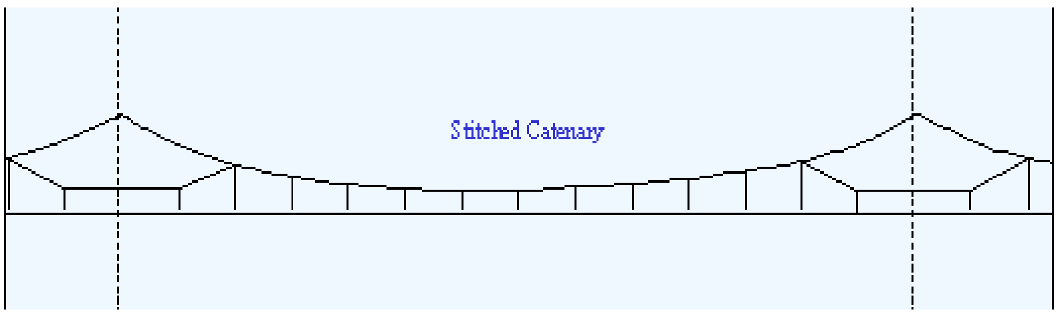


Figure 5 : Stitched catenary system

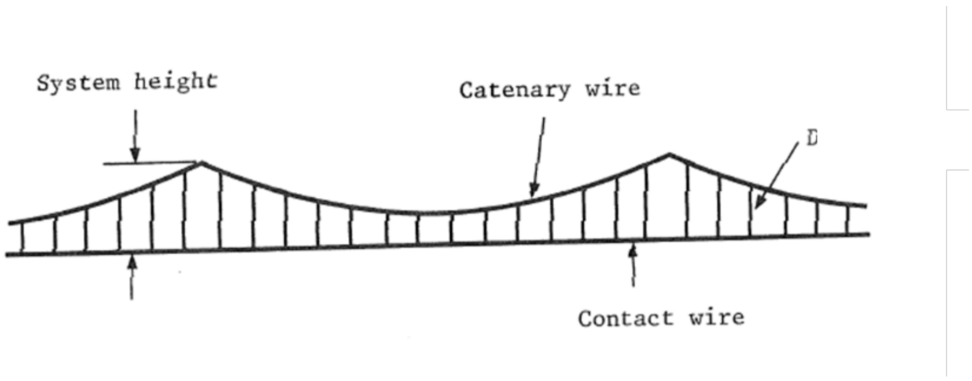


Figure 6 : Simple Catenary

5.5.8 The design of both the overhead contact line system and pantograph shall take into account the required relevant speed. The performance of the overhead contact line and pantograph should consider geometric and static characteristics. Dynamic behavior can be predicted in the design phase by computer simulation and verified on the installed overhead contact line system with measurements. The simulation programs shall be validated in accordance with EN 50318. The measurements shall be undertaken in accordance with EN 50317. For a train with multiple pantographs, the performance of each pantograph both separately and with the pantographs used collectively shall be assessed.

5.5.9 Construction Plan

Table 3 shows the construction plan of the OCS. First, the supports, including pole, beam, hinged cantilever, etc., will be installed. Secondly, feeders, protective wires, and lightning protection cables will be attached to the supports. Thirdly, overhead contact lines will be installed on the track. Finally, other OCS items, such as arresters, and earthing equipment, will be attached. Construction of the OCS will be completed half a year before the beginning of commercial operation.

Table 3 : Construction Plan of OCS

	D	D+1	D=2	D+3	D+4	D+5
Completion of trackworks						
Supports						
Wires, cables						
Overhead contact line						
OCS others						
Test						
Examination						
Operation training						
Beginning operation						

6. STUDIES REQUIRED

The Private Party shall carry out a number of studies/simulations on which his overall design shall be based. Before proceeding to the detailed design phase the Private Party shall have these studies/simulations approved by the Engineer's Representative.

6.1 Traction Power System Study

6.1.1 This study shall consist of a full 2 x 25kV and 115kV study of the HSR traction power supply network and its effects on the MEA/PEA network.

6.1.2 The 2 x 25kV part of the study will show that under all electrical operating conditions (both under normal conditions and under emergency feeding condition (one supply out of service and entire railway traction network fed from remaining supplies, table 4 provides typical simulation scenario's) and with the envisaged train service and type of EMU the following stipulations are met:

(1) The minimum voltage with all the train pantographs meets the voltage requirements stipulated in BS EN50163.

(2) The transformers are correctly rated (both for short term loads and continuously) for the load pattern required.

(3) The switchgear (both 115kV and 25 kV) is correctly rated in respect of the loading that it will be subject to and the short circuit requirements.

(4) The AT's are correctly located and rated (both for short term loads and continuously) for the load pattern required and the short circuit requirements.

(5) The OCS equipment is correctly rated (both for short term loads and continuously) for the load pattern required.

(6) The voltage on any part of the OCS equipment is not allowed to rise above that stipulated in BS EN50163 due to the effects of the AT's or the capacitance effects of the OCS equipment.

Table 4 : List of typical scenarios for traction power simulation study

MODE	SCENARIO'S OF SIMULATION
Normal mode	All substations and traction equipment in service
Downgraded TSS	Outage of whole TSS
Downgraded AT	All AT in one SSP out of service
Downgraded AT	All AT in one SP out of service
Downgraded TSS-Feeder	One feeder (heaviest loaded) in each TSS out of service
Speed at Neutral section	Simulation will be conducted to identify the speed of Train at Neutral Section before switch off of Circuit Breaker of Locomotive, So, there will be low risk of stalling a train at Neutral Zone of Power.

6.1.3 In addition, the 2 x 25kV report shall detail:

(1) The impedance of the OCS system for each line in the form x+iy as seen by the feeding circuit breakers at the supply point. This calculation will take into account the material and cross-sectional area of the various conductors (contact wire, messenger wire, Aerial Earth Wire (AEW), negative feeder wire, rails and any screening cables)

together with their mutual inductance/capacitance due to their proposed spatial geometry.

(2) The instantaneous, 1 minute, 5 minute and 30 minute loadings on the 115/ 2x25kV traction transformer throughout a 24 hour weekday period.

(3) The monthly energy consumption in terms of MWhr, MVAhr and MVArhr. These shall take into consideration all transformer losses on the system.

(4) The overall power factor at the railway sub-station and if the requirement of PSA are not met in regard to minimum power factor, the time of day and if the limits on the power factor is exceeded – the Private Party shall make proposals forward to bring the power factor back within the PSA's limit should it be determined that it is outside the limits.

(5) The maximum instantaneous line currents for each of the tracks.

(6) The levels of harmonics present on the 2x25kV network.

6.1.4 The 115kV part of the study shall be carried out in conjunction with PSA and shall be in three parts as follows:

(1) A voltage unbalance study using the output of the loadings identified in the 25kV study and calculating the unbalance for each of the PSA feeding and outage conditions. The total unbalance as seen at the point of common coupling with PSA shall then be calculated taking into account the unbalance cause by the traction supplies, any unbalance caused by the auxiliary supplies and the existing background level of unbalance on the PSA network.

(2) A harmonic impact study using the level of harmonics (both for total harmonic distortion and individual harmonic) derived from the 25kV study at the 25kV busbars, converting this to the levels then seen on the 115kV network and adding to the existing background levels for each of the PSA loading, feeding and outage conditions.

(3) A voltage flicker study, the report will identify any cases where the results exceed the PSA's requirements and give recommendations as to how the problems can be overcome. Any remedial action required (e.g. the provision of load balancing equipment, harmonic filters or power factor correction equipment) shall form part of this Contract.

6.2 Wind Survey

6.2.1 This study will access the maximum wind conditions using the 50-year maximum wind speed for the Bangkok area suitably factorized for each of the topographical conditions on the railway route to determine wind loadings on structures and maximum OCS span lengths for that area.

6.3 OCS Dynamic Behavioural Study

6.3.1 This study will demonstrate that with the OCS equipment proposed (including arrangements, components, conductor sizes, conductor tensions and maximum span differentials) together with the mechanical properties of the pantographs proposed to be used and their configuration (number of pantographs, all pantograph spacing arrangements and in the case of single arm pantographs both for the knuckle leading and knuckle trailing conditions) that the current collection is within the standards set by BSEN50119 and that the pantograph forces are within the range allowable for the pantograph and that the contact wire uplift is within the free uplift tolerance.

6.4 Earthing and Bonding Study

6.4.1 This study shall calculate (with the proposed earthing and bonding arrangement and maximum short circuit levels) the maximum step and accessible voltages appearing along the length of the electrified railway under both normally operating conditions and fault conditions to ensure that these conform to the requirements of BSEN50122. The earthing arrangement especially in double rail track circuited areas shall be in accordance with the track circuit arrangement and the allowable positions for impedance bonds to connect the traction earthing system to the rails.

6.4.2 It should be noted that a large percentage of the railway to be electrified is on concrete viaduct and the Private Party shall take this into account in the study.

6.5 Induced Voltage Study

6.5.1 This study shall calculate the maximum induced voltage in any copper cable running parallel to the OCS equipment taking account of the short circuit level, the maximum exposure length of the cable and the degree of compensation provided by the AT system.

6.6 LV Distribution Study

6.6.1 This study shall determine all the 400V 3-phase loads on the railway network and their load centers and the degree of balancing over the 3-phases that can be obtained at each location. It shall also determine:

(1) The number and rating required of all outgoing ways required for each LV switchboard at each station or depot.

(2) The rating required of the UPS equipment to give 8-hour standby in the event of total loss of 22kV supplies to a location.

(3) The required rating of the 22/0.4kV transformers.

(4) The required rating of the standby diesel generator sets.

6.6.2 It should be noted however that part of the railway is in an open trench and therefore drainage pumps will be fed from the 22 kV supply. The Private Party shall be given the required ratings and locations of these pumping locations prior to undertaking this study.

6.7 22 kV Distribution Study

6.7.1 This study shall determine the 22 kV 3-phase distribution networks required to provide the necessary power to feed the depots and any wayside equipment to meet the RAMS requirement detail in Clause 7 below. It shall also determine:

(1) The number and locations of all necessary 22/0.4kV sub-stations

(2) Number of ring mains required

(3) 22kV cable sizes

(4) Electrical protection arrangements

(5) Rating of the 115/22kV transformers at substation supply point

(6) Ratings of 22 kV/400 V 3 Phase transformers for all Stations and depots

(7) Overall degree of balancing on the 22 kV network that can be achieved

(8) Any harmonic problems.

(9) UPS requirements for all Stations and Depots

(10) Size of Stand-by generators for all Stations and Depots

(11) SCADA Interfaces with the civil building services and HV/LV monitoring and controls.

7 RAMS REQUIREMENTS

7.1 General

7.1.1 The Reliability, Availability, Maintainability and Safety (RAMS) processes and procedures shall be planned, integrated and developed in conjunction with the operating objectives, and the engineering, development and production functions to permit the most effective and economical achievements of the systems and equipment engineering objective.

7.1.2 The systems shall meet or exceed the requirements for safety and reliability performances achieved by recognized Transit Authorities and International Standards. The reliability of the systems engineered, supplied and installed is the principal element for availability. It is essential that the system reliability is as high as reasonably practicable.

7.1.3 A high engineering standard incorporating redundancy, if practicable, flexible system arrangement, together with good quality products, and adherence to strict construction standards, are required to ensure high reliability of systems installed for smooth, safe and reliable operation of train services.

7.2 Reliability

7.2.1 The reliability requirements of this Specification shall support the availability and maintainability requirements of this Specification.

7.2.2 Sub-systems and equipment proposed by the Private Party shall have been in use and have established their performance reliability on at least two mass rapid transit systems or sub-urban railway system in revenue service over a period of at least two years.

7.3 Availability

7.3.1 The Electric Power System shall be engineered for a minimum operational life of 30 years based on the equipment being in continuous use and achieving a minimum service availability of 99.99%.

7.3.2 Quantitative targets have been set in this Specification. These objectives are set to ensure the availability of the systems, on the rail link, remains within specified limits.

7.3.3 Loss of any single MEA/PEA supply shall be transparent to the safety systems and operational critical systems of the rail link transit system.

7.3.4 Failure at the TSS of any single item of equipment shall not cause a loss of system availability and shall be transparent to the operating transit system.

7.3.5 As far as reasonably practicable, failures of the overhead line, or support equipment shall not cause loss of traction supply to more than one line, nor to sections of route that do not pass over the section of line where the fault occurred. Provision shall be made, through section isolators and other means, to allow reconfiguration of the traction power supply to feed the overhead line in areas not directly affected by the fault.

7.3.6 Means shall be adopted, in the engineering and installation of the system, to prevent equipment and component failures or overhead line structural collapse, as far as reasonably practicable. Mechanical joints of conductors, which may be susceptible to failure, shall, where practicable, not be located in close proximity to passenger platforms.

7.3.7 Overhead line equipment over each track on mainlines shall be supported independently, the engineering of supports for depot and secondary lines shall be of sufficient robustness so that an impact by a train pantograph shall not cause a failure affecting other running lines.

7.3.8 OCS tensioning devices shall be installed with sufficient lubrication to prevent mechanical failure.

7.4 Maintainability

7.4.1 The Private Party shall undertake maintainability analysis to assess the preliminary maintainability targets of the systems.

7.4.2 The Private Party shall state the maintainability requirements, and demonstrate that system maintainability is sufficient to support the claimed system reliability and availability performance. The Private Party shall demonstrate that maintenance errors have been considered, and, as far as is practicable, the appropriate engineering has mitigated the risk of maintenance-induced faults.

7.5 Safety

7.5.1 The design, construction and subsequent operation of the overall electrical system (both for traction and auxiliary supplies) shall be based on minimizing the risk of danger either to the equipment itself or to any individual (Private Party's staff, railway staff or member of the general public). The Private Party shall compile statistics of all accidents or near misses during construction and should an accident or near miss occur procedures shall be developed and implemented to prevent a re-occurrence.

7.5.2 Method statements for the construction shall be developed by the Private Party and all Private Party's staff working on the project shall be properly trained in their duties.

7.5.3 Safety Legislation and Regulations of Thailand require operator safety rules to be provided for the safe operation and maintenance of equipment comprising the traction system and auxiliary systems and these shall be developed by the Private Party and submitted to the Engineer’s Representative for approval.

7.5.4 The engineering shall incorporate measures to avoid presenting safety hazards to people.

7.5.5 At all locations where members of the public or maintenance staff may intentionally or inadvertently come within close (less than 3m) proximity of the 2x25 kV traction equipment this equipment shall be suitably screened to prevent any hazards arising.

7.5.6 Suitable warning notices shall be required throughout the electrified area to warn staff and the general public of the dangers associated with the electrified system.

7.5.7 The design and locations for erection of these warning notices and the information contained on them will be subject to discussion between the Private Party, the State Railway Authority and the Government Regulatory Authority.

7.5.8 The systems engineering shall incorporate measures to provide for its safe management, maintenance and operation.

7.5.9 The systems shall not give rise, or be subject to, dangerous interactions within the railway or with other external party systems.

7.5.10 The engineering of the systems shall consider the safety and reliability of interface to the adjoining SRT lines. The installation shall meet the fire safety requirements of NFPA 130 guidelines.

7.5.11 The engineering of the earthing system shall conform to EN50122-1 and the Engineering Institute of Thailand 2001-45 standard and these Specifications.

7.6 Risk Assessment

7.6.1 The Private Party shall show that the systems can be operated and maintained safely. The Private Party shall prepare a risk assessment report identifying the risk to people and property. The Assessment may be based on a comparison of system features and operating practices with other metro transit systems for which risk levels are known.

7.6.2 The Private Party shall demonstrate that risk to passengers, members of public, including trespassers is as low as reasonably practicable. Residual risks shall be recorded in the hazard log and operator rules and procedures developed to mitigate them. These shall be proposed by the Private Party, for review and approval by the Engineer’s Representative.

7.7 Proximity of 3rd Rail DC Railway Systems

7.7.1 It should be noted that there are DC railways in the vicinity of Phaya Thai station on the Bang Sue to Hua Mak line. The Private Party shall take cognizance of this DC railway especially in regard to DC stray currents emanating from it and take any suitable steps to reduce to a minimum any corrosion effects arising from the DC stay currents on the equipment being provided under this Contract.

8. ENGINEERING DESIGN CONDITIONS

8.1 General

8.1.1 The Private Party shall develop the engineering based on this Specification and on proven and reliable engineering. The engineering details shall be submitted with technical data and calculations to the Engineer’s Representative for review and approval.

8.1.2 The Private Party shall propose the maximum short circuit level on the 2x25kV OCS system taking into account the effect this proposed short circuit level will have on signaling equipment, telecommunication equipment, voltage profile along the railway, the OCS and power supply equipment and earthing and bonding requirements.

8.1.3 The Private Party shall propose the AT spacing taking into account this spacing shall have both on the traction voltage profile along the line and the amount of un-compensation of the electro-magnetic fields produced by the OCS equipment. extent of un-compensation of electro-magnetic fields will take into account not only effects that these electro-magnetic fields have on the railway signaling and telecommunications equipment but also on public or private telecommunication company's equipment that run parallel and in close proximity to the railway line. In proposing these AT spacings the Private Party shall also take into account AT outage conditions (either for maintenance or through AT fault conditions).

8.1.4 For the purpose of this Specification an AT spacing of approximately 13km (approx.) has been assumed.

8.1.5 The Private Party shall propose the short circuit levels on the 22 kV auxiliary supply network, and the number of ring mains required to meet the RAMS requirements.

8.2 PSA Quality of Supply and PSA Connection Requirements

8.2.1 Quality of Supply

The quality of the PSA 115kV power supplies that may be expected is indicated in the following table below. The Private Party shall take these into account in his design.

PSA 115kV Power Supplies Quality

Item	Value	Note
Frequency	50±0.5Hz (normal operation)	Data from EGAT
Voltage Supply	230kV	Nominal voltage +5%
	115kV	106.4 – 117.6kV (nominal) 96.0 – 123.0kV (emergency)
Voltage Flicker	Pst less than 0.8	Refer to planning level in IEC 61000-3-7
	Pit less than 0.6	
Harmonics Voltage	THDv less than 3.0%	Refer to planning level in Engineering Recommendation G5/4 table 4 and 5 which also include individual harmonic.

Note: The specified values of harmonics, flicker and unbalance are planning level. MEA/PEA try to control these disturbances in power system which generated from the operation of customer load to be within the planning level. But due to the diversification of customer load and some uncontrolled circumstance, the levels of these disturbances maybe exceed the specified values above in some duration or some area. So customers should design their equipment to operate in environment that disturbances can be up to compatibility level which generally higher than planning level. Compatibility levels for harmonics, flicker and unbalance are shown in above reference standards.

MEA/PEA Connection Requirements

Before MEA/PEA will agree to the connection of their network with the railway a number of requirements have to be met. The Private Party ·shall ensure that the load to be connected complies with MEA/PEA's regulations indicated the following table:

MEA/PEA Connection Regulations

Item	Value	Note
Load size	230kV	Not available
	115kV	Larger than 15MVA
Maximum step voltage change		
	Max. step voltage change at PCC due to customer load variation must less than 3.0% of nominal voltage	
Power Factor	Between 0.9 – 1.0 lagging	The PF shall not be permitted to lead.
Voltage Flicker	Limit Pst and Pit created by customer at PCC. The limits depend on load size and system capacity.	Refer to assessment method from IEC 61000-3-7
Harmonics Current	Limit Individual harmonic current up to order 50^{th}. The limits depend on lad size, system capacity and fault level at PCC.	Refer to planning level in Engineering Recommendation G5/4 and assessment method from IEC 61000-3-6
Unbalance Current	Limit negative sequence current. The limit depends on load size, system capacity and fault level at PCC.	Refer to assessment method from IEC 61000-3-13 (CD)
EMC	See references	Refer to EN 5022-1, 500612 and IE 61000

8.3 Traction Power Supply Equipment

8.3.1 The engineering, supply, installation and commissioning of the traction supply system shall meet all International Standards, the engineering criteria and performance requirements of this Specification. The Private Party shall consider the reliability of the MEA/PEA and the power supplies and engineer the Electric Power System to satisfy the required operational reliability specified in these Contract Specifications.

8.3.2 Based on the traction power system requirements as determined by the power system study, the short circuit levels, the load flow studies on the system and fault analysis, the power supply system shall be engineered and sized for the safe rating for all equipment, cables, conductors, earth bus and conductors, joints, jumpers, as well as ancillary equipment and instrument transformers.

8.3.3 The traction transformer shall be rated for the following load capacity:

- 100% of capacity continuously
- 300% for 2 minutes (rated current)

8.3.4 The VT and CT ratios, numbers and types shall be suitable for their application, e.g. protection, metering or indication.

8.3.5 The details of calculations and equipment specifications shall be submitted by the Private Party for review and approval by the Engineer's Representative.

8.3.6 The electrical protection system to be proposed and all protection relay calculations and proposed relay settings shall be submitted to the Engineer's Representative for review and agreement. It should be noted that the electric trains that will run on the routes may have a re-generation capability when braking and the protection system proposed must take this into account. A fault on the traction system shall still be cleared by the track circuit feeder circuit breakers at Bang Sue bulk supply point even if there is a train or trains in re-generative mode on the system.

8.4 AT Locations

8.4.1 The locations and spacing between AT locations shall be calculated and designed by the Private Party. These shall be on the basis of maintaining the necessary voltage to the train pantographs and at the same time meeting the required level of suppression against EMI effects in adjacent signaling and telecommunication cables (both those belong to the railway and those belong to outside parties). This spacing shall take account of an AT being out of service either through fault conditions or for maintenance. The Private Party shall be responsible for preparing the ground and procuring all materials and constructing these AT installations.

8.4.2 Based on the traction power system requirements as determined by the power system study, the short circuit levels, the load flow studies on the system and fault analysis, the AT locations shall be engineered and sized for the safe rating for all transformers, equipment, cables, conductors, earth bus and conductors, joints, jumpers, as well as ancillary equipment and instrument transformers.

8.5 OCS Equipment

8.5.1 The design line speed will be 176 km/hr for the section Don Mueang to Suvarnabhumi and 275 km/hr for the section Suvarnabhumi to U-Tapao. The maximum operational speed within the depot area will be 25 km/hr.

8.5.2 The OCS equipment on all main and loop lines shall however be designed for and operational speed of 250 km/hr with a 10% over speed capability. The OCS equipment within the EMU and rolling stock depot shall be designed for a maximum operational speed of 50km/hr.

8.5.3 The OCS equipment will be simple equipment consisting of contact wire and messenger wire together with the necessary droppers which shall be of the current carrying design. Stitch wires will not be permitted.

8.5.4 Cantilever tubes supporting the contact and messenger wire shall be of aluminum or aluminum alloy for ease of maintenance. Suitable bimetallic liners or other approved bimetallic joints shall be provided at all copper or copper alloy connections to aluminum or aluminum alloy to prevent bimetallic corrosion.

8.5.5 The OCS support masts/portals shall be of steel construction (preferably of "H" beam construction for ease of maintenance and subsequent painting). Drop tubes where required shall either again be of "H" beam construction or box shaped.

8.5.6 On viaducts and at transition areas, single track cantilever masts and the base of the legs of portal structures shall be of the bolted base design. The Private Party shall design and install suitable OCS base plinths on the viaduct box sections and at locations to be determined by the Engineer’s Representative.

8.5.7 Where OCS support structures are "At grade" the Private Party shall provide his own foundations and these shall again be of the bolted base design or direct planted. The design of the foundations shall normally be of the side bearing type although dependent on ground conditions gravity pads or piled foundations may be required. The top of all OCS base foundations shall be level with the "Top-of-Rail".

8.6 Earthing and Bonding

8.6.1 Earthing General

(1) An earthing system shall be engineered to ensure personnel safety and protection of installations against damage. It shall also serve as a common voltage reference and to contribute to the mitigation of disturbances.

(2) To achieve the primary goal of assuring personnel safety, a low impedance path shall be made available to the large current generated due to lightning or power system fault. The potential differences (touch and step voltages) between any two points shall be as low as possible. Safety considerations also require any chassis or enclosure to be earthed to minimize shock hazards to people.

(3) To achieve the secondary goal of providing protection for sensitive and interconnected electronic and electrical systems, earthing shall be engineered to minimize the noise voltages generated by currents from two or more circuits flowing through common earth impedance and to avoid creating earth loops susceptible to magnetic fields and differences in earth potential. In this respect, the earthing system shall be designed on the radial principle rather than as a mesh network and no earthing conductor carrying

traction operating or fault current or lightning conductor shall run through any room containing electronic equipment or be routed adjacent to copper cables carrying signals or power to electronic equipment.

(4) Earthing shall also be engineered to accomplish the following minimum requirements:

(a) Protect personnel and equipment from electrical hazards, including lightning, where practical.

(b) Reduce potential to system neutrals.

(c) Provide a clean zero-volt reference point for signals in electronic equipment.

(d) Reduce or eliminate the effects of electrostatic interference and electromagnetic interference arising from within the rail link area.

8.6.2 Earthing Specific

(1) An earthing and bonding scheme shall be proposed to meet the requirements of BSEN50122-1 and the Engineering Institute of Thailand EIT2001-45 Standard and in accordance to these Specifications.

(2) A safe return of the traction current and earthing of all metallic parts, e.g. OCS masts, un-energized metal supports of the OCS system, etc. is required. An AEW shall therefore be provided running the length of the railway and connected to all OCS masts and un-energized metalwork.

(3) The tasks of the traction system earthing am as follows:

(a) Control of potentials with regard to avoiding undue contact potentials under operation and under short circuit conditions.

(b) Limitation of inductive interference to parallel signaling and communications systems.

(c) Protection against undue high potentials in case of a failure of a contact wire/feeder wire by secure triggering of protection devices.

(4) System protective earthing (grounding) is required to provide electrical safety at stations, sub-stations, line-side buildings, Bang Sue depot and viaduct track sections. The Private Party shall engineer the earthing system on the basis of safety for people against hazardous touch and step potential and fire hazards. The earthing system shall conform to EN50122-1 or equivalent standard and in accordance to these Contract Specifications. The earthing arrangement (earth mat, perimeter earthing, etc.) and compound surface at Bang Sue bulk supply point shall be designed for the

3-phase short circuit level on the 115kV MEA network as advised by MEA and shall be in accordance with IEEE80 and Engineering Institute of Thailand 2001-45.

(5) Buildings shall include lightning protection systems in accordance with the Building Regulations of Thailand and in accordance to these Specifications. Lightning conductors shall be connected to the structure common earth mat.

(6) A high AEW or wires connected to the sub-station earth mat to give a low impedance path shall be provide for lightning protection. The cone or cones of protection of these AEW(s) will cover all the electrical equipment within the sub-station (circuit breakers, isolators, VT's and CT's, transformers, etc.) however the building (or buildings) may have its own lightning protection again connected to the sub-station earth mat.

(7) At stations and line-side structures, copper earth mats and connecting conductors shall be used. Down conductors fixed to viaduct columns, connecting the structure earth mat/spike to the viaduct bus bar may be provided as aluminum conductors (approximately 240mm2).

(8) The conductivity of earth systems and deep earth shall meet the criteria of the following table:

Earth System Conductance

Location	Earthing System Conductivity to deep earth
Traction Sub-Station	2.0 Siemens (Mhos)
Stations, depot and buildings	2.0 Siemens (Mhos)
Structure Earthing (Viaduct and tunnel)	0.2 Siemens (Mhos)

(9) Structure earthing system for structures and viaduct sections of the track.

(10) The equipotential bonding of the metallic reinforcing in station and line-side buildings shall be connected to the associated building earth system. Viaducts shall be sectionalized at, approximately two structure lengths. The bonding of metallic reinforcing in viaduct structures, slab-track bed, OCS masts, handrails, and the like, shall be connected to a common structure earth at least every 100m.

8.6.3 Bonding

(1) Bonding all exposed metallic parts of all equipment and connecting them to the earthing network is a way for meeting safety requirements and to minimize noise voltages due to potential differences.

(2) Direct bonding shall be used wherever practical. Where indirect bonding via bonding strap is used to connect two isolated items, the bond shall satisfy the following minimum requirements and prevailing international. standards, for example, IEC61000-5-2.

(a) Low bonding resistance, from 50Hz to at least 2GHz

(b) Low bonding inductance, from 50HZ to at least 2GHz

(c) Bonding procedures and materials, including appropriate surface treatment before and after the bonding process, shall be proposed to the Engineer's Representative for review and approval.

8.7 Auxiliary Supply Equipment

8.7.1 The auxiliary power system is to be designed to provide continuous, reliable power to all stations, the rolling stock depot, the OCC, the substations and other wayside facilities. The design principle to be applied throughout is based on averting a system failure as a result of a single equipment failure.

8.7.2 The auxiliary power sub-system shall be sized in accordance with the Private Party's calculations on the total power load requirement for the railway for the year 2050.

8.7.3 The auxiliary power requirements of this part of the overall specification is to make available a low voltage supply (400V 3-phase) for the overall requirements of the various users at the stations, depot, OCC, etc. These users will include the power requirements for the station (lifts, escalators, lighting, air conditioning, etc.), the necessary power required for the depot complex, the requirements of the signaling and telecommunications works and any power requirements needed by the Private Party who will be undertaking this part of the overall specification. The Private Party shall therefore liaise with all these parties to ascertain their load requirements and the number and rating of the outgoing ways required in the LV switchboards to be provided at the various locations.

8.7.4 Some of the loads taken by the signaling, telecommunications and to some extent this part of the overall contract are considered as essential loads for the operation of the railway even during HV/LV switching or outage conditions and therefore the Private Party shall provide UPS equipment to power these essential loads even on a total loss of the LV supply. The Private Party shall again liaise with the relevant parties involved to ascertain the loadings involved and the number and rating of the outgoing ways required from this

UPS. The UPS shall therefore be sized to supply this load for a minimum 8 hours on the total loss of the LV supply.

8.7.5 It should be noted that the Private Party has also to supply a diesel generator to provide back up for total loss of supply. Suitable diesel start up signals and facilities shall therefore be provided in the LV switchboard. It shall be possible to start up the diesel generator for periodic testing purposes whilst the LV switchboard is energized from the 22kV supply and therefore the necessary interlocks to allow this shall be provided.

8.7.6 The Private Party shall determine the requirement or otherwise the need for the inclusion of fire suppression systems for the HV, transformer and LV switch rooms in the stations, depot, etc. in accordance with Thai law and local practice.

9. FUNCTIONAL REQUIREMENTS

9.1 General

9.1.1 The traction power supply 2x25 kV OCS system and the 22 kV auxiliary power supply systems providing 400 V 3-phase and 220 V single-phase for essential and non-essential auxiliaries supplies for stations, depot and OCC shall be supervised from the OCC by a SCADA system. The normal mode of operation shall be automatic mode.

9.1.2 The Private Party shall prepare engineering submittals, which provide a clear description of the functional requirements of each of the system, sub-system and equipment proposed shall indicate acceptable levels of performance, for system/sub-system equipment within the stipulated environment.

9.1.3 The Private Party shall provide a detailed interlocking and protection scheme to prevent inadvertent operation of switchgear resulting in electrical accident by spurious re-energization of the supply. The operating arrangement incorporating the system interlocking requirements shall be proposed by the Private Party for review and approval by the Engineer's Representative.

9.1.4 The traction and auxiliary transformers shall be of the high efficiency and low loss type. The Private Party shall provide calculations to demonstrate that the life cycle cost for transformer energy losses is optimized.

9.1.5 To the extent possible all components shall be modular in construction to facilitate easy troubleshooting and replacement of components to minimize down time of the system.

9.1.6 All the power supply, OCS and auxiliary supply equipment and components adopted in the project shall have proven satisfactory commercial service in a railway environment with similar conditions to those prevailing in Bangkok.

9.2 Traction Power Supply Equipment

9.2.1 All power supply and OCS equipment shall be adequately protected by fast acting protection relays. The failure of one relay or a circuit breaker shall not prevent the clearance of fault conditions so in addition to reliable relays and circuit breakers back up protection shall also be supplied by the tripping of the next circuit breaker upstream from the one circuit breaker or protection relay that has failed. All protection calculations and protection co-ordination curves showing clearance time against level of fault current shall be provided by the Private Party for review and approval by the Engineer's Representative.

9.2.2 Auto re-closure of a tripped 25 or 2x25kV circuit breaker shall take place (assuming no conditions exist that would prevent a re-closure) however if the fault still exists the circuit breaker will remain open but not locked out. Subsequent re-closures shall then be available to the electrical operator at the OCC once he has established where the fault is and taken steps to disconnect the faulty equipment (e.g. arranging to have the pantographs on any faulty train lowered or by the operation of OCS isolators to isolate faulty sections of OCS equipment).

9.2.3 Auto re-closure of 115kV circuit breakers shall not be allowed.

9.2.4 All operations of circuit breakers whether automatic or by control by the OCC shall be reported to the OCC via the SCADA equipment.

9.2.6 Requirement for installation

The traction power capacity of SS must:

- bear maximum power per hour and peak maximum power.
- provide traction power by an extended feeding system from the next SS over the failed one, in the case of a power outage.
- assure reliable operation for the presumed traffic demands in a future train operation plan.

The distance between SSs shall be such that:

Any fault current occurring in a feeding circuit can be detected and then cut off.

Any voltage drop must not impede the normal operation of electric motor cars and must not overheat the motors.

Any instantaneous maximum voltage drop should not adversely affect the operation of any electric motor car and auxiliary apparatus.

9.2.7 Maintainability

Knock out panels, floor drains, access hatches, and other items shall be made available.

Sufficiently clear space shall be allocated to areas around the equipment to facilitate removal, replacement, and servicing. Provisions shall be made for shaft, tube and filter pull space, access door swings, and removal of miscellaneous components.

Duct access doors shall be installed where necessary.

9.2.8 Voltage Level

Voltages of loads shall be 25 kV single phase AC for the train traction.

1) Location and Space

Criteria for selecting SS locations:

- Keeping minimum feeding voltage which is required for train operations, within the distance between SSs.
- With easy accessibility to receive power from PSA transmission lines that have enough capacities.
- Easy to relocate SS equipment from other sites and easy to move SS equipment within the site.
- Have adequate space for expanding SS equipment in the future.
- The equipment of SSs shall be installed mainly on the ground, and local equipment of SCADA and distribution boards are in power rooms.
- The area of SSs shall have sufficient space including future unit enhancement and placement properly.
- Power rooms shall have sufficient space to house electrical equipment, including future unit enhancement, and to ventilate the equipment properly. Adequate space shall be provided for working clearances and service aisles, where required, and for the removal or replacement of the equipment.
- The system shall be designed with spare space capacity for possible future maintenance and/or expansion. All main switchboards shall be user-friendly, modular and aesthetically designed, as well as termite- and vermin-proof. All mechanical fittings (including portable fire extinguishers), cable trays, trunking, wire ways, and brackets shall have spare capacity for future maintenance and/or expansion.

2) Basic Design Philosophy

The design philosophy should meet the following criteria:

(a) Application of state-of-the-art Technology

(b) Service proven design

(c) Design life 30 years

(d) Minimum life cycle cost

(e) Lower maintenance cost

(f) Use of interchangeable, modular components

(g) Extensive and prominent labelling of parts, cables and wires

(h) Use of unique serial numbers for traceability of components

(i) High reliability

(j) Low energy loss

(k) System safety

(l) Adequate redundancy in system

(m) Environment friendly

(n) Adherence to operational performance requirements

(o) Maximum utilisation of indigenous materials and skills, subject to quality conformity.

3) Power Receiving System

The HSR SS will receive power via two receiving lines. The main bus is installed on the primary side of two feeding transformer sets and two distribution transformer sets.

The system will have the following characteristics:

- Two HV receiving lines, making it highly reliable with redundancy.
- The receiving lines and feeding transformer set can be operated independently. Therefore, the personnel of power authority can perform operation, maintenance, upgrading, and expansion of HSR facilities without any assistance from power authority.

The example of power receiving diagram is shown in **Figure 7** and typical feeding diagram is shown in **Figure 8.** The number of SS for main line is two and another SS for depot.

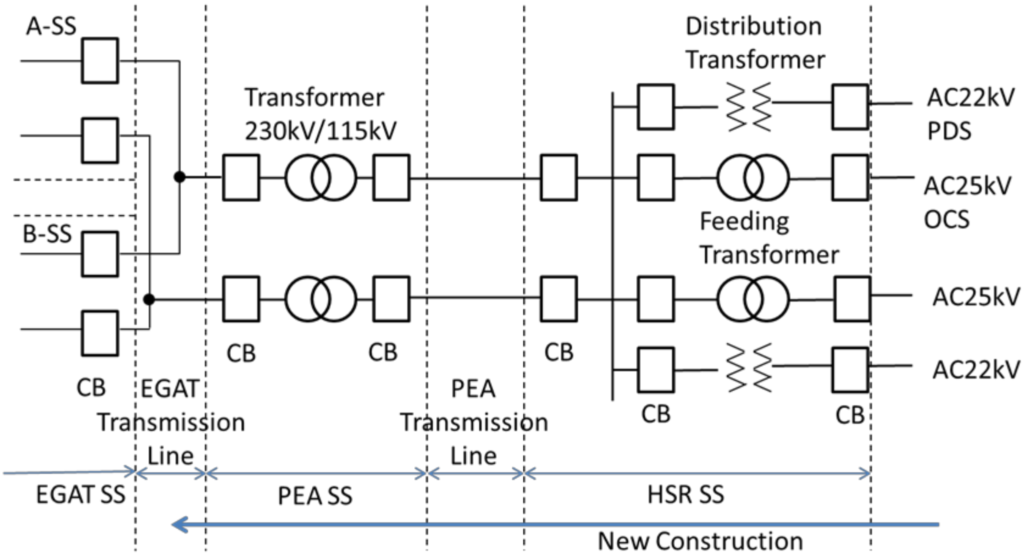


Figure 7 : Example of power receiving diagram

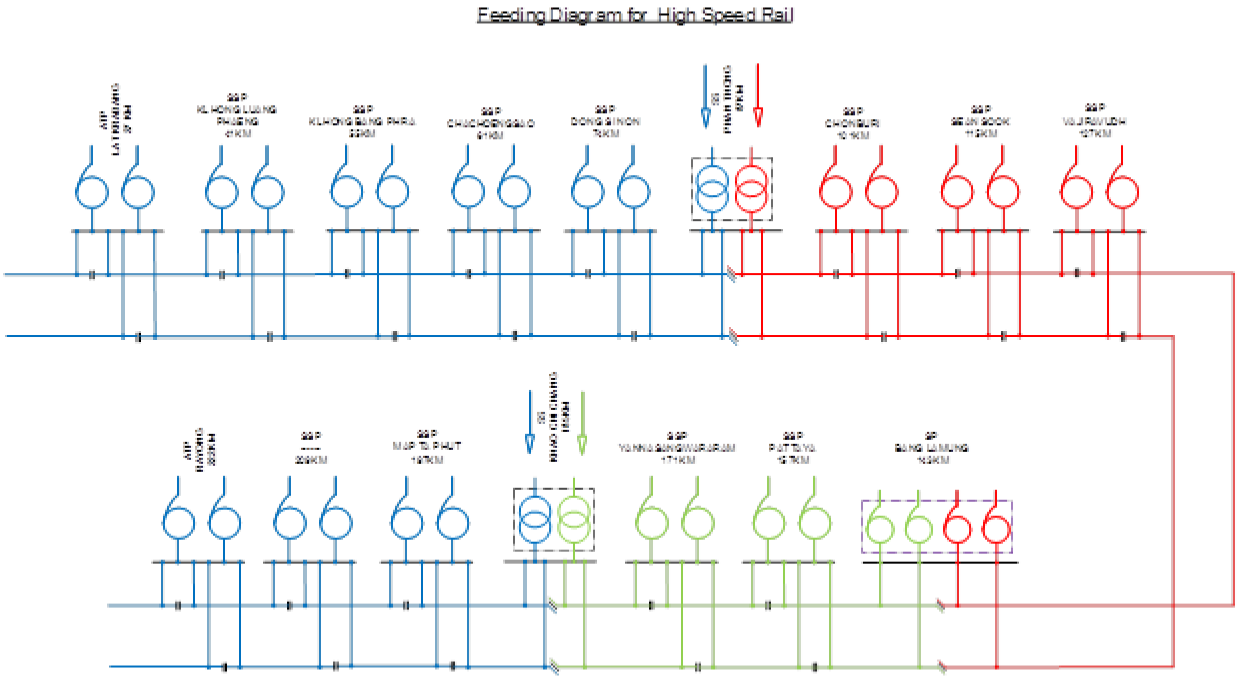


Figure 8 : Typical feeding system for mainline except depot

9.2.9 SS Type

1) Indoor and Outdoor Type

The SS can be classified into indoor and outdoor types. As most important thing is the construction cost of SS so that the outdoor type SS is recommended for the construction of HSR.

2) Sectioning Post (SP)

There is a border of power supply in the middle of two substations to separate the power supply. So neutral section is installed and called sectioning post. One substation can supply beyond the section in case of another substation fail, therefore the SP is equipped with disconnecting switch. And AT is equipped inside the SP usually.

3) Sub Sectioning Post (SSP)

In the feeding area between SS and SP, some separation is required to reduce the power failure area in case of accident. For this purpose, disconnection switch is installed and called SSP. And AT is equipped inside the SP usually.

4) AT Post (ATP)

The location of AT besides SS, SP, SSP, some places for installation of AT is required.it is called AT post.

5) Area for SSs Plant

Table 5, Figure 9 – Figure 14 show the examination results of the SSs plant.

Table 5 : Comparison of SS Plant Area

Item	Area of facilities	Notes
SS for Main line	About 15,000 m²	2x25kV system Receiving voltage 230 kV
SS for Depot	About 8,000 m²	1x25kV system
SP	About 6,000 m²	
SSP	About 2,000m²	
ATP	About 2,000m²	Nearly the same as the SSP

Figure 9 : Example of Outdoor SS

Figure 10 : Example of Auto-transformer

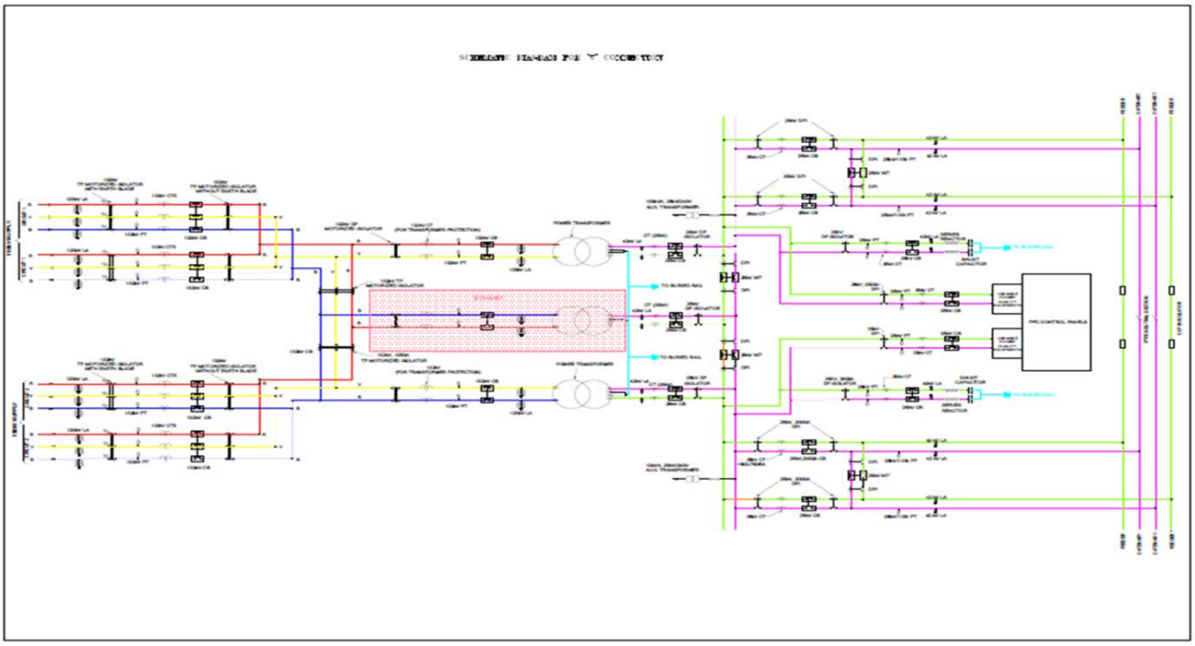


Figure 11 : Outdoor Type Substation

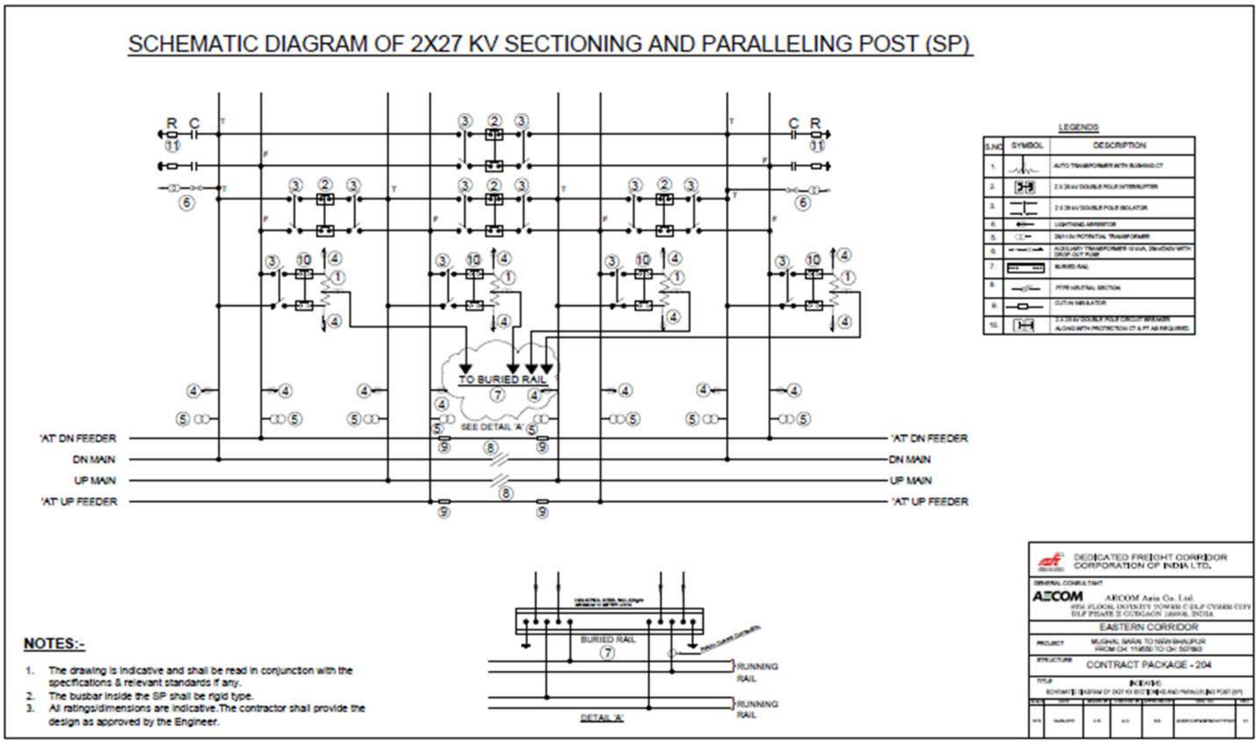


Figure 12 : Outdoor Type Sectioning post (SP)

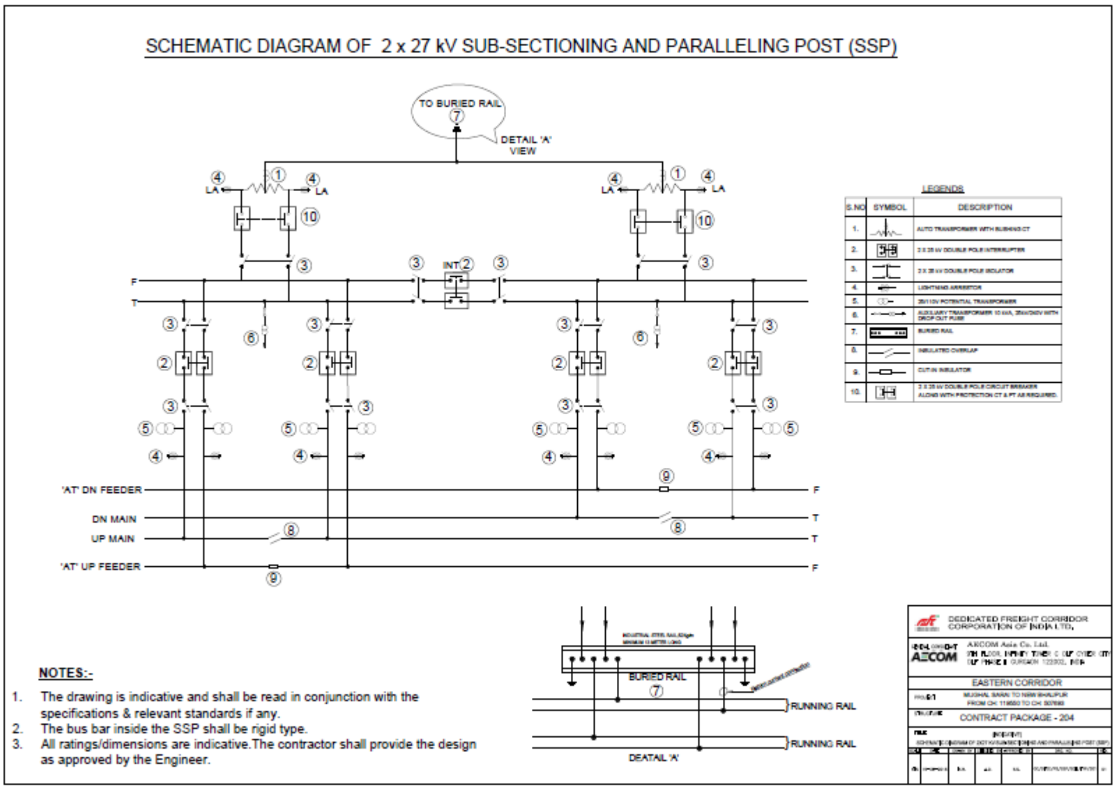


Figure 13 : Outdoor Type Sub-Sectioning post (SSP)

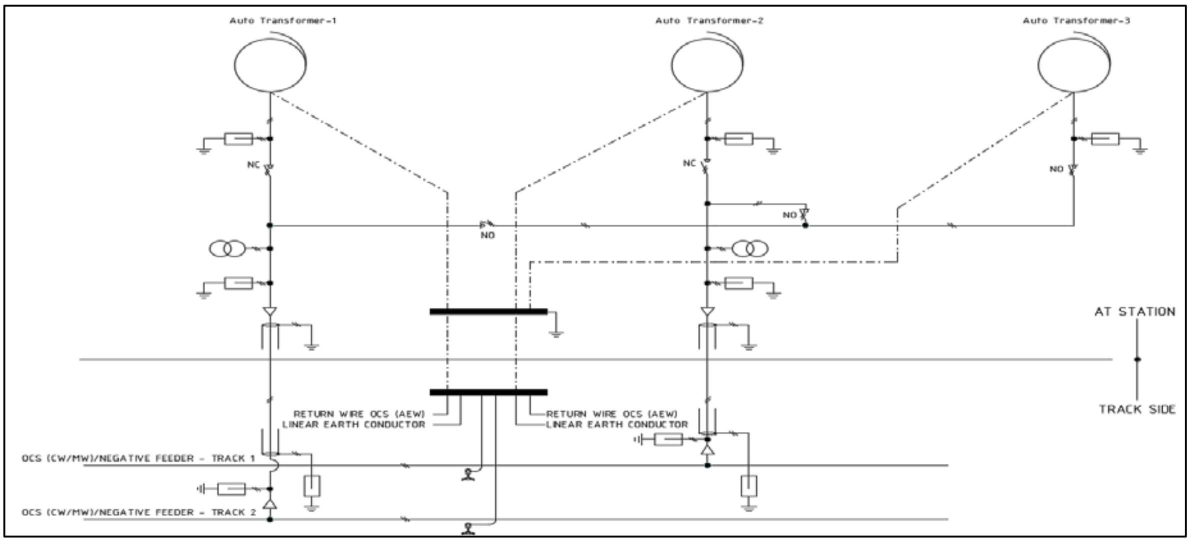


Figure 14 : Outdoor Type AT-post

(1) It is proposed that the traction transformers will be single-phase with a single primary winding connected across two phases of the PSA 230 kV supply and a secondary winding with the. secondary winding centre tapped (taken out of the transformer tank via a 25kV bushing) and connected to earth to give a 2x25kV supply with each phase being 180 degree apart. If however this arrangement does not meet the unbalance criteria required by PSA, other transformer arrangements (e.g. Scott connected transformers with if necessary separate AT) or the supply of full balancing equipment using SVC's may be considered.

(2) Normally under healthy conditions traction supply will supply the designated sections. On the loss of one PSA 230 kV supply or the loss of a 2x25 kV transformer (either through maintenance outage or through fault conditions) the remaining healthy supply will take over the total load. It is estimated that each traction supply requires to be rated at 120MVA (allowing for all the electrification equipment fed from one transformer but this figure shall be confirmed by the Private Party as part of the power system study that he is required to undertake. Dependent on the output of the power system study on the actual loads that will exist on the present proposed railway it may be that this 120MVA will have to be increased or decreased. A decision on this shall be taken at the end of the power system study.

9.3 AT Locations

9.3.1 Each AT shall be fed through a load making/load breaking switch or isolator enabling the AT to be switched in or out of service whilst the OCS equipment is still energized.

9.3.2 The operational requirements associated with the AT's shall be as follows:

(1) The tripping of a single-track feeder circuit breaker at the bulk supply point without an AT fault.

(2) When the track circuit breaker associated with one track trips on protection the A T's will preferably remain connected to the OCS equipment. If, however, this causes problems to the protection system due to the amount of inrush current caused by both the AT's and any trains in the section still with their pantographs up and their circuit breakers closed, before the circuit breaker at the bulk supply point is auto re-closed the AT's will be disconnected from the OCS equipment under a no volt situation. The circuit breaker will only then auto re-close on confirmation that all AT's have been disconnected. Once the OCS equipment has been proven fault free the AT's (one at a time) will automatically be reconnected to the OCS equipment. All sequences of events shall be adequately timed between operations and shall be transparent to the OCC.

(3) The tripping of a single-track feeder circuit breaker due to an AT fault.

(4) If a fault occurs on an AT the fault will be cleared by the operation of the track feeder circuit breaker at the bulk supply point. All AT's associated with that track shall be disconnected from the OCS equipment and after this has been proved the track feeder circuit breaker at the bulk supply point shall auto re-close. This shall be followed by the sequential reconnection of all other healthy AT's associated with that track with the failed AT remaining locked out of service. All sequences of events shall be adequately timed between operations and shall be transparent to the OCC.

9.4 OCS Equipment

9.4.1 The OCS equipment shall be engineered to provide safe, efficient and continuous operation all in accordance with the engineering criteria specified in the Contract. Consideration shall be given to the following aspects of the OCS equipment:

(1) The engineering shall be based on simplicity of installation.

(2) The engineering shall require the minimum of maintenance.

(3) The engineering shall feature high reliability factors coupled with economic prudence.

(4) The engineering shall be suitable for local environmental conditions, including high ambient temperature, high relative humidity, heavy pollution, high salinity, wind and heavy rain.

(5) The engineering shall incorporate the use of best construction materials to relevant international standards and quality control guidelines.

(6) The engineering shall utilize local materials wherever possible.

9.4.2 The OCS equipment shall be suitably rated for its duties as determined in the results of the power system study. In any event the continuous current carrying rating of each track shall not be less than 600A for mainline equipment and 300A for tram wire equipment in the depot area. These ratings shall apply with the contact wire in the fully worn condition.

9.4.3 The OCS equipment including all conductors, droppers, fittings, etc. shall also be rated for the full short circuit capability of the system as proposed by the Private Party.

9.4.4 The OCS equipment shall be adequately sectioned by the use of 25kV or 2x25kV OCS isolators as appropriate across insulated overlaps or section insulators to enable sections of OCS to be isolated (either under fault conditions or for maintenance purposes). In the case of 2x25kV equipment these isolators will not only switch the contact and messenger wires but also the negative feeder wire, i.e. it is not permitted to leave the associated negative feeder wire associated with the section of OCS being isolated energized.

9.4.5 To maintain supplies to the OCS equipment on sections of track which are not affected when sections of OCS are isolated alternative feed isolators (25kV or 2x25kV as appropriate shall also be required.

9.4.6 A number of motorized isolators monitored and controlled from the OCC should be allowed for within the Private Party's submission to quickly isolate (and earth) strategic sections of OCS equipment. The Private Party in conjunction with the Engineer's Representative will determine such locations. As an example, one such location where a motorized earth isolator or isolators shall be required is at the EMU and rolling stock maintenance depot such that should an incident occur where there is danger to life within this depot complex the depot complex can be quickly isolated and earthed to make it safe whilst retaining supplies to the rest of the main line railway.

9.4.7 The Private Party shall provide a full sectioning diagram giving details of all electrical sub sections that can be separately isolated and the positions of all isolators and alternative feed isolators. This diagram shall be submitted to the Engineer's Representative for approval.

9.4.8 In station areas no live equipment shall be allowed over station platforms.

9.4.9 The Private Party shall design all OCS Pole and Gantry bases and submit to the Engineer's Representative for approval.

9.5 Auxiliary Supply Equipment

9.5.1 All auxiliary power supply equipment (both HV and LV) shall be adequately protected by fast acting protection relays. The failure of one· relay or a circuit breaker shall not prevent the clearance of fault conditions so in addition to reliable relays and circuit breakers back up protection shall also be supplied by the tripping of the next circuit breaker upstream from the one circuit breaker or protection relay that has failed. All protection calculations and protection co-ordination curves showing clearance time against level of fault current shall be provided by the Private Party for review and approval by the Engineer's Representative.

9.5.2 The main form of protection on the 22 kV cable ring networks shall be by unit or differential protection and grey transmission fibers (i.e. fibers carrying no other signals or communication) shall be provided in main telecommunications cable for this purpose. Over-current protection shall however also be provided.

9.5.3 All HV circuit breakers and LV incoming and bus section circuit breakers shall be monitored and controlled by the OCS as will be the circuit breaker feeding the UPS equipment. The status of the UPS equipment shall also be able to monitor from the OCC.

9.5.4 The power supply modes include the normal mode power supply from SS, the maintenance mode power supply, the accident mode power supply and the emergency power supply from the standby generator. The details will be provided by the Private Party based on simulation studies and the power supply arrangement approved by the Engineer's Representative.

9.5.5 Emergency Power Supply

Standby generators are designed to provide emergency power to essential loads in the event that the dual system of power distribution lines fails. The essential loads are as follows:

- All facilities at the OCC
- Signaling system
- Telecommunication system
- PSD
- Air conditioners for the signaling system
- Fire detection system and other devices for implementing disaster prevention measures
- Emergency lighting
- Emergency power outlets
- Other essential loads for the operation of the railway

The distribution of emergency power is arranged when the bus coupler in the middle of dual power source fails

9.5.6 Back Up of Power Supply for Signaling and Telecommunications

The UPS power supply for the signaling and telecommunication systems is excluded from the design of the power distribution system. The dedicated UPS for signaling will be provided in the signaling system design. The dedicated UPS for the telecommunication will be included in the telecommunication systems for the telecommunication equipment room.

The UPS for the signaling system and the telecommunication system must be backed up with power from a standby generator, because they will not be able to continue the operation of the signaling system and telecommunication system for more than 10 minutes.

It is recommended that a simple, rational, secure, and easy-to-maintain power distribution system be adopted. The system will be designed to minimize errors made during the maintenance window of electrical equipment and to ensure the safety of passengers and railway staff.

(1) Functional Requirements for Power Distribution System

a) Vibration Isolation

Equipment producing vibrations shall be isolated from the structure using spring or rubber-in-shear vibration isolators. All piping and ductwork connecting to this equipment shall have flexible connections.

b) Equipment Mounting

Equipment to be mounted on the floor shall be placed on reinforced concrete equipment pads.

In the case that a unit is suspended from the ceiling, the support system shall be adequately braced to ensure stability during unit start up, operation, and shut down.

c) Maintainability

Knock out panels, floor drains, access hatches, and other items shall be made available.

Sufficiently clear space shall be allocated to areas around the equipment to facilitate removal, replacement, and servicing. Provisions shall be made for shaft, tube and filter pull space, access door swings, and removal of miscellaneous components.

Duct access doors shall be installed where necessary.

d) Voltage Level

Voltage for the power equipment of the railway facilities shall be 400 V 3-phase or 220V 1-phase, as required.

e) Location and Space

The power distribution equipment shall be installed in power rooms, and standby generator rooms.

Power rooms shall have sufficient space to house all electrical equipment, including future unit enhancement, and to ventilate the equipment properly. Adequate space shall be provided for working clearances and service aisles, where required, and for the removal or replacement of the equipment.

The system shall be designed with spare space capacity for possible future maintenance and/or expansion. All main switchboards shall be user-friendly, modular and aesthetically designed, as well as termite- and vermin-proof. All mechanical fittings (including portable fire extinguishers), cable trays, trunking, wire ways, and brackets shall have spare capacity for future maintenance and/or expansion.

f) Basic Design Philosophy

The design philosophy should meet the following criteria:

- Application of state-of-the-art Technology
- Service proven design
- Design life 30 years
- Minimum life cycle cost
- Low maintenance cost
- Use of interchangeable, modular components
- Extensive and prominent labelling of parts, cables and wires
- Use of unique serial numbers for traceability of components
- High reliability
- Low energy loss
- System safety
- Adequate redundancy in system
- Fire and smoke protection
- Use of fire retardant materials
- Environment friendly
- Adherence to operational performance requirements
- Maximum utilization of indigenous materials and skills, subject to quality conformity.

(2) Technical Requirements for Power Distribution System

- Power supplies to individual services shall be coordinated so that any equipment or supply failure will not affect the system supply capacity.
- The electrical power system shall be designed to limit voltage drop (based on normal low voltage) to less than the standard level.
- All equipment shall be clearly labeled. The labels shall be firmly affixed and of a non- corrodible type.
- Where a wiring system passes through elements of building construction, such as floors, walls, roofs, and ceiling, the openings remaining after passage of the wiring system shall be sealed according to the degree of fire resistance required.

a) Distribution Diagram for Power Distribution System

The distribution diagrams for the power distribution system in depot are shown in Figures 15. The figures show all the location and the number of SSs/Signal/Telecommunication equipment, the numbers of power rooms in depot, the capacity of transformers, and the size of cables depend on the report of other experts.

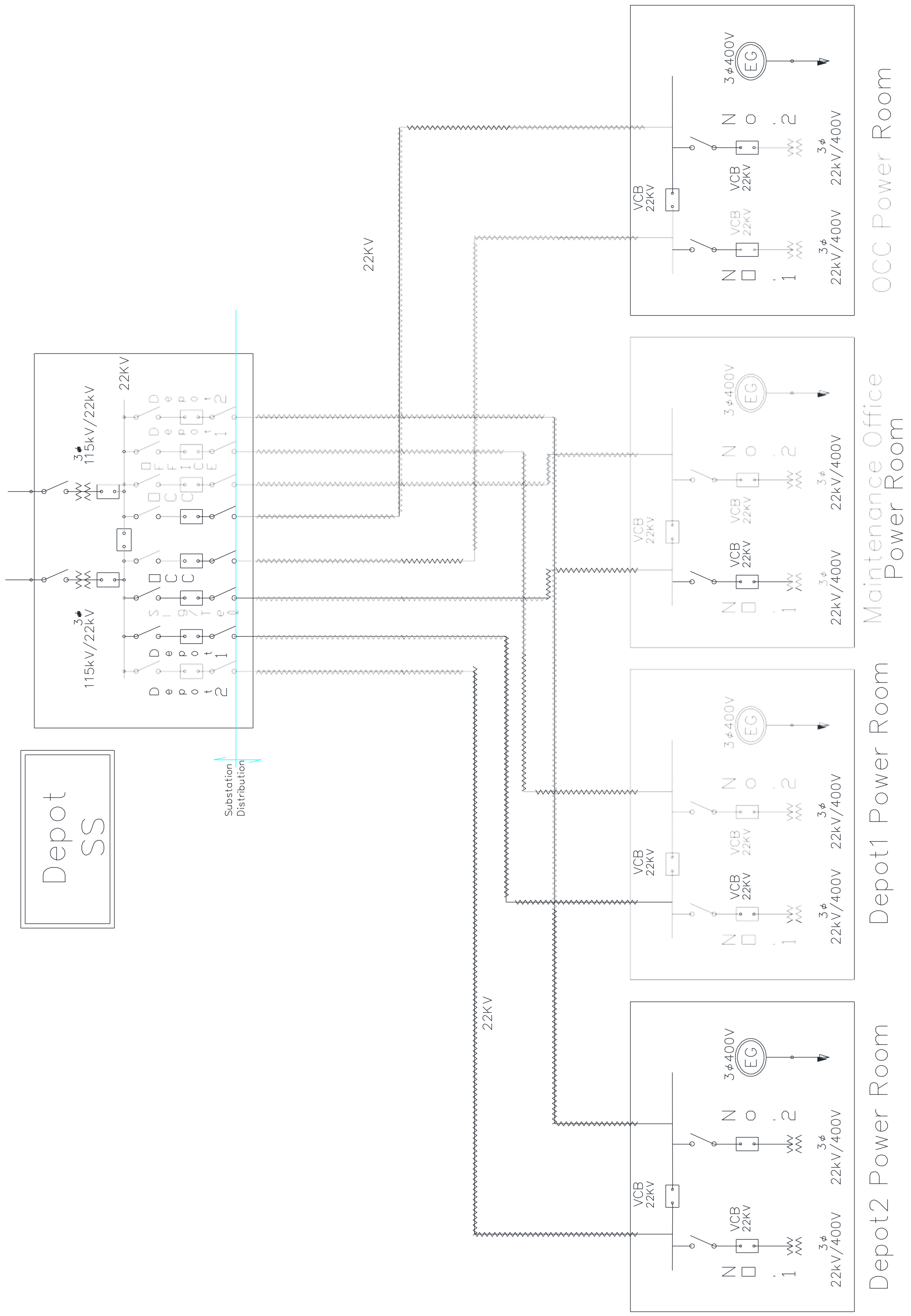


Figure 15 : Single Line Diagram for the Power Distribution (Depot)

10. TECHNICAL REQUIREMENTS

10.1 Traction Power Supply Equipment

10.1.1 Circuit Breakers

(1) All 230 kV circuit breakers shall use SF6 as the insulation and arc control medium.

(2) All 2x25kV or 25kV circuit breakers shall use either SF6 or vacuum as the insulation and arc control medium shall be of the indoor type and shall be fully withdraw able for maintenance or repair. Fully automatic lockable shutters shall therefore be provided on both the busbar and cable side connections to ensure safety to maintenance staff when the circuit breaker is in the withdrawn position.

(3) All circuit breakers whether at 230 kV, 2x25 kV or single phase 25kV shall use spring wound motors as their means of operation.

(4) All circuit breakers shall comply with IEC60056 or equivalent standard.

10.1.2 Traction Transformers

(1) The traction transformers shall comply to EN 50329/ IEC 60076 or equivalent standard however it should be noted that in the case of these transformers the operating circumstances associated with an electrified railway system subject the supply point transformer to rapid and repeated load current fluctuations within the range from zero to twice full load current and also to a high incidence of system short circuits of varying magnitude applied to the transformer lower voltage terminals.

(2) With the use of thyristor controlled motive power units, consideration must be given to the effects of harmonics and rate of change of current which can be imposed on the supply point transformer and which may manifest itself as an adverse electro-mechanical duty. It is envisaged that the load current will contain odd harmonics of varying magnitude to the 50th order and that the presence of even harmonics cannot be ruled out.

(3) The transformers covered by this Specification must, therefore have their windings suitably braced, etc. so that they are capable of withstanding without detriment or exception of any kind, the cumulative or singular consequences of the short circuit duty described above. They must also be capable of withstanding without detriment any rate of change of current or harmonic effects.

(4) The Private Party shall recommend the requirement or otherwise of the necessity of fitting winding tapping equipment (either motorized or manual) depending on the outcome of the power system study and the MEA/PEA voltage limits as stated in the above table.

(5) Traction transformer plinths shall have their own oil containment facilities to ensure that any transformer oil either spilt or released during a transformer fault does not get into any water courses or the environment.

10.1.3 Control and Protection Equipment

(1) Protection Equipment

(a) The Private Party shall define the philosophy and furnish a scheme of protection with fast discrimination and reliable operation based on latest state-of-the-art computerized logic protection scheme. The zones of protection shall overlap providing back-up protections. The scheme for protection of the MEA/PEA 230 kV service shall be fully coordinated with MEA/PEA. The protection scheme to be provided shall not rely on one multi-functional protection relay per circuit such that all protection is removed in the case of a protection relay fault. Alternatively, if this is the case fully redundant protection relays shall be provided with both relays supervising the lines.

(b) The protection system to be engineered for busbar, feeders, service transformers, intake transformers and other equipment and shall comply with IEC255 or BS142 or equivalent standards.

(c) The protection scheme shall include the following state-of-the-art protection functions according to International Standards and as a minimum, shall include the following:

i) over current protection

ii) earth fault protection

iii) under voltage protection

iv) over voltage protection

v) no voltage protection

vi) where appropriate distance impedance protection

vii) where appropriate differential protection.

(2) Protection Control Unit (PCU)

(a) The Protection Control Unit (PCU) shall be an intelligent microprocessor based self-diagnostic, protection, and control and metering unit. The PCU shall consist of protection relay module, control module and metering module functioning.

(b) Control Module In general, the control module shall include but not limited to the following:

i) Control of the Bang Sue bulk supply point, AT locations, OCS, line side motorized isolators, OCC supply and associated disconnection facilities.

ii) All controls and indications shall be required to operate the power supply system. The Private Party shall ensure that the engineering shall take into consideration high security and reliability required for the control of high voltage switchgear and sub-station control panels.

iii) Controls shall be performed either automatically or manually from the OCC control facility. Indications shall be available both at the PCU and remote OCC control facility.

iv) All PCU's shall be capable of performing all necessary control functions required at a sub-station in the event of failure of the SCADA system or during maintenance activities.

(3) Metering Module

The Specification requirements of the metering module within the PCU shall include for each supply but not limited to the following:

(a) Ammeter current indication in the following:

i) 230 kV MEA supply panels.

ii) 2x25kV and 25 kV ac supply panels

(b) Current at the TSS between earth and traction neutral bus.

(c) Voltmeter

i) not used

ii) 2x25kV ac supply panels

(d) Energy meter (kWh, 15min./30min. summated kVA, kVAR) and Power Factor meter (PF).

(e) Stamping of maximum demand over a pre-determined period shall include associated date and time.

(f) High voltage transformer protection monitoring and control devices will include, but not limited to:

i) control cubicle

ii) motor-drive unit for on-load tap changer

iii) Buchholz relay

iv) differential relay also providing earth fault protection

v) dial type oil temperature indicator

vi) dial type winding temperature indicator

vii) magnetic oil level gauge

(4) Fault-Diagnostic Facilities

Full Built-in Tests (BIT) shall be incorporated in the PCU system. The BIT shall self-test all system hardware, software and interfaces of the systems. The BIT shall enable the operator/maintenance personnel to carry out troubleshooting and maintenance of the system effectively.

10.1.4 Control and Power Cables

(1) The power system cabling including supply, laying, jointing and terminations of LV cables and earth conductors shall be submitted to the Engineer's Representative, for review and approval.

(2) Control cables shall not be run in the same trunking as power cables. In the case of cable trenches, etc. where there is a necessity to run these control and power cables in the same trench they will be metallically screened from each other.

(3) Cables to be used shall include the following features:

(a) Cable insulation and sheaths shall be non-toxic.

(b) Cable sheaths shall be impregnated with repellents for rodents and Termites.

(c) Cable sheaths shall be embossed with identification marks for cables of different voltage grades.

(d) The insulation and sheaths of cables used in the above-ground or in buried cable troughs sections shall be XLPE insulated, fire retardant and low smoke. Mylar or other suitable nonmetallic armor sheathing may be employed. In buildings, they shall be Low Smoke Zero Halogen (LSOH).

(e) All control and LV power cables shall be properly terminated into cable termination blocks and each contain identification markers or numbers.

(f) All cables shall be identified with cable markers, at reasonable intervals, for easy selection during fault location or corrective maintenance activities.

10.1.5 Switchgear and Panels

(1) General

(a) All switchgear and panels shall be of robust construction, vermin proof and finished with anti-corrosion paint.

(b) Anti-condensation heaters shall be supplied, if necessary.

(c) The complete interlocking scheme shall be subject to the review and approval by the Engineer's Representative.

(d) All switchgear shall be provided with an integrated system of strong mechanical and electrical interlocking devices to prevent any dangerous or inadvertent operations. The interlocks shall ensure the correct sequence of operation of all circuit breakers, disconnecting and earthing switches and their associated equipment.

(e) The interlocking between switchgear panels associated with traction or auxiliary transformers shall also include prevention of short circuits between phases of the intake supplies.

(f) The switchgear shall be engineered such that **it** is safe to carry out inspection, maintenance and repair work on a de-energized circuit breaker while the busbar compartments and track cables remain energized. The cables shall be located in a compartment partitioned separately from circuit breaker and busbar compartments. Any busbar or cable side shutters separating the busbar or track cables from the circuit breaker shall automatically close when the circuit breaker is withdrawn.

(g) Conductors for the busbars and various connectors shall be of copper, adequately dimensioned for normal current and short circuit ratings. Wherever necessary, expansion joints to compensate for thermal expansion of busbars may be provided.

(h) Switchgear shall comply with latest relevant international/national specifications. Some of the governing standards are EN50152, EN60947, EN60298 and EN60694.

(2) Ratings, Construction and Features

(a) The switchgear metal enclosure inclusive of exhaust vent for de-ionized gases shall be of robust construction and shall be engineered to prevent the ingress of moisture and vermin. Metal panels shall be provided with inter-panel dust proof seals of corrosion resistant material. All panel doors shall have latching mechanism to be held in fully open position.

(b) All cables entering metal cabinets shall be by means of appropriate cable glands.

(c) The busbars shall be air insulated and where connections have to be taken through metal panels this shall be carried out by dielectric bushings. Secondary insulation of busbars, etc. will not be permitted to reduce air clearances.

(d) The switchgear shall be engineered such that it is safe to carry out inspection, maintenance and repair work on a de-energized circuit breaker while the busbar compartments and track cables remain energized. The cables shall be located in a compartment partitioned separately from circuit breaker and busbar compartments. Any busbar or cable side shutters separating the busbar or track cables from the circuit breaker shall automatically close when the circuit breaker is withdrawn.

(3) Batteries and Battery Chargers

(a) A sub-station battery and associated battery charger shall be provided.

(b) The battery voltage shall be chosen by the Private Party to suit the equipment being provided. The battery should provide a minimum 8 hours standby on loss of the L V domestic supply whilst still providing its standing load. In addition, during this 8 hour period a minimum of 5 circuit breakers operations (open and close) should be able to be undertaken with the battery still maintaining the minimum voltage at the end of the 8 hour period.

(c) The batteries shall be of the minimum maintenance type (sealed lead acid or equivalent) and the chargers should be compatible for the type of batteries being supplied.

10.2 AT Locations

10.2.1 The AT shall comply to EN 50329/IEC60076.

10.2.2 AT plinths shall have their own or a common oil containment facility to ensure that any transformer oil either spilt or released during a transformer fault does not get into any water courses or the environment. The Private Party shall be responsible for the preparation of the ground and procurement and construction of all AT Buildings and installations. All Equipment bases shall be piled to SRT standards and be complete with handrails and steps as necessary. The Private Party shall submit all locations of AT's and their Installations and buildings designs to the Engineer’s Representative for approval.

10.2.3 All other details shall basically follow the requirements of the power supply equipment as specified in these Specifications.

10.3 OCS Equipment

10.3.1 General

(1) The OCS shall comprise:

(a) Electrical sectioning

(b) Tension lengths and tensioning equipment

(c) Overhead line configuration of contact wire, feeder wire AEW and droppers, support brackets and masts. Please see Appendices 4,5 and 6 for single, double or 3-span overhead line configurations.

(2) The system shall be for a complete, safe, reliable and readily maintainable overhead line system with the following items forming the principal components:

(a) Completely auto-tensioned single contact wire system for the complete main running lines, sidings, depot lines and crossovers.

(b) All the necessary messenger wires for the suspension of contact wire.

(c) All necessary - 25kV feeder cables including support arrangements

(d) All necessary 25kV insulators

(e) All the necessary jumpers to make up for the defined current capacity.

(f) All the weight tensioners or alternative tensioners to satisfy the auto tensioning requirements.

(g) All the supports, brackets, masts and foundations necessary for the support of the overhead line system.

(h) All the section insulators, neutral sections and isolators to satisfy the sectioning requirements as specified in this Specification.

(i) All the masts, wiring, isolators, neutral section and section insulators requirements for the depot.

(j) All cabling for the overhead line system.

(k) All interface works as specified in this Specification.

(3) The OCS system should comply to EN 50119 or equivalent standard.

10.3.2 Outline of OCL

- The overhead contact line normally consists of a contact wire for supplying power to motive power units through the pantograph and a catenary wire for suspending the contact wire horizontally to a constant height above the track. Construction of the overhead contact line is often determined on the basis of operating conditions (speed, output and frequency of trains) of the electric trains.
- The supports are for supporting overhead contact lines, line feeders, and consist of poles, footings, hinged cantilevers and cross arms. The support will designed mainly on the basic of composition of overhead contact line and meteorological condition.
- The line feeder is a conductor to supply power from a substation to successive

feeding points. In the case of AT feeding system, power is delivered to autotransformers installed along the track, and thus AT line feeders are installed throughout the whole length of the railway line.

- The line feeder is a conductor to supply power from a substation to successive feeding points. In the case of AT feeding system, power is delivered to autotransformers installed along the track, and thus AT line feeders are installed throughout the whole length of the railway line.
- The return circuit is for current fed to motive power returning to substations, and running rails are normally used as returning circuit.
- The protection wire is used to protect the overhead contact line and equipment from abnormal voltages and to prevent the expansion of damage during insulation failure or grounding fault.

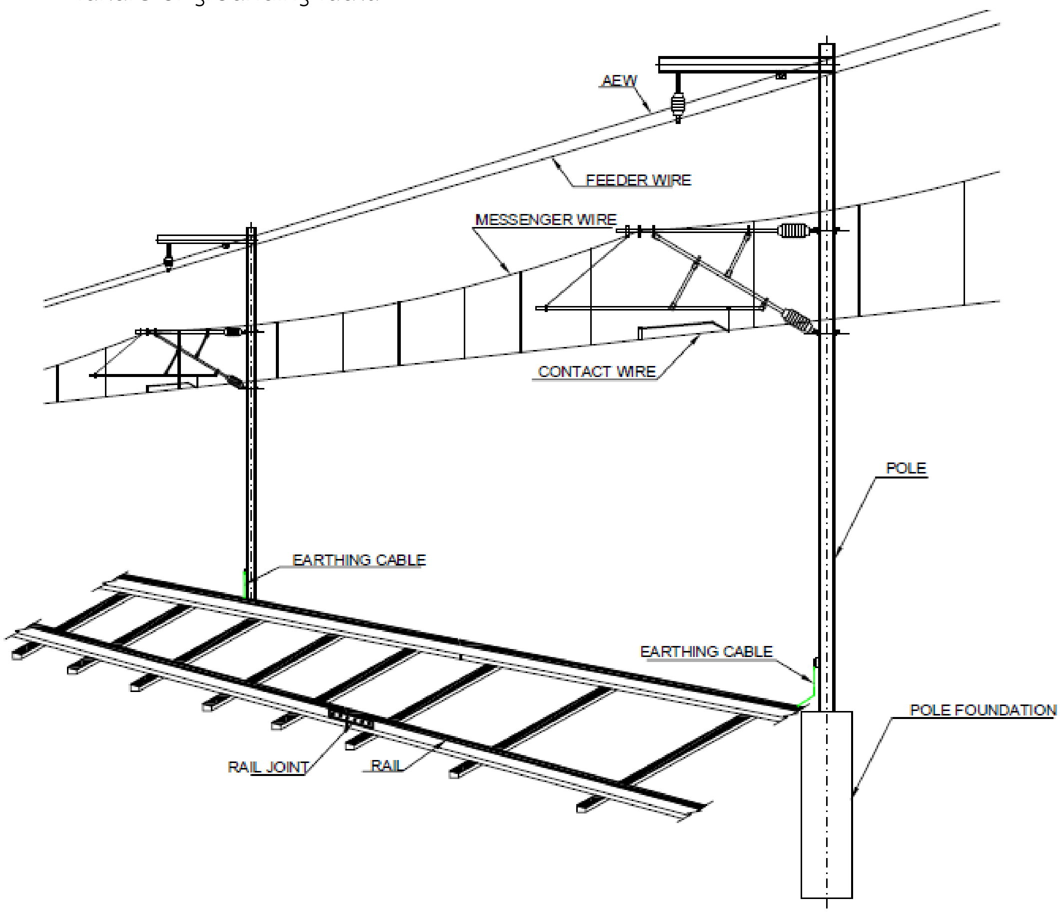


Figure 16 : Typical OCS arrangement for 2x25 kV System

10.3.3 Contact Wire and Catenary Wire

(1) Contact wire

- Material and kind of contact wire

The contact wire should be of low electrical resistance, high mechanical strength (tensile, bending and wear) and high heat resistance.

The conductors most suited to these requirements are mainly hard-drawn copper wire or hard-drawn copper alloy wire. The copper alloy is made of copper with silver (Ag) added in order to improve the heat resistance. The copper alloy is made of copper with tin (Sn) or magnesium (Mg) or chromium (Cr)/zirconium (Zr)/silicon (Si) or tin (Sn)/indium (In) added in order to improve the wear-resistance.

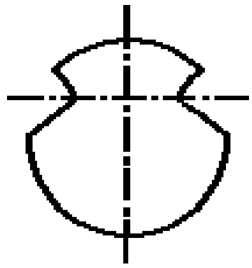


Figure 17 : Typical Cross Section of Hard-Drawn Copper Contact Wire

- Wear of Contact Wire

The contact wire wears electrically and mechanically due to the sliding of the pantograph, and its cross-section. A decreasing in the tensile strength of the contact wire due to its wear can cause the break of the wire. The allowable wear limit is the amount of wear can cause the break of contact wire when the tensile strength of the worn contact wire reaches the standard tension multiplied by a safety factor and the diameter of the contact wire at that time is called the allowable residual diameter.

It is economical to use the contact wire up to the allowable wear limit. Therefore, when selecting the kind and cross-section of the contact wire, it is necessary to review the tensile strength and current capacity at the allowable residual diameter of the contact wire in addition to the current collection characteristics. The wear limit shall be 30%.

(2) Catenary Wire

The catenary wire is used to suspend the contact wire with droppers. Because of this, the catenary wire must have excellent mechanical characteristics with• respect to stress, bending and vibration. Moreover, it must have the conductivity necessary for the flowing a part of the load current. Either steel or copper alloy wire is used for the catenary wire. The wires employed for the catenary wire is shown in **Figure 18.** Steel stranded wires and copper alloy stranded wires are available with 7 or 19 strands.

Figure 18 : Typical Cross-section of Catenary Wire

10.3.4 Electrical Sectioning

(1) In determining the locations of the electrical sectioning the follow principles shall be adopted:

(a) The OCS equipment shall consist of separate sections and sub sections. At electrical sectioning locations, the messenger wires and contact wires shall be sectioned at the same location along the track.

(b) The location of OCS traction supply in-feed isolators and related OCS electrical sectioning shall be arranged such that it is as close to the traction sub-station as practicable.

(c) At turnouts, section insulators shall be installed as close to the diversion as practicable to give adequate clearance to pantographs and to minimize the train service disruption following fault isolation.

(d) At crossovers, section insulators shall be installed to electrically separate adjacent lines.

(e) At the end of lines insulation shall be installed above the buffer stops.

(f) Where practicable, insulated overlaps shall be employed instead of section insulators, for the sake of better dynamic performance.

(g) Neutral sections shall be installed at in-feed locations to prevent the interconnection of two separate supply phases.

(2) Detailed specific requirements of the major equipment used in sectioning are as follows:

(a) All section insulators shall be equipped with arcing horns and have arc extinguishing capability to prevent any damage due to arcing. Section insulators shall permit bi-directional pantograph movement, at the maximum line speed of 250 km/hr. The pantograph shall collect current without interruption during its passage without any loss of contact or introduction of unreasonable longitudinal forces and bouncing.

(b) On the main line, insulated overlaps shall be arranged at intervals for electrical sectioning and each shall be fitted with a by-pass isolator. Where practicable, insulated overlaps shall be employed instead of section insulators. Insulated overlaps at station ends shall be close to the platform as possible.

10.3.5 Overlaps

Since the overhead contact line must be continuously extended along the track and terminated for every proper constant length, the overhead contact wires at the terminated point must be properly connected electrically without disturbing the passage of pantograph. In order to give this function, two adjacent overhead contact wires are overlapped in parallel throughout a gap. For the insulated overlap, a static horizontal clearance of not less than 460mm shall be provided between the contact wire and messenger wire of each of electrical section, and the supports to which they are attached shall maintain a minimum of 300mm clearance in all directions under all temperatures and wind speeds. For the uninsulated overlap, the mechanical clearance at supports between contact wire and messenger wire of each tensioned section shall preferably be the same as that for an insulated overlap but shall not be less than 200mm.

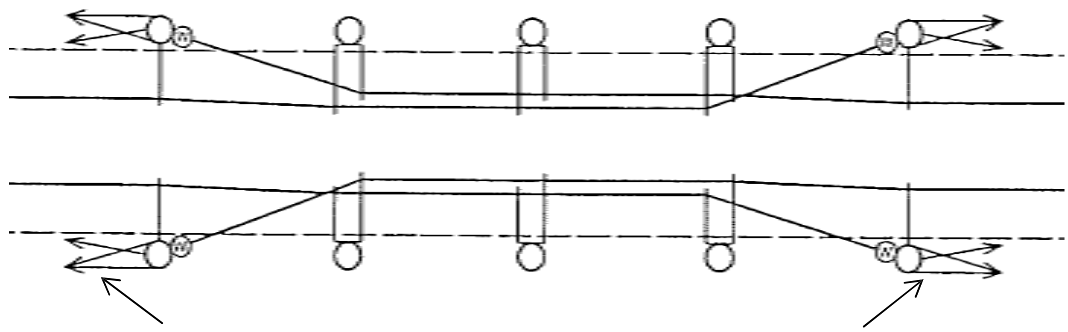


Figure 19 : Overlap Arrangement

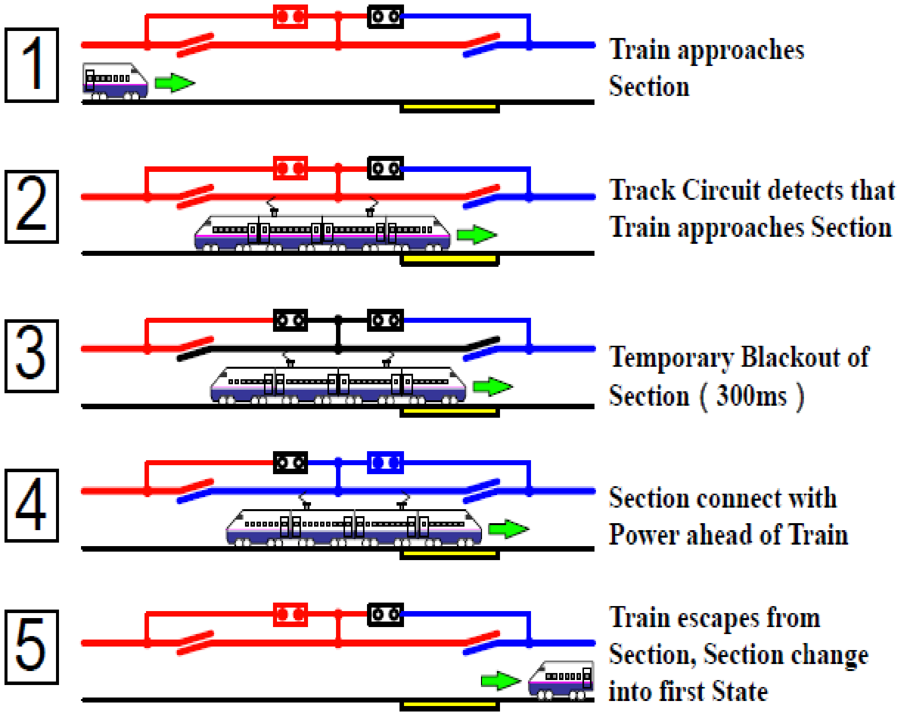
10.3.6 Neutral Sections

(1) The neutral sections to be provided can either one of two types. These types are:

(a) Consist of two sets of arc extinguishing section insulators separated by short-earthed sections of messenger wire and contact wire, or

(b) Of the double insulated overlap type. In this case alternative feed isolator will be provided to energize under controlled conditions the center section of contact and messenger wire so that a stranded train can get out of the neutral section without assistance.

(2) Neutral section is necessary, in front of substation and sectioning post in the case of AC feeding system, so structure of neutral section is examined. Figure 20 shows principle of changeover section for 250km/h speed operation. This changeover section has same power of a light-hand side. When train enters in this changeover section, train is detected by signal circuit. This section became temporary blackout about 300ms. After that, this changeover section connects power ahead of the train.



If train escapes from this section, section changes into first state. A characteristic of this section is that the power running is possible without cutting off circuit-breakers on the train, and train having bus line connecting pantographs can pass under of this section. Therefore, this section is suitable to install high density driving sections or incline sections of high-speed railway line.

Figure 20 : Principle of Changeover Section

(3) The rolling stock power control equipment shall be automated for trains to pass through a neutral section of the OCS. In the case of the double section insulator type of neutral section the section insulators shall be equipped with arcing horns in order to avoid any damage from arcing in the event of the circuit breaker of a multiple-unit set or a locomotive failing to open. Section insulators with a long air

gap are recommended for good arc-extinguishing ability. The overall length of neutral section shall typically be 10 m using a double section insulator type.

(4) Any neutral section shall be sited in accordance with the gradient of the track, the position of all signals and away from any stations to prevent electric trains becoming stalled in the neutral section due to loss of power. The arrangements for the OCS neutral section configuration shall therefore be proposed by the Private Party, in order to eliminate any problems that may arise.

10.3.7 Tension Lengths

(1) The tensioning length must be determined by the performance of automatic tensioning devices. In determining the locations of tensioning equipment and the distance between them the follow principle shall be adopted.

(2) For mainlines the maximum length of a tension length shall be determined such that tension loss along half a tension length (i.e. from the fixed point to auto-tensioning device) due to cantilever drag and along track movement, shall not reduce the current collection performance of the contact system. Tension length shall not be longer than 1,500m. The maximum half tension length shall not exceed 750m in length. Mid-point anchors shall be used to form a fixed point for tension lengths with balance weights at both ends. Individual tension lengths shall be engineered for crossovers wherever possible. The end of a tension length shall extend past the start of the next length to form an overlap. Overlaps which can either be insulated or un-insulated shall allow the bi-directional passage of pantographs from one tension length to the next, maintaining contact with the contact wires of both tension lengths for a suitable distance in the overlap span.

10.3.8 Tensioning Equipment

The conductor temperature varies due to the changes in ambient temperature and the load current, which results in expansion or contraction of the conductor in accordance with the coefficient of linear expansion. Because of this, tensioning devices for absorbing the expansion and contraction are used at the termination points of the overhead contact line. The automatic tensioning of the OCS shall be achieved using Spring type tensioning device. The spring type shown in Figure 21 can adjust tension by following the spring motion. Its adjustment length is shorter than that of the balance weight type. Because the spring balancer requires little maintenance, it is suitable for high-speed railways with frequent train operation. These ATD’s shall be used where required to achieve the contact performance for all operating environmental conditions and train speeds. ATD’s shall be engineered such that in the event of a catenary system failure the anchor equipment (including weights, pulley wheels and supporting steelwork) shall not foul the structure gauge or cause further damage. ATD’s shall not be located in platform area where passengers may stand and should not cause obstructions. Both catenary and contact wires shall be automatically tensioned separately

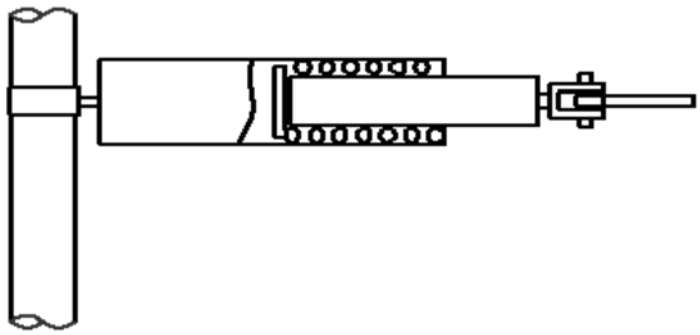


Figure 21 : Spring Tensioning Device

10.3.9 Tram Way Equipment

For depot lines with a maximum speed of 25 km/hr, fixed termination tramway equipment may be used. If however fixed tramway equipment is used the Private Party shall take due account of the maximum tensions that will occur in the contact wire (under the lowest temperature condition) whilst still retaining a minimum factor of safety of two in the fully worn contact wire condition. Main line equipment shall be used for other lines (i.e. depot arrival and departure).

10.3.10 Overhead Line Configuration

(1) The messenger wire shall be in the range of 135 to 150 mm^2 hard-drawn copper or copper alloy strands, supporting a contact wire of 120 to 150 mm^2 hard drawn copper/copper alloy contact wire by means of conducting droppers of 10 mm^2 bronze stands, and shall be automatically tensioned so that the messenger wire and the contact wire are respectively maintained at constant tensions of not less than 12kN.

(2) The choice of sizes and material shall conform to that used in the power system study.

(3) The choice of material for the messenger wire shall be such to reduce conductor creep but shall not be copper cadmium.

(4) The negative 25kV feeder wire shall be of 65 to 120 mm^2 copper or copper alloy (again not copper cadmium) or the Private Party may propose an aluminum or aluminum alloy with equivalent copper cross sectional area.

(5) The messenger wire shall always be located vertically above the contact wire at supports. The dropper spacing shall be optimized to achieve satisfactory current collection quality under the worst operating conditions.

(6) An AEW of steel reinforced aluminum strands with fixed termination shall be erected parallel to the OCS system, electrically connected to each OCS structure and be

simultaneously utilized as a common earth wire and as a continuous path for normal current return and fault current return. The AEW shall be sized to limit the potential rise due fault currents in ace accordance with EN50122-1.

(7) The contact wire/trolley wire used on this project shall be grooved, copper or copper alloy conforming to standard EN50149 (2001) or equivalent standards.

(8) The contact wire shall be continuous and splicing or jointing of the conductor is not permitted between terminations or cut in insulations.

10.3.11 Overhead Line Parameters

(1) Electrical and Mechanical Clearances

(a) The minimum electrical and mechanical clearances shown in the table below shall not be infringed under the worst operating conditions of overhead line equipment, the rolling stock and pantograph. The value in the right column shall be used only where absolutely necessary shall be reviewed on a case by case basis.

Minimum Electrical Clearances (mm)

Item	**Normal mm**	**Absolute Minimum mm**
25kV Live metal to earth		
• Static	270	200
• Dynamic (passing)	200	150
25 kV Live Metal to Vehicles		
• Static	270	(N.A)
• Dynamic (passing)	200	N.A.
Phase Difference (55kV allowing 10% tolerance on MEA supply Voltage)		
• Static	600	N.A.
• Dynamic (passing)	440	N.A.
Between conductors of different electrical sections		
• Gap at Insulated overlap	4460	N.A.
• Gap at Non-insulated overlap	4460	200
Swayed Pantograph Envelope to Common Live Metal including Fixed Ends of Steady Arms		
• Normal to cross track level	80	80

Item	Normal mm	Absolute Minimum mm
• Parallel to cross track level	150	100
Swayed Pantograph Envelope to steady arms and any fittings directly attached to a CW (with fully worn pantograph and 33.3% CW wear)		
• Normal to cross track level	15	15
• Parallel to cross track level	150	100

(b) All the overhead line equipment shall be so arranged that the live metal parts shall have a vertical clearance of at least 4.5m to the walkway, or the ground level accessible to passengers or staff.

(c) In stations, no live equipment (including the dead end of insulators) shall be allowed to project over the platform edge. Where this is impossible to achieve due to staggers, etc. no more than half the insulator will be allowed to project over the platform edge.

(d) The mechanical clearance required between the pantograph head and any registration arm or registration arm drop bracket shall I be 15mm with the contact wire in its fully up lifted position.

(e) The minimum height of the contact wire over road level crossing in the depot shall be 5.8m under the worst conditions. Load gauges and special warning signs shall be provided by the Private Party to limit the road vehicle height.

(f) In the case of across-track bare feeders crossing an electrical subsection, to which they are not connected, there shall be at least 2.75m clearance between the feeder and the highest conductor and other live metalwork of the section below, under all conditions. This clause also applies if the occasion arises where the negative 25kV cable has to pass over electrical subsections to which they are not associated.

(2) Contact Wire Height

The normal contact wire heights are shown in the following table. The contact wire height at supports shall be engineered to ensure that the lowest point of the contact wire will never be lower than the absolute contact wire height in any case and under the worst operating conditions. The effect of the temperature variation, the pre-sag, and the tolerance of installation and measurements shall also be taken into consideration for determining the contact wire height at supports.

Contact Wire Height

Item	Contact Wire Height above Track (m)
Minimum contact wire height at supports (except in tunnel and reduced clearance areas)	4.6
Absolute Minimum contact wire height at any point in span	4.6
Normal contact wire height at Supports on viaducts	5.0
Normal Contact wire height at Supports at grade and embankment	5.0
Normal contact wire height at Supports in tunnels and underneath structures	4.6
Normal contact wire height at stations (see Note ii below)	5.0
Normal contact wire height at Supports in Depot	6
Contact wire height at Level Crossing (Depot)	6

Notes:

i) The Private Party shall check the validity of these heights against the SRT's structure and kinematic gauges and the rolling stock parameters in respect of the working range of the pantograph.

ii) At certain stations or places within a station a contact wire height of 5m may not be entirely possible due to the architectural design of the station. 5m contact wire height should be the target or as close to it as is reasonably feasible with different support arrangements, etc. In any event the absolute minimum contact wire heights at stations shall be 4.6m but this will only apply where there are low platforms.

(3) Positioning of Negative 25kV Feeder Cable

The negative 25kV feeder shall be so positioned to be as far as is possible the same distance from the signaling and telecommunication trough as from the contact wire to the cable trough to give maximum compensation against electro-magnetically induced interference. In certain station areas, the bare negative 25kV feeder cable will have to be replaced by a HV cable. The negative 25kV feeder conductor shall also be so positioned such that should it break it will fall onto the railway and not onto any place where the public have access (except at level crossings).

(4) System Height

The normal OCS system height is anticipated to be 1.2m - 1.6m on the open line. In order to increase the span length or solve the low clearance problems, the system height may be altered to suit the clearance available. The nominal minimum dropper length shall be 0.15m. Where this cannot be reasonably achieved, lower values may be used.

(5) Span Lengths

(a) In calculating the maximum displacement of the contact wire for the span length, the following shall be taken into account:

i) blow-off (i.e. contact wire displacement at mid-span due to wind on the contact wire and the messenger wire)

ii) alignment (e.g. versing)

iii) stagger effect (i.e. the effect of equal or unequal stages at supports)

iv) mast deflection due to wind loading

v) temperature effect (i.e. the effect stagger changes due to temperature variation)

vi) net pantograph sway allowance for movement without wind effect (the dynamic effect of the pantograph on track tolerance shall be included)

vii) the static and dynamic effect of tack tolerances on pantograph sway with no wind if they are not included in net pantograph sway

viii) erection tolerance

ix) effect of increasing span lengths by 2m if necessary during construction

(b) The following shall be considered in the span length calculation:

i) the angle of deviation of contact wire at a support shall be limited in order to avoid large horizontal loads which cause excessive uplift of the steady arm or overloading of any part of the support.

ii) the minimum dropper length at the mid-span should normally be 150mm. Where this cannot be reasonably achieved, lower values may be used provided they do not alter the current collection performance or alternative types of droppers used which will not be subject to fatigue failure (e.g. loop droppers). In some extreme cases it may be necessary to, dispense with the messenger wire, converting it to a contact wire and then run the two contact wires side by side so the pantograph collecting surface is in contact with both contact wires. Under this arrangement the span lengths will have to be very short.

iii) the maximum permission contact wire sag of the single trolley wire shall be 150mm.

iv) The maximum span for OCS pole interval shall generally be designed according to the following tables.

Table 6 : Maximum Span for Straight Track

Category	Standard span	Maximum span
Open area	50m	60m
Tunnel area	45m	50m

Table 7 : Maximum Span for Curved Track in Open Area

Radius of Curvature	Standard span	Maximum span
1,100m and above	50m	60m
800m and above	45m	45m
600m and above	40m	40m
400m and above	35m	35m
300m and above	30m	30m
200m and above	20m	20m

Table 8 : Maximum Span for Curved Track in Tunnel Area

Radius of Curvature	Standard span	Maximum span
1,100m and above	45m	50m
700m and above	45m	45m
600m and above	40m	40m
500m and above	35m	35m
400m and above	30m	30m
300m and above	25m	25m
200m and above	20m	20m

Maximum difference of successive span length shall be 15m. However design target should be 10m.

(6) Staggers

(a) Spans and staggers shall be carefully arranged to ensure that the contact wire will never be displaced by more than half the width of the pantograph carbon from the center line of the pantograph at any in running point in- span, under the worst operating conditions of the OCS system, the rolling stock, the track both in alignment and super elevation and the pantograph.

(b) In calculating the maximum displacement of the contact wire for the stagger, the following shall be taken into account:

i) pantograph sway under viaduct lateral air velocity or with the project base wind speed on the open line

ii) temperature effect (i.e. the effect of stagger changes due to temperature variation)

iii) static and dynamic effect of track tolerances (if they are not included in pantograph sway)

iv) erection tolerance

v) the contact wire height

(c) The contact wire stagger for each location shall be individually but wherever possible one value of stagger shall be used for tangent trac and one value for curved track. The value of the stagger shall also be chosen such that even under maximum wind conditions there is a positive force between the registration arm and the registration drop bracket of the cantilever unless a wind stay arrangement is provided to ensure this.

(d) The Private Party shall liaise with the rolling stock provider to ascertain the physical details of the pantographs (width of head, shape of horns, and contact width) and dynamic properties of the electric trains (sway characteristics, etc.) and pantographs and take this information into account when determining the maximum stagger that can be applied.

(7) Overhead Line Supports

(a) Catenary support and registration shall be by means of independent hinged cantilever assemblies enabling fine adjustments of height and stagger. The registration arms of the cantilevers shall always be in tension.

(b) In station areas the use of head spans fixed to the station roof may be required.

(c) The supports for fixed termination conductors should these be used shall be engineered to accommodate tension variations in adjacent spans.

(d) Masts for single track cantilevers or portal structures shall preferably be of "H" beam construction for ease of maintenance and subsequent painting.

(8) Fixings on Elevated Sections

(a) On elevated sections, bolted based portal masts providing totally independent registration for each track mounted masts planted onto plinths which form an integral part of the elevated section structure shall be used to support the OCS system.

(b) Masts, poles or structure support spacing must not exceed a span of 68m. The mast spacing shall not be placed at a maximum distance to allow for along - track relocation. Back ties shall not bridge the expansion joints constructed into the civil works. It should also be noted that signal gantry structures have to be provided every 700m along the length of the railway and these signal gantry structures shall also be used as OCS support structures.

(9) Foundations

(a) Where the Private Party has to provide foundations for OCS equipment these shall normally be of the side bearing type.

(b) In bad ground conditions there may be the need for gravity pads or piled foundations.

(10) OCS for the Depot Workshop

(a) Two tracks in the EMU maintenance depot will be engineered for trainset inspections and shall be equipped with OCS facilities that will enable maintenance or removal and replacement of roof mounted equipment. This will require the use of overhead or wall mounted cranes and therefore the OCS equipment should be of the moveable type to allow the use of the overhead cranes.

(b) Operation of the equipment shall be interlocked with the traction power switchgear such that no unsafe situation can arise.

10.3.12 Insulators

In general insulators shall be manufactured from porcelain or composite (glass fibre core with a silicone rubber sheath). Normally porcelain insulators shall be used but there may be a equipment due to weight or vandalism considerations to use composite insulators. The design of and number of the sheds on the insulators shall take into account the minimum maintenance requirements and self-cleaning performance by the action of rain. The typical specification of insulators is as detailed in the following table:

Typical Insulator Specifications

Characteristic	Value
Related Voltage	25 kV to earth (44 kV System Voltage)
Power frequency wet withstand voltage kV	110
Impulse Withstand voltage kV	250
Minimum Creepage distance mm	1060

10.3.13 Environmental Conditions

(1) The OCS equipment shall be engineered to perform satisfactorily through the following conditions:

(a) Ambient temperature 15°C to 46°C, Humidity 100%

(b) Spot temperature above stationary train maximum 55°C

(2) The OCS shall be engineered and constructed such that under the conditions and requirements detailed in this Specification, conductor temperature rise above ambient does not exceed 50°C for hard drawn copper.

10.3.14 Isolator to Overhead Line Jumpers

Flexible annealed copper strands of 100 to 120 mm^2 shall be employed as the electrical connector between the isolator and the overhead line equipment. In the case of a simple overhead line system, the jumper configuration shall be such that the contact and messenger wire each has two connections to each isolator terminal so that failure of any one of part of the assembly will not lead to failure of the circuit. In the case of the depot trolley wire, one connector shall be connected to the contact wire. The maximum resistance at the compression joint between the flexible annealed copper strands and the electrical connection clamp or lug, and at the contact point between the clamp and messenger wire or contact wire, shall be less than the resistance of the conductor of the same length. The maximum temperature rise at the compression joint and at the contact surface shall not be higher than that of the conductors.

10.3.15 Jumpers

Equipment to equipment and potential equalizing jumpers:

(1) Jumpers of annealed copper strands shall provide electrical continuity between different overhead line equipment’s at un-insulated overlaps and at turnouts.

(2) In areas of the simple overhead line construction, these jumpers shall comprise two individual cables of each connecting to both the messenger wires and both contact wires.

(3) For trolley wire equipment, two jumpers of 100 to 120 mm^2 will be installed between both the contact wires as close to a support as practicable.

(4) Potential equalizing jumpers shall be provided between the messenger wire and the contact wire at intervals under 400m unless the Private Party can prove that the use of current carrying droppers is adequate to equalize the current distribution between contact and messenger wires. Additional jumpers shall be installed if the droppers

cannot provide reliable and sufficient current paths between the two main conductors.

10.3.16 Factors of Safety

(1) The following allowances shall be made, as a factor, on loading which may be experienced under the operating conditions defined in the specification. In the event of a conflict between these safety factors and relevant international standards, the more stringent requirement shall prevail:

Factor of Safety

Component	Factor of Safety
Contact wire (33.3% worn)	2.2
Messenger wire	3.0
Feeder Wire	2.5
Aerial Earth Wire	2.5
Other wires and fittings	3.0
Insulators: • In tension • In bending	 2.5 3.0
Fixings set in concrete or masonry	3.0
Structures	2.5
Against slip for clamps and other gripping devices	1.5

(2) The factor of safety shall be interpreted by the formula shown above:

(3) Factor of Safety < Maximum Allowable Strength quoted in relevant standards/Worst Operating Load

10.3.17 Protection against Corrosion

All ferrous metalwork shall be fully protected by galvanizing or other approved treatment to give a minimum 20-year protection before any remedial action is required against corrosion (e.g. painting).

Any damage to the protective coating of the ferrous metalwork sustained during storage or construction provided it is minor will be repaired by the application of a zinc rich paint. If major damaged is sustained to the protective coating the item will be sent for re-galvanizing.

(1) Facilities for the High Speed Railway Project, Bangkok – U-Tapao Line

The OCS will be designed taking into account the following facilities

(a_ Stations

Stations are plan as follows:

Table 9 : Stations Location

Station	Chainage	Abbr.	Type of platform	Particularity
SA Terminal (Airport)	28+650	SVB (E8)	island platforms, underground	4 tracks, PSDs
Chachoengsao	64+839	CCS	Island platforms	4 tracks
Chon Buri	113+449	CHB	Side platforms	4 tacks
Si Racha	136+119	SRA	Island platforms	4 tracks
Pattaya	160+929	PAT	Island platforms	4 tracks
U-Tapao	196+410	UTP	Island platforms, underground	4 tracks,PSDs

a) Sub Stations

The substation facilities for HSR including 3 Sub Stations (hereinafter referred to as “SS”), 1 Sectioning Post (hereinafter referred to as “SP”) and 11 Sub Sectioning Posts (hereinafter referred to as “SSP”) and 2 Auto Transformer Posts (hereinafter referred to as “ATP”).

Sub Stations are plan as follows:

Table 10 - Sub Stations Location

Name	Location (km)	Remarks
SS-1	Km. 86+900	
SS-2	Km. 185+000	

Name	Location (km)	Remarks
SS-3	Km. 57+000	In Depot
SP-1	Km. 143+000	
SSP-1	Km. 41+000	
SSP-2	Km. 55+000	
SSP-3	Km. 61+000	
SSP-4	Km. 74+000	
SSP-5	Km. 101+000	
SSP-6	Km. 115+000	
SSP-7	Km. 127+000	
SSP-8	Km. 157+000	
SSP-9	Km. 171+000	
SSP-10	Km. 197+000	
SSP-11	Km. 209+000	
ATP-1	Km. 26+700	Lat Krabang Station

b) Depot

Depots are plan as follows:

Table 11 : Depot Location

Depot	Location(km)
Depot	Km. 53+000

c) Operation restricted by Wind

The train operation will be restricted by following wind speeds

Table 12 : Wind Speed for Operation Restriction

Wind Speed	Restriction
25 m/s and above	Operation Restricted
30 m/s and above	Stop of Operation

d) Train Operation Condition

The OCS will probably supply electric power to the high-speed trains. The main train operation conditions, deduced from the HSTP Line operation diagram, are as follows:

- Train set: 8 cars consisting of 6 motor cars and 2 trailers
- Number of train sets: 10 trains per hour
- Operation intervals: 6 minutes

- Maximum designed train speed: 250km/h
- Maximum electric current for the train set with the above conditions: 460A
- Balance current for 250km/h running condition: 165A.

e) Trainset Speed

The OCS is designed for following train operation speed:

- Main Line 250 km/h
- Siding 70 km/h
- Depot and Stabling yard 55 km/h

10.3.18 Configuration of OCS

(1) Feeding System

The following values are recommended as the standards for HSTP line:

- Nominal voltage 25.0kV
- Maximum voltage 30.0kV
- Minimum voltage 22.5kV

These values of voltage are expressed by root-mean-square value (r.m.s.). The maximum voltage is that at the time when a substation supplies no traction power and the minimum voltage is the voltage at the pantograph of an electric train and must not fall below the specified value under normal operation.

- The nominal voltage of feeding system shall be AC 25kV 50Hz. The maximum allowable voltage for continuous shall be 30KV and the minimum allowable voltage shall be 22.5KV. The minimum voltage for the short-time for no more than 20 X 10-3 sec is 20KV.
- The Auto transformer (AT) feeding system shall be applied for the OCS. The feeding system shall be such that the eastern and western sections are fed by different phase sources from a substation and then In and Out bound track at each section (East or West) shall be the same phase.
- There will be two Sub Stations (SS) for the main line tracks as described in Section

2) Sectioning Posts (SP) will be provided between the Sub-Stations. Sub Sectioning Posts (SSP) or Auto Transformer Posts (ATP) will be provided between the Sub Station and the Sectioning Post.

- A neutral of impedance bond shall be connected to Protective Wire (PW) through a Connection of Protective Wire (CPW) at approximately 5km intervals along the track. A neutral of AT shall be connected to a neutral of impedance bond by the Neutral Wire (NW).

10.3.19 Environment Conditions

(1) Temperature

Temperatures for OCS design shall be as follows:

Table 13 : Design Temperature

Item	Standard value	
Air temperature	Maximum temperature	46 degree C
	Standard temperature	30 degree C
	Minimum temperature	15 degree C

(2) Solar Radiation

Design solar radiation shall be 1.0kW/m^2

(3) Wind

Wind speed for OCS bearing and deviations of wires shall be as follows:

Table 14 : Design Wind Condition

Area	Direction of wind	Wind speed	
		for bearing	for deviation of wire
Open	in any direction	40 m/s	35 m/s
Tunnel	in the direction parallel to track	30 m/s	7 m/s
	in the right angle direction to track	7 m/s	

A wind speed of 0.5 m/s shall be applied for the conductor temperature rise calculation.

4) Weather Conditions for OCS Bearing

For a calculation of bearing of the OCS, the following table shall be applied. The most severe conditions shall be used.

Table 15 : Weather Conditions for OCS Bearing

Season	Item	Condition
Summer season	Temperature	30 degree C
	Wind speed	40 m/s
Winter season	Temperature	15 degree C
	Wind speed	35 m/s

(5) Weather Conditions for Deflection and Displacement

For a calculation of deflection of the OCS structure and displacement of OCS wires, the following table, whichever is the severer, shall be applied.

Table 16 : Weather Conditions for Deflection and Displacement Calculation

Season	Item	Condition
Summer season	Temperature	30 degree C
	Wind speed	35 m/s
Winter season	Temperature	15 degree C
	Wind speed	30 m/s

10.3.20 Standard Cross Section of OCS

(1) Standard Cross Section for Open Area

LEGEND

GW : GROUNDED SHIELD WIRE

PW : PROCTIVE WIRE

AF : AT FEEDER WIRE (NEGATIVE FEEDER) M : CATENARY WIRE (MESSENGER WIRE) T :

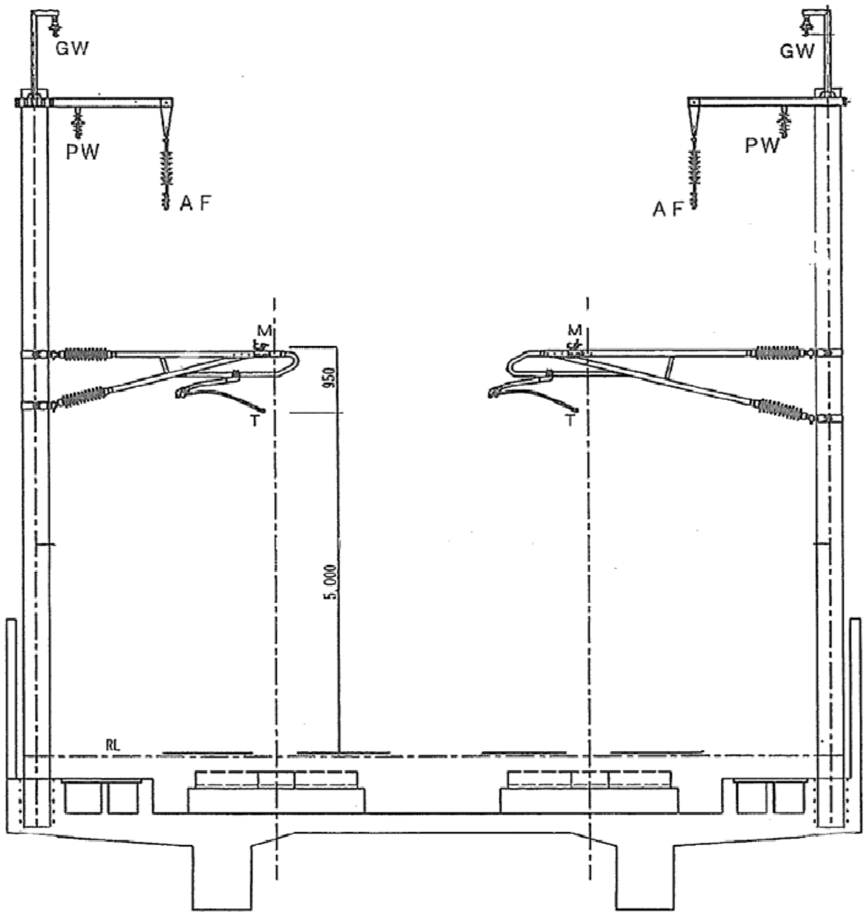


Figure 22 : Standard Cross Section for Open Area

(2) Standard Cross Section for Tunnel Area

LEGEND

PW : PROCTIVE WIRE

AF : AT FEEDER WIRE (NEGATIVE FEEDER) M : CATENARY WIRE (MESSENGER WIRE) T : CONTACT WIRE

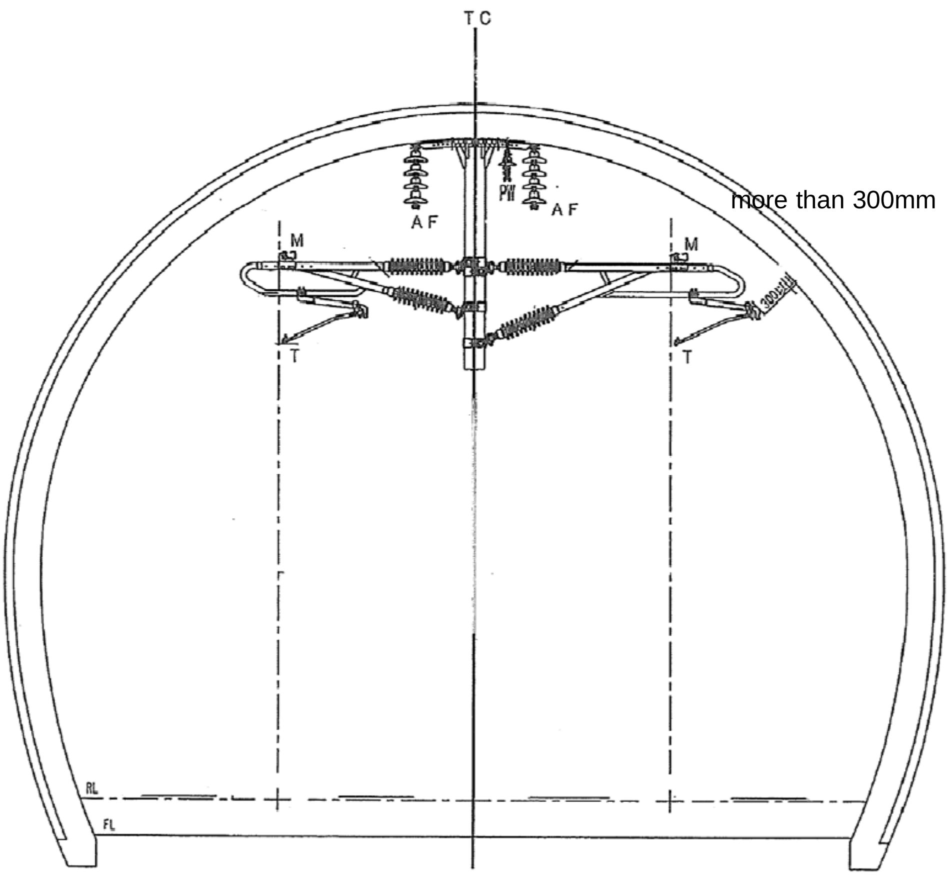


Figure 23 : Standard Cross Section for Tunnel Area

10.4 Earthing and Bonding

10.4.1 All traction bonding shall consist of minimum 150mm^2 aluminum PVC sheathed cable. The Private Party shall however check this size against the loadings identified the power supply system study and the proposed short circuit level.

10.4.2 The Private Party may however suggest alternative material for these bonds to reduce the incidence of theft of these bonds if this is considered a problem. Any substitute material shall however have the equivalent copper cross sectional area as the 150mm 2 aluminum cable.

10.4.3 Where traction bonding has to be connected to the running rail this shall preferably be by the use of studs thermally welded to the neutral axis of the web of the rail. No weld however shall be placed within 150mm of any other rail weld or failed weld to prevent weakening of the rail.

10.5 Auxiliary Supply Equipment

10.5.1 Circuit Breakers

(1) 22kV 3-phase circuit breakers shall use either SF6 or vacuum as the insulation and arc control medium shall be of the indoor type and shall be fully withdraw able for maintenance or repair. Fully automatic lockable shutters shall therefore be provided on both the busbar and cable side connections to ensure safety to maintenance staff when the circuit breaker is in the withdrawn position.

(2) All HV circuit breakers shall comply with IEC60 056 and or equivalent standard.

(3) All LV circuit breakers shall be air insulated and air break and shall comply with IEC60 439 and or equivalent standard.

10.5.2 Auxiliary Supply Transformers

The auxiliary supply transformers shall comply with IEC60 076 and/ or equivalent standard. At Bang Sue bulk supply point they shall be oil insulated transformers. At all stations and depots, etc. If the 22/0.4KV transformers are located indoors they shall be of the dry (cast resin) type.

10.5.3 Control and Protection Equipment

These shall basically follow the requirements for the traction power supply equipment.

10.5.4 Control and Power Cables

These shall basically follow the requirements for the traction power supply equipment.

10.5.5 Switchgear and Panels

These shall basically follow the requirements for the traction power supply equipment.

10.5.6 Uninterruptible Power Supply (UPS)

(1) General Requirements

(a) The UPS shall consist of a rectifier/battery charger, batteries, inverter, static bypass transfer switch, synchronizing equipment, protective devices, external mechanical bypass switch and accessories. Continuity of electric power to essential loads shall be maintained for an emergency period of at least four to eight hours or longer, if so determined by the hazard analysis, with the inverter supplied by the batteries

(b) The UPS shall be indoor, metal enclosed, free standing, vermin proof and fully tropicalized. Space heater with thermostats shall be provided for each panel. All UPS shall have proven track records of use in other installations on tropical conditions. The cubicle shall have the feature of provisions for padlocking with up to two padlocks.

(2) Quality Assurance

(a) The UPS shall be engineered for continuous operation with a "Mean Time Between Failures (MTBF)" of more than 9000 hours.

(b) Schedule of Standards

The whole of the UPS shall be engineered and constructed in accordance with the latest version of the following standards and/or equivalent standards.

i) IEC146

ii) IEC896

iii) EN50121

(3) UPS Functional Requirements

The UPS shall be engineered to operate in the following modes.

(a) Normal

The inverter shall continuously supply the essential loads. The rectifier/battery charger shall derive power from the mains supply and supply DC power to the inverter while simultaneously float-charging the battery.

(b) Emergency

Upon failure of the mains supply the essential loads shall be supplied by the inverter, without any switching, obtains its power from the storage battery. There shall be no interruption of supply to the critically essential loads upon failure or restoration of the mains supply.

(c) Recharge

Upon restoration of the mains supply, and after a planned delay, of no more than 10 minutes, to allow mains supplies to stabilize, the rectifier/battery charger shall power the inverter and simultaneously recharge the battery. This shall be an automatic function and shall cause no interruption of supply to the essential loads. The charging rate shall be sufficient to restore the battery from a discharge condition to a fully charged condition within 10 hours with the full load connected.

(d) Static By-Pass

The static bypass transfer switch shall transfer the loads to an alternate source without any interruption of supply to the loads. The alternate source shall be supplied from a different bus in the main LV switchboard from that supplying the UPS main supply. Re-transfer the load to inverter supply shall be automatic after an adjustable time delay without any interruption of supply to the loads.

(e) Downgrade

If the battery only is to be taken out of service for maintenance, it shall be able to be disconnected by means of a circuit breaker. The UPS shall continue to function as specified herein, except for power outage protection.

(f) Maintenance Bypass Mode

The UPS shall be provided with an external maintenance bypass switch to manually bypass the entire UPS for major maintenance and servicing purposes. Load transfer to and from the bypass source shall be a "make-before-break" type switching such that disturbances seen by the load during a bypass shall not be greater than specified in this Specification.

(4) Equipment Functional Requirements

(a) Self-diagnostic Aids

Each UPS shall be provided with sufficient built in diagnostic aids to facilitate troubleshooting, maintenance and circuit calibration. Each circuit module of a UPS shall be accompanied by suitable indicators and test points allowing the current status of each module to be monitored as required.

(b) Ventilation

Adequate forced air cooling/air conditioning shall be installed to ensure that all components are operated within 20 degrees of their maximum operating temperatures. Fan blowers and essential air conditioning shall be supplied from the UPS and treated as an essential load. All blowers shall be equipped with wind vanes sensor connected to raise an alarm to OCC in case of fault. All air intakes shall be provided with dust filters that cover their entire area. Batteries should be maintained at a temperature of 24°C±2°C or as recommended by the battery supplier.

(c) Rectifier/Charger Unit

i) The rectifier/charger unit shall be provided with moulded case circuit breaker at the "input".

ii) A dry type power transformer of the isolated winding type shall be used for the rectifier unit.

iii) the rectifier/charger unit shall have an adjustable current limiting facility to limit the charger output.

(d) Inverter Unit

The output frequency of the inverter shall be maintained in a phase- locked condition with the frequency of the alternate source as long as it is within the specified limits. In the event the bypass line frequency goes out of tolerance, the inverter shall phase lock to a built-in temperature compensated oscillator. In such a case, the total frequency deviation, including short time fluctuations and long-term drift, shall not exceed ±0.25% from the nominal frequency of 50Hz.

(e) Battery Circuit Breaker

Each UPS shall be provided with a battery circuit breaker.

(f) Control and Indication

i) Instrumentation

As a minimum, the UPS shall be provided with meters that have an accuracy better than ±2% of full scale, as follows:

- Input voltage and current with phase selection
- DC battery charge/discharge current
- DC battery voltage
- UPS output voltage, current and frequency with phase selection
- Alternate source input voltage and current with phase selection

ii) Alarms and Indications

Local alarms shall be provided, as follows:

- Rectifier
  - Input supplies unhealthy
  - Over-temperature shutdown
  - Blown fuse
- Battery
  - Breaker open
  - Discharging
  - Battery low voltage
- Inverter
  - Output voltage unhealthy
  - Phase lock lost
  - Over-temperature shutdown
  - Overload
  - Inverter off
- Static Transfer Switch
  - Transfer to alternate inhibited
  - Re-Transfer to inverter inhibited
- Cabinet Fan failure

iii) Control

System control function shall be provided, as follows:

- UPS bypass transfer/re-transfer switch
- Lamp test/reset push buttons
- Audio alarm test/reset
- AC output voltage adjustable for ±5%

iv) Mimic Bus

- A mimic bus with LED indicating lights shall be provided on the control and indication panel or the system control cabinet. The mimic shall depict a complete single line diagram of the UPS.
- Circuit breakers shall be indicated as below:
  - module AC input circuit breaker
  - battery circuit breaker
  - system output circuit breaker
  - system bypass circuit breaker

(g) Storage Battery

i) battery cells shall be sealed valve regulated lead acid type conforming to IEC896-2 and or equivalent standard. The cells shall be equipped with a low pressure, self-re-sealing safety pressure relieve valve which prevent ambient air from entering but permit gas escape. The cell container and cover shall be reinforced flame retardant material and the battery cells maintained at a temperature of 24°C±2°C.

ii) batteries shall have a design life of not less than 8 years.

iii) a calculation of battery bank sizing shall be submitted to the Engineer's Representative for approval.

iv) batteries shall be supplied with:

- insulated racks in epoxy powder coated cubicles protected with electrolyte resistant paint
- inter-cell and interior connectors protected with anti-corrosive plastic covers

v) all batteries for the UPS shall be of a non-gassing type.

(5) UPS Status

The UPS status (e.g. on-line, by-pass, etc.) shall be indicated at OCC/SOR equipment. Changes in status, such as load on battery, load on auxiliary source, low battery, and malfunctions shall be alarmed and logged at OCC/SOR equipment in accordance with the specifications herein.

(6) Performance requirements: Protection

The UPS shall have built in self-protection against short circuits at the output terminals.

(a) Power semiconductors in the UPS shall be fused with fast acting fuses so that the loss of any single power semiconductor will not cause cascading failures. Each fuse shall be provided with a blown fuse indicator on the panel.

(b) Thermostats shall be fitted to monitor the temperature of the power semiconductors, such that when over temperature is sensed, the UPS shall automatically be shut down and the essential load transferred to the alternate source via the static bypass switch.

(7) Electrical Characteristics

(a) Input

i) Voltage : 0.4 kVac±10%

ii) Frequency : 50Hz±2%

iii) Power factor : Unity to 0.71agging

(b) Output

i) overload capacity 125% for 3 minutes, 150% for 10 seconds

ii) steady state output voltage ±5% manual adjustable regulation loads for balance load

iii) dynamic output voltage ±8% for 50% full load regulation step, ±5% for loss of AC input, ±5% for return of AC input, ±5% for uninterrupted transfer on essential load from UPS to bypass or vice versa, recovery time under all conditions to nominal voltage within 100ms

iv) harmonic content: 3% maximum for any single harmonics, 5% maximum for total value

(8) Efficiency

The efficiency shall be 80% minimum when UPS is supplying rated load w

battery fully charged.

(9) Radio Suppression

When operating, the UPS shall limit radio interference in accordance with IEC62040, EN50091 and or equivalent standards.

(10) Labelling and Protective Covers

(a) Danger signs and labelling required by local regulations, standards and electrical supply company shall be displayed prominently at appropriate places on the UPS. UPS panels shall have a main identification nameplate and each outgoing circuit shall be clearly identified by a device code and circuit name in accordance to its function. Labels shall be installed at the front and back of panels. Each label shall be fixed with self-taping screws.

(b) The Private Party shall supply all necessary primary and secondary cable terminals, cable terminals for control, grounding system assemblies, specification nameplate and other necessary assemblies.

10.5.7 Standby Diesel Generator Set

(1) For each station and depot and any other strategic installation using the 22kV auxiliary supplies, the Private Party shall supply and install a suitably rated diesel engine generator set, complete with skid plate base, LV switchboard and control panel and all pipe fittings, suitable insulation protection and fuel, lubricant and water tanks.

(2) The Private Party shall carryout a study of all required installations and calculates the maximum loads required to ensure the generator set he supplies is sufficient for all essential power requirements in the event of a loss of the mains power. The Private Party shall also include in the report the type and rating, manufacturer and supplier's specifications for all installations to the Engineer's Representative for approval within 180 days after NTP.

(3) The Private Party shall also give details on operation and maintenance of the diesel engine and generator set, switchboard and control panel to the Engineer's Representative for approval.

10.6 HV Cables, Cable terminations and Cable Joints

10.6.1 HV Cables

All 25kV single-phase (44kV system voltage) and 22kV 3-phase cables shall comply with IS060 502 and have XLPE as their insulation medium and be low smoke, zero halogen for inside applications. The following shall also apply:

(1) Cable insulation and sheaths shall be non-toxic

(2) Cable sheaths shall be impregnated with repellents for rodents and termites

(3) Cable sheaths shall be embossed with identification marks for cables of different voltage grades

(4) The insulation and sheaths of cables used in the above-ground or in buried cable troughs sections shall be fire retardant and low smoke, zero halogen. Mylar or other suitable nonmetallic armor sheathing may be employed.

(5) All cables shall be identified with cable markers, at reasonable intervals, for easy selection during fault location or corrective maintenance activities. The format of the

markers shall be submitted by the Private Party to the Engineer's Representative for approval prior to installation of the cables.

10.6.2 HV Cable Terminations

All HV cables shall be terminated using approved proprietary termination products suitable for the cables being terminated. All cable terminations shall be carried out by suitably qualified and certified staff.

10.6.3 HV Cable Joints

(1) Ideally there should be no HV cable joints however if there is a HV cable run greater than the length of cable able to be wound on a cable drum and joints have to be provided these joints shall use proprietary cable jointing kits suitable for the cables being jointed.

(2) The position of any cable joints will dearly be shown on cable plans, etc.

10.7 Power SCADA

10.7.1 General

(1) To ensure normal electric operation, the electric power dispatcher monitors and control the SS, the overhead catenary system, the transmission line, and the distribution line, as well as performs power supply management, work management, measurement of electric power used, etc. The Power SCADA for SS is a computer system that supports the work of the electric power dispatcher.

(2) The method of presentation of information and the method of control shall be via full colour LCD 21" flat screen monitors so as to be uniform in presentation with the Signaling and communications systems monitors in the (OCC) CCR and SOR's, etc. with mouse and standard QWERTY keyboards and mouse controlling windows. The size of VDU display shall be 21". There shall be two control positions within the electrical control room and it shall be possible to carry out full control and receive indications at either of the two positions. The SCADA equipment shall control and monitor both the traction and auxiliary supply networks. Each control position it is envisaged shall have two VDU's- one showing the traction network and the other the auxiliary supply network though these should be inter-changeable between VDU's. The Private Party may however propose only one VDU per control position however in this case it must be clear as to what system is being displayed. Both systems shall not be displayed on the same VDU page.

(3) In addition to the VDU's an indicate only mimic panel or wall display shall be provided showing the overall track layout and the traction feeding arrangement and a separate display for the auxiliary supply feeding arrangement.

(4) The VDU's, wall display panel and the print out on the SCADA logger printers shall have the Thai language as the basis. Although most of the machinery operations of dispatching will be performed automatically, the decision-making will be done by the dispatchers, such as planning power supply, managing maintenance work, giving instructions in the case of accidents or equipment failure, coordinating competing maintenance work, etc. Table 18 shows basic Items of monitoring and control for Power SCADA. Table 19 shows basic functions of power SCADA. Figure 25 shows configuration of power SCADA

Table 17 : Basic Items of Monitoring and Control for Power SCADA

Items for Monitoring	Items for Control
Switchgear for power receiving	Switchgear for power receiving
Power transformer	Switchgear for power supply (25kV)
Switchgear for power supply (25kV)	Switchgear for power distribution line
Switchgear for power distribution line	

Table 18 - Basic Functions of Power SCADA

No.	Subject	Content
1	Individual control function	The dispatcher controls the items of equipment individually.
2	Specification control function	Perform pattern control of the feeding system and power distribution system
3	Scheduled operation function	Energize/de-energize, perform routine operation based on a schedule set up in advance
4	Monitoring function	Display the operation status of the equipment and the system on a display screen, supervise any failure or status change, output alarm, and renew display
5	Processing function when failure occurs	Protect against linkage interception, and energize/de- energize power transmission line and power distribution line in case of failure.

No.	Subject	Content
6	Operation/failure recording function	Accumulate control contents, status change contents, and breakdown record as information of the time series; and output to a display or a printer, if required.
7	Measurement value display function	Display various measurement values on a skeleton screen or in a tabular format in real time.
8	Data recording function	Record the amount of electric power, etc.; output various daily and monthly reports; and perform data management.
9	Maintenance statistics processing function	Accumulate information on operation time and frequency based on data on the status and failure of the equipment, and utilize the information as maintenance support data.

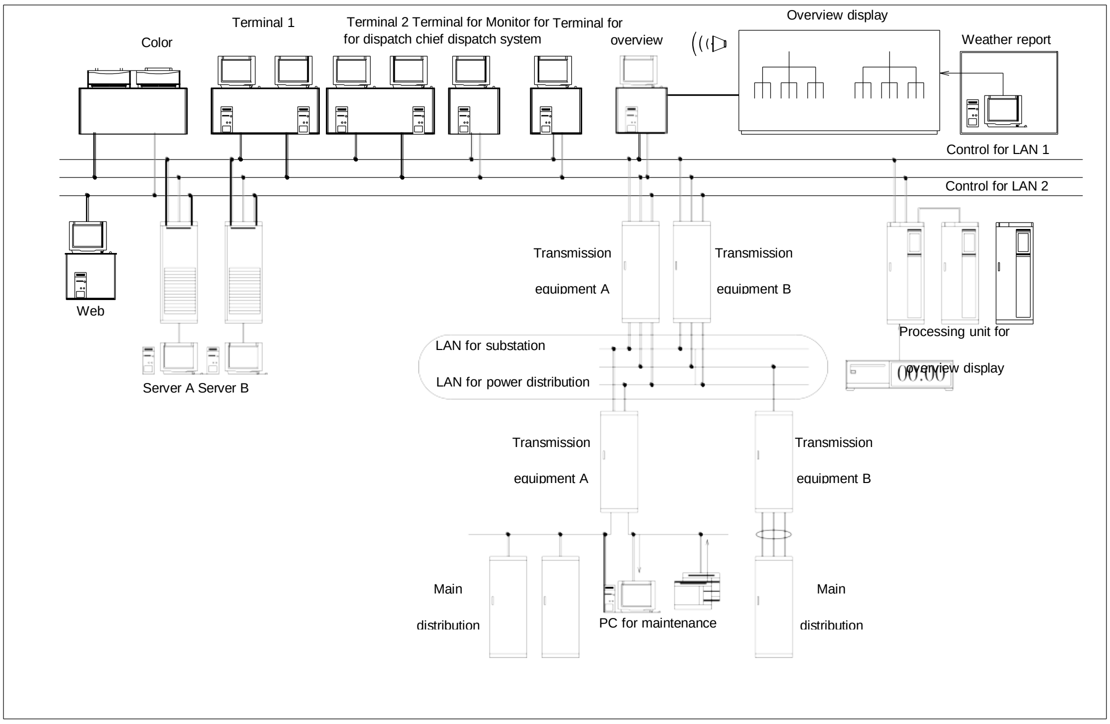


Figure 24 : Configuration of Power SCADA

(5) The SCADA equipment to be supplied will report any change of occurrence at a sub station or station within 4 seconds of an event occurring. These 4 second times will

be the maximum time between the event occurring and the information being displayed to the electrical control room operator with all relevant pages on the VDU updated with the new information and available to the operator.

(6) This 4 second interval will also apply to a control command being initiated at the control room to the information being received back of the new state of the equipment and displayed to the operator.

(7) The system should be capable of extension by a further 20% of sub-stations or Remote Terminal Units (RTU's) whilst maintaining the times given above.

(8) All unsolicited changes of state, be they either single bit alarms or changes to the position of controlled devices shall, on detection in the control room, ring a bell or sound a buzzer to bring to the operator’s attention that an event has taken place. The sound of the audible devices shall be different for a master station generated alarm to that of an outstation generated alarm. Preferably there should also be a different sound for an alarm generated within the traction equipment to that generated by the auxiliary supply equipment.

(9) The power SCADA shall be highly reliable and it shall have adequate redundancy.

10.7.2 Master Station Equipment

(1) The master station equipment will consist of a duplicate master stations with one running the system and the other on warm standby automatically taking over control of the system should a fault occur on the operational system.

(2) Should the system change over to the standby machine this shall be fully on line within 5 minutes of the changeover occurring. Should however it become necessary to carry out a command at any one outstation during this five minute period the equipment should be capable of being forced to update its data base for that outstation in preference to other outstations to allow that command to proceed. Alternatively, a hot standby system where both master’s stations are on line and are being updated as far as their data basis is concerned on a real-time basis can be offered. In this case however the Private Party will be expected to prove that a fault on the on-line machine will not transfer itself to the off-line machine or vice-versa.

(3) The system architectural arrangement of the master station should be such that the eventual user or maintainer of the SCADA system can easily alter the data base {adding additional RTU's, or adding or removing control and indication facilities and analogue facilities, etc.) without interfering with the base software programmers running the system.

(4) VDU Presentation to the Operator - VDU Display

Note: All VDU displays shall be submitted by the Private Party to the Engineer's Representative for approval.

(1) Master Station Page

A master station page shall be provided giving the following information:

(a) Details of the master stations on and off line and their status

(b) The status of the wall displays

(c) The state of the event loggers

(d) The pilot in operation for each sub-station or RTU

(e) The number of delivery failures of the pilot system during the previous half-hour for each sub-station

(f) Any alarm conditions relating to the master station equipment

(g) The status of the UPS equipment and the display of any alarm conditions relating to this equipment.

(2) Traction Display

(a) The presentation to the operator on the VDU shall be by means of graphic pages similar to what would be shown on a mimic diagram. In this respect, the Private Party shall propose a colour coding for the various tracks i.e. up lines, down lines, bi-directional lines, loop lines, sidings, 115kV connections, 2x25kV or 25kV connections, etc. This colour coding should be such that the different tracks and feeders re easily identifiable.

(b) The presentation shall be presented on the following pages:

i) Overview Page

- this page will show the complete traction system with the general layout of the major feeding arrangements. It will also show the position of all circuit breakers and motorized isolators however it shall not be possible to carry out any controls from this page. The sub-station/AT location names shall normally be written in black letters. However should there be an outstanding alarm at a particular outstation the sub station name shall be boxed in red. In the case of an alarm at an outstation being present but not yet accepted this red box will flash.
- from this page by clicking the mouse on the sub-station name it shall be possible to go directly to sub-station page.

ii) Sub-station Pages

- there shall be a page for each sub-station from which controls can be executed. In addition to the actual sub-station which controls are required to be performed, this page shall also show the state of the circuit breakers/motorized isolators at adjacent sub-stations and which are at the other end of the electrical sections from the sub-station whose page is displayed. It shall not however be possible to control these circuit breakers/isolators at the adjacent sub-stations from this page.
- controls shall be carried out by clicking the mouse on the symbol of the item to be controlled. This will cause the selected device symbol to flash and a window will then appear giving the option of control, i.e. whether an open or closed command is requested.

Note: It shall be possible to put through an individual command, e.g. to open or dose a circuit breaker/isolator even although the circuit breaker/isolator may already be in that condition.

- a check-back routine to ensure the correct device is selected at the sub-station will be used before any command is given to the device. This can either be done when the device is selected or just before the command is given. Invalid selection of the correct device at the sub-station will abort the execution command.
- once the option of command is chosen (i.e. open or close) the window shall then be replaced with another window giving the option of operation and once chosen the master station equipment shall arrange to operate the device.
- it shall be possible to abort the command at any stage up until the mouse is clicked on the operate section of the operate window. Also if any window has been on the VDU screen for a period of 30 seconds (this time should be adjustable within the software between 5 seconds and 1 minute) and no selection having been made the window will disappear and any selection made de-selected.
- the SCADA equipment shall be able to differentiate:
  - a successful command in which case the symbol on the VDU will change.

  - a trip on close command in which case this will be brought back as an alarm condition.
  - a failure of the command, i.e. the device has not operated. In this case the symbol of the device will not change but a banner message shall appear at the foot of the VDU screen that the command has been unsuccessful.

- mass closure of circuit breakers (closure of more than one circuit breaker with one dose control command) will not be acceptable however mass tripping of circuit breakers may be acceptable.
- it shall be possible to provide a software lock on any circuit breaker or motorized isolator to prevent the operator trying to control the device without a conscious effort to remove the software lock before operating the device. Indication shall appear next to the device symbol that this software lock has been applied.
- each circuit breaker or motorized isolator shall be capable of displaying the three possible states of the device, i.e. open, closed and indeterminate where the auxiliary contacts on the circuit breaker or isolator 13re in the 0,0 or 1,1 states. In the case of three position motorized isolators being proposed the SCADA shall also be capable of displaying the four states, i.e. open, close, alternative and indeterminate.
- should control of the outstation be lost between the operate command and the indication back of the position of the device the system in addition to indicating loss of control will also show the device in the indeterminate state.
- the choice of the symbols denoting a device in the open, closed or indeterminate position shall be such that it is clear to the operator which of the above three states the device is in. These will also have to be agreed to by the Engineer's Representative.
- in regard to a controlled device changing state without an operate command being given the appropriate symbol on the VDU will flash and the alarm bell or buzzer sound; It shall be possible to accept the new state of this device from the sub- station page by clicking the mouse on the flashing device which will then produce a window giving the option selecting the new position of the device and silencing the alarm bell or buzzer. Should more than one device change state each device shall have to be separately acknowledged. The alarm bell or buzzer shall not be silenced until the last device has been accepted. Likewise, if a single bit alarm condition is received at the same time as this unsolicited

change of state the alarm bell or buzzer shall continue to sound until all alarms are accepted.

- on the sub-station pages for the Bang Sue bulk supply point next to the transformer symbol shall be a box denoting the following analogues: busbar voltage, power demand during last 30 minutes and power factor.
- it shall be possible to tell from the sub-station page if there are any single bit alarms at that outstation and any indication of an incoming alarm will be displayed on this page. Controls however should still be operational even although there a alarms not accepted on the system.
- at the top or bottom of the sub-station page there shall be displayed the major single bit alarms as an alpha-numerical code. These will normally be white when in the healthy condition, flashing red when in alarm but not accepted and steady red when accepted.

iii) Alarm Pages

- an alarm page (one for each sub-station) for single bit alarms shall be provided broken down into permanent and fleeting alarms. These pages shall be accessible directly from the respective sub-station page. Acceptance of incoming alarms and silencing of the alarm bell or buzzer for these single bit alarms shall be carried out only from this page.
- the alarm page shall show the date and time the alarm appeared together with a full description of the alarm.
- all fleeting alarms shall be displayed until they are accepted when they shall disappear.
- all permanent alarms will flash until they are accepted at which stage they will go to a steady indication. Whilst the silencing of the alarm bell or buzzer will silence the alarm for all un-accepted alarms at that sub-station (if there are other sub-stations with un-accepted alarms the bell or buzzer should continue to sound) each alarm condition will have to be accepted individually for them to go steady.
- the clearance of a single bit alarm (i.e. it returning to the healthy state) shall be treated exactly like an incoming alarm with the exception that on acceptance the alarm banner will disappear.
- a separate alarm page accessible from the master station page will be provided detailing all master station alarm conditions. This alarm page can be incorporated in the master station page if required. These alarms

will be treated inexactly the same manner as an alarm condition arising from an outstation.

iv) Sectioning Pages

- sectioning pages giving the track layout and major electrical equipment shall be provided. On these pages, it shall be possible to "hand dress" within the software the position of any manually operated overhead line or sub-station isolators.
- it should be noted that some isolators may be three positions (open, closed and alternative or open, closed and earth) and the software should be capable of showing these three states.

v) Event Log Pages

- a number of pages shall be allocated to record events handled by the SCADA equipment over a period of time. This information will be identical to that printed out on the event printers
- sufficient space shall be allocated to store a minimum of 4000 entries. Once the store is full the first 1000 entries shall be deleted such that there is always a chronological log of events. Alternatively, a rolling scroll of events will be acceptable where once the event list becomes full any future events required to be added to the list shall delete one off the front of the list to make room for the latest event. In any event it shall be possible to download all or certain sections of the event log to external electronic storage devices (CO's or other data storage devices) for permanent storage or to analyze separately the sequence of events associated with a major incident.
- the information contained in this list should be capable of being printed out either in full or in part on either of the event printers.

(3) Auxiliary Supply Display

(a) The representation of the auxiliary supply network and its control and indication shall follow as far as possible that described for the traction network described above.

(b) There shall also be event log pages associated with the auxiliary supplies.

10.7.3 Mimic / Wall Display

(1) An indication only mimic/wall display shall be provided to show the over track layout and feeding arrangement both for traction and auxiliary supply the mimic/wall display shall be positioned such that it is possible to view t entire display whilst seated at the control desks.

(2) A fault on the drive to the mimic/wall displays shall not interfere with the operation of the VDU's.

10.7.4 Event Printers

(1) Two event printers shall be provided. One of these shall log all SCADA housekeeping information including a print out of the number of delivery failures to each sub-station each hour whilst the other will log all operational information such as initiation of commands, alarm conditions, changes of state, etc. The switching off of an event printer for changing paper, etc. will not mean the loss of the information to be printed but the information will be kept in buffer storage until the printer is back on line. It shall be also possible to arrange all information to be printed out on one or either of the printers on the long-term loss of a printer. there should be three event printers- one for housekeeping information,

(2) The Private Party shall determine from an operational point of view whether there should be three event printers – one for housekeeping information, one to record all operational information on the traction system and the third record all operational information on the auxiliary supply system.

10.7.5 Communication with Remote Terminal Units (RTU's)

(1) Communication with the RTU's on the project shall be by duplicate A and B pilots. The SCADA system should operate on both pilots with the facility of locking an individual RTU onto either the A or B pilot. Control of which pilot an individual RTU is locked onto shall be carried out either from the individual station page or from the master station page.

(2) Any changeover from one pilot to the other shall take place without interruption to the system.

(3) The system shall operate in point to point mode (preferred) or on an omnibus system however the controlling factor will be to meet the timings stated in these Contract Specifications.

(4) The system shall operate in full duplex mode. The communications network which shall be over fiber optic networks provided by the telecommunications part of this Contract.

10.7.6 Software Security

Entry into the software to change the database will be restricted by a two-stage software password so that only authorized personnel have access. The first stage will restrict access to picture configuration and data information and the second stage will restrict access to the system program.

10.7.7 Remote Terminal Units' (RTU)

(1) RTU's shall be provided at each location where control and monitoring facilities are to be required. They shall be run off the sub-station battery at the TSS or in the case of stations the station UPS. If the SCADA RTU at TSS is run off the 400/220V domestic supply it shall be capable of automatically switching to the battery supply in the event of failure of the AC supply.

(2) The RTU's can either be intelligent (i.e. they may undertake routine operations themselves without the intervention of the master station although information will be required to be transmitted back to the OCC) or be purely slaves.

10.7.8 Two RTU's should be provided with the various control and indications divided between the RTU's at BCC so that the failure of one individual RTU or the transmission network to it will not mean the total loss of control at the bulk supply point.

10.7.9 These RTU's shall include:

(1) All printed circuit cards for the operation of the system.

(2) An input and output terminal block

(3) Any necessary devices to drive remote operational devices e.g. motorized overhead line isolators.

(4) Line termination units and line changeover devices.

10.7.10 In regard to the input (single bit and controls)/output requirements these shall be proposed by the Private Party but shall be submitted to the Engineer’s Representative for approval. An additional 20% shall then be added for possible future alarms and controls.

10.7.11 Power Supplies at the Control Room

The master station equipment and Man Machine Interfaces (MMI's) at the OCC shall take power from the main UPS equipment supplying power to all other operationally critical equipment with the OCC.

10.7.12 Details of the state of this UPS shall be shown on the master station page of the SCADA equipment as stated in these Specifications

10.7.13 Emergency Control Facility

An emergency control facility shall be provided at a location as approved by the Engineer’s Representative that should a total loss of control from the main OCC be experienced or an emergency evacuation of the OCC is required (due for example to a fire in the building), the control function can be exercised from a different location

10.7.14 This emergency control shall consist of one master station, one workstation and one event printer.

10.7.15 The presentation on the VDU at the workstation shall be identical to that at the main electrical control room with the same control and indicate facilities.

10.7.16 Normally this emergency control facility shall be off line and not powered up however facilities shall be provided for the periodic powering up and testing of the equipment. This facility shall be provided such that it does not affect the main operational equipment.

10.7.17 The Private Party may however propose a different approach to the provision of this emergency control facility provided the overall objectives are met.

10.7.18 Optical isolator

In the case of supply point of incoming SCADA and telephone lines are by means of copper cables, optical isolators shall be provided on the incoming SCADA and telecommunication lines to separate the earth of the sub-station from the rest of the telecommunications network.

10.7.19 Provision of a Personal PC

In addition to the SCADA equipment described above the Private Party shall also provide a Personal Computer (PC) so that the operator can type reports, receive and send emails, etc. without these tasks having to be carried out on the main SCADA MMI computers.

11. TESTING, COMMISSIONING AND VERIFICATION

11.1 General

Tests shall be performed in accordance with the requirements of this Specification as outlined below.

11.2 Testing and Commissioning Plan

11.2.1 The Private Party shall develop a testing and commissioning plan and test specifications for putting all electric power systems into working service, for approval by the Engineer's Representative.

11.2.2 As a minimum, the Private Party's testing and commissioning plan shall include the following:

(1) Factory Acceptance Tests

(2) Bench Tests

(3) Installation Tests

(4) Sub-system Test. (inducing PSA supply interface)

(5) System Integration Tests

(6) Systems Interface Tests

(7) Integration Systems Test

(8) Structure Gauge Test

(9) System Dynamic Tests

(10) Test Running Tests

(11) Trial Running Tests

(12) Maintenance Demonstration Tests

(13) Reliability Tests

(14) Environmental Tests.

11.3 Certification of Tests

11.3.1 Test records and test certificates duly endorsed by the Private Party's professional engineer are to be submitted for the review and approval by the Engineer's Representative in accordance with the Specifications of this Contract. These test records and certificates shall be supplied for all tests, whether or not the Engineer's Representative has witnessed them. The information given on such test certificates shall be sufficient to identify the materials or equipment to which the certificate refers.

11.3.2 The Private Party shall cooperate with the SRT's independent checking engineer for verification and certification that the Electric Power system is fit for use.

11.4 Demonstration Tests on Completion

Integrated Testing refers to those tests undertaken in order to demonstrate that the T various components of the rail link transit system operate satisfactorily between another and meet all specified requirements for engineering, operability, safety, if integration with other works and systems. In particular the Private Party demonstrate that the application of a short circuit to the OCS equipment (location(s) to be proposed by the Private Party but approved by the Engineer's Representative) will not affect the signaling and telecommunications equipment and that the voltage limits for step and accessible voltages specified in BS EN50122 are not exceeded and that the induced voltage into the longest running parallel physical copper cable (either telecommunications or signaling) is under the maximum allowable voltage specified in the ITU requirements. The final Integrated Testing and commissioning shall be carried out after the SCADA/SMS system and OCC have become operational.

11.5 Trial Running

The Private Party shall provide special and general attendance during the service trials period such that the persons who carried out the On-Site Testing and Commissioning are available on site to solve any problem arising from the service trials.

12. DOCUMENTATION

12.1.1 The documents delivered within the Private Party scope of supply will be in accordance with IEC, EN, VDE and International Standards. The documents that are required for all of the works of the Electrical Power Systems must be made available according to the milestones set for the detailed works schedule.

12.1.2 The documentation structure is divided in a hierarchical order, providing the information for service, operation and maintenance in the form of:

(1) General documentation - will present an overview of all of the power supply system and contain system-wide information such as:

(a) Designation system

(b) Symbol list

(c) Overall System single line (drawings)

(d) Information concerning interconnection between stations

(e) Major and minor feeding diagrams.

(2) Sub-station documentation - The sub-station documentation both for traction and auxiliary supplies will show details of the equipment such as:

(a) Equipment arrangement drawings

(b) Sub-station single line (drawings)

(c) Circuit manuals and electrical schematics

(d) Cable lists and termination drawings

(e) Construction engineering drawings

(3) OCS Documentation

(a) Standard system drawings including design information, general arrangements, assembly arrangements, sub-assembly arrangements and components.

(b) OCS layout plans

(c) OCS cross sections

(d) Switching cross sections

(e) Height and Stagger tables

(f) Foundation details

(g) Isolation Diagrams

(h) Earthing and bonding Diagrams

13. EMC AND ENVIROMENTAL

13.1 Electro-magnetic Compatibility (EMC) Requirements

13.1.1 General

(1) The requirements for EMC compatibility as stated below shall be read in conjunction with the EMC requirements in this Specification and all the relative standards as proposed by the Private Party and agreed by the Engineer's Representative.

(2) An EMC control plan shall be submitted to the Engineer's Representative for review and approval.

(3) The EMC control plan shall include measures to reduce conducted, Induced and radiated emissions, especially the levels of harmonics, to acceptable values as specified by the relevant international standards.

(4) The plan shall analyze EMI/EMC impacts on the engineering of the train, all other train borne equipment and trackside equipment as well as the general environment. Particular attention should also be paid to additional requirements in grounding, bonding, shielding, filtering, and cabling arrangements.

(5) The Private Party is required to provide "Type Test" certification that EMC is demonstrated. Testing shall include but not limited to the following standards:

(a) Overall compliance:

i) EN50121-1

ii) EN50121-2

iii) EN50121-5

iv) EN50123

(b) Specific standards: Immunity

i)	Electrostatic discharge	IEC61000-4-2
ii)	Radio frequency fields	IEC61000-4-3
iii)	Power frequency magnetic field	IEC61000-4-8
iv)	Pulse magnetic field	IEC61000-4-9
v)	Damped oscillatory magnetic field	IEC61000-4-10

(c) Emission:

i)	Radiated emission	EN50121-5
ii)	Conducted emission	EN50121-4
iii)	IEC61000-2-6/	
iv)	IEC61000-3-2/	
v)	IEC61000-3-3/	

vi) IEC61000-3-4

13.1.2 The achievement of EMC, with respect to the above standards, shall be demonstrated to the Engineer's Representative.

13.2 Environmental Compatibility

13.2.1 General Requirements

(1) In engineering, construction and operation of the rail link system, the rules relating to electrical safety and protective provision and immunization of equipment against EMI conducted traction currents from adjacent transit systems shall be followed. The Private Party shall investigate and take appropriate action to minimize the effects of any DC system may have on the HSR project area especially in regards to cathodic corrosion.

(2) The Private Party shall engineer the entire system of earthing, bonding, and connections of return current circuit, means of measuring of track voltages and leakage currents, determination and calculation of safe touch and step potentials, measurement of conductivity of Structural Earth (SE) against reference electrodes.

(3) The Private Party shall coordinate with the Mass Rapid Transit Authority (MRTA) and Bangkok Transit System (BTS) for a study of safety equipment for achievement of EMC between the transit systems and, and report if any immunization is to be provided, to the Engineer's Representative.

13.2.2 Traction Return System

(1) The traction return shall be the running rails, the negative feeder. (where supplied, overhead ground wire and general mass of the earth)

(2) The traction return bus shall be connected to earth.

(3) The engineering of the traction return or earthing system shall not compromise broken rail detection by track circuits of the signaling system.

13.2.3 Lightning Protection

Surge arrestors with counters shall be provided in accordance with the OCS schematic drawings, at the following locations:

(1) At all feeder circuit breaker terminals as an integral part of the circuit breaker housing or immediately outside the circuit breaker.

(2) Where 25kV cables are installed between the feeder circuit breaker and the OHL or where the negative 25kV feeder is replaced by a HV cable, surge arrestors shall be installed on the OHL side of the cable and connected to the cable terminations.

(3) At AT locations to provide protection to the AT.

14. LIST OF APPROPRIATE STANDARDS

14.1 International Electro Technical Commissions (IECs)

IEC 60076-1 (2011)	General for transformer
IEC 60076-2 (2011)	Temperature rise for liquid-immersed transformer
IEC 60076-3 (2011)	Insulation levels, Dielectric test and external clearance in air
IEC 60076-5 (2006)	Ability to withstand short circuit
IEC 60076-10 (2001)	Determination of sound level
IEC 60076-15 (2008)	Gas-filled power transformer
IEC 60214 (2003 etc.)	On-load tap changers
IEC 60616 (1978)	Thermal and tapping marking for power transformer
IEC 62067 (2011)	Power cables with extruded insulation and their accessories for rated voltage-Test methods and requirements
IEC 60060 (2011)	High-voltage test techniques
IEC 60071 (2011)	Insulation co-ordination
IEC 60183 (1984)	Guide to the selection of HV cables
IEC 60228 (2004)	Conductors of insulated cables
IEC 60229 (2007)	Tests on extruded over sheaths with a special protective function
IEC 60230 (1966)	Impulse test on cables and their accessories
IEC 62271 (2011)	HV switchgear & control gear
IEC 60051 (1997 etc.)	Direct acting indicating analogue electrical measuring instruments & their accessories
IEC 60059 (2009)	IEC standard current ratings
IEC 60068 (1988 etc.)	Environmental testing
IEC 60073 (2002)	Basic and safety principles for man-machine interface, marking and identification –Coding principles for indicators and actuators
IEC 60085 (2007)	Thermal evaluation and classification of electrical insulation
IEC 60270 (2000)	HV test techniques partial discharge measurements

IEC 60376 (2005)	Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment
IEC 60439 (2005)	Low-voltage switchgear and control gear assemblies
IEC 60445 (2010)	Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals and conductor's terminations
IEC 60447 (2004)	Basic and safety principles for man-machine interface, marking and identification - Actuating principles
IEC 60480 (2004)	Guidelines for the checking and treatment of sulfur hexafluoride (SF6) taken from electrical equipment and specification for its re-use
IEC 60502 (2010)	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV)
IEC 60507 (1991)	Artificial pollution tests on high-voltage insulators to be used on AC. Systems
IEC 60529 (2001)	Degrees of protection provided by enclosures (IP Code)
IEC 60695 (2009 etc.)	Fire hazard testing
IEC 60721 (2002 etc.)	Classification of environmental conditions
IEC 60909 (2001 etc.)	Short-circuit currents in three-phase ac. Systems
IEC 61000 (1992 etc.)	Electromagnetic compatibility
IEC 62271-102 (2001)	HV switchgear and control gear - Part 102: Alternating current disconnecting and earth switches
IEC 60137 (2008)	Insulating bushings for alternating voltages above 1000 V
IEC 60865 (2011 etc.)	Short-circuit currents - Calculation of effects
IEC 60168 (2001)	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000 V
IEC 60273 (1990)	Characteristic of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V

IEC/TS 60815 (2008)	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
IEC 60871 (2005 etc.)	Shunt capacitors for AC Power systems having a rated voltage above 1000 V
IEC 60044 (1996 etc.)	Instrument transformers
IEC 61131 (2003 etc.)	Programmable controllers
IEC 60255 (2009 etc.)	Measuring relays and protection equipment
IEC 62052 (2003 etc.)	Electricity metering equipment (AC)
IEC 60099-4 (2009)	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for AC systems
IEC 61936-1 (2010)	Power installations exceeding 1 kV ac. - Part 1: Common rules
IEC 62128-1 (2003)	Railway applications – Fixed installations - Part 1: Protective provisions relating to electrical safety and earth
IEC/TS-TR-60479 (2005 etc.)	Effects of current on human beings and livestock
IEC 60364-4-41 (2005)	Low-voltage electrical installations - Part 4-41: Protection for safety - Protection against electric shock
IEC 61140 (2009)	Protection against electric shock - Common aspects for installation and equipment
IEC 60850	Railway application-supply voltage to traction systems
IEC 60913	Electric traction overhead lines
IEC 60502-1 Ed.2.1:2009	Power cables with extruded insulation and their accessories for rated voltages from1 kV up to 30 kV - Part 1: Cables for rated voltages from 1 kV and 3 kV
IEC 60502-2 Ed.2.0:2005	Power cables with extruded insulation and their accessories for rated voltages from1 kV up to 30 kV - Part 2: Cables for rated voltages from 6 kV up to 30 kV
IEC 60287-3-1 Ed.1.1:1999	Electric cables - Calculation of the current rating - Part 3-1: Sections on operating conditions - Reference operating conditions and selection of cable type

IEC 60287-3-2 Ed.1.0:1995	Electric cables - Calculation of the current rating - Part 3: Sections on operating conditions - Section 2: Economic optimization of power cable size
IEC 60287-3-2 Amd.1 Ed.1.0:1996	Amendment No. 1 to IEC 60287-3-2
IEC 60296 Ed. 3.0:2004	Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear
IEC 62271-1 Ed. 1.0:2007	High-voltage switchgear and control gear - Part 1: Common specifications
IEC 60099-5 Ed.1.1:2000	Surge arrestors - Part 5: Selection and application recommendation
IEC 62305-1 Ed. 2.0:2010	Protection against lightning - Part 1: General principles
IEC 62305-4 Ed. 2.0:2010	Protection against lightning - Part 4: Electrical and electronic systems within structures
IEC 60364-5-54 Ed.2.0	Electrical installations of buildings - Part 5-54: Selection
:2002	and erection of electrical equipment - Earthing arrangements, protective conductors and bonding conductors
IEC 60034	Rotating electrical machines
IEC 60038	IEC standard voltages
IEC 60050	International electromechanical vocabulary
IEC 60056	High-voltage alternating current circuit breakers
IEC 60077	Rules for electric traction equipment
IEC 60129	Alternating current dis-connectors (isolators) and earthing switches
IEC 60146	Semiconductor converters
IEC 60156	Insulating liquids - Determination of break down voltage at power frequency - Test Method
IEC 60185	Current Transformer
IEC 60258	Direct acting recording electrical measuring instruments and their accessories

IEC 60265	High voltage switches
IEC 60269	Low-voltage fuses
IEC 60298	AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52kV
IEC 60332 Part 1	Tests on electric cables under fire conditions-Part 1: Test on a single vertical insulated wire or cable
IEC 60332 Part 3	Tests on electric cables under fire conditions-Part 3: Test on bunched wires or cables
IEC 60354	Loading guide for oil-immersed power transformers
IEC 60420	High voltage alternating current switch fuse combinations
IEC 60517	Gas insulated metal enclosed switchgear for rated voltages of 72.5kV and above.
IEC 60521	Class 0.5, 1 and 2 alternating-current watt-hour meters
IEC 60542	Application guide for on-load tap changers
IEC 60551	Determination of transformer and reactor sound levels
IEC 60664	Insulation co-ordination for equipment within low voltage systems
IEC 60694	Common specifications for high-voltage switchgear and control gear standards
IEC 60722	Guide to the lightning impulse and switching impulse testing of power transformers and reactors
IEC 60726	Dry type Power Transformer
IEC 60754-2	Test on gases evolved during combustion of electric cables-Part 2: Determination of degree of acidity of gases evolved during the combustion of materials taken from electric cables by measuring pH and conductivity
IEC 60811	Common test method for insulating and sheathing materials of electric cables
IEC 60859	Cable connections for gas-insulated metal-enclosed switchgear for rated voltages of 72.5kV and above

IEC 6004-3	Photo voltaic devices. Part 3: Measurement principles for terrestrial photo voltaic (PV) solar devices with reference spectral irradiance data
IEC 60947-1 Ed. 5.0:2007	Low-voltage switchgear and control gear - Part 1: General rules
IEC 60947-1 Amd.1	Amendment 1 - Low-voltage switchgear and
Ed. 5.0:2010	control gear - Part 1: General rules
IEC 60947-2	Low-voltage switchgear and control gear-Part 2: Circuit breakers
IEC 60947-3	Low-voltage switchgear and control gear-Part 3: Switches disconnectors, switch disconnectors and fuse combination units
IEC 60947-5-1	Low-voltage switchgear and control gear-Part 5: Control circuit devices and switching elements. Section1Z: Electromechanical control circuit devices
IEC 60831	Shunt power capacitors of the self-healing type for ac systems having a rated voltage up to and including 1000V
IEC 61000 5-1	Electro Magnetic Compatibility (EMC) Part 5 Installation and Mitigation Guidelines - Section 1 General Considerations
IEC 61000-4-8	Electromagnetic Compatibility - Part 4: Testing and Measurement Techniques Section 8: Power frequency magnetic field immunity test basic EMC publication
IEC 61034	Measurement of smoke density of electric cables burning under defined conditions
IEC 61133	Electric traction - Rolling stock - test method for electric and thermal/electric rolling on completion of construction and before entry into service
IEC571-1	Electronic equipment used on rail vehicles Part 1: General requirements and tests fiber electronic equipment
IEC571-2	Electronic equipment used on rail vehicles Part 2: Standardization of certain mechanical and electrical quantities- Principles of test devices

IEC571-3	Electronic equipment used on rail vehicles Part 3: components, programmable electronic equipment and electronic reliability
IEC61000-1-1	Electromagnetic compatibility Part 1: General Section 1: Application and interpretation of fundamental definitions and terms
IEC61000-2-1	Electromagnetic compatibility Part 2: Environment Section 1: Electromagnetic environment for low-frequency conducted disturbances and signaling in public power supply systems
IEC61000-2-2	Electromagnetic compatibility Part 2: Environment Section 2: Compatibility levels for low-frequency conducted disturbances and signaling in public low-voltage power supply systems
IEC61000-2-3	Electromagnetic compatibility Part 1: Environment Section 3: Description of the environment- radiated and non-work-frequency-related conducted phenomena
IEC61000-2-4	Electromagnetic compatibility Part 2: Environment Section 4: Compatibility levels Industrial plants for low frequency conducted disturbance
IEC61000-2-5	Electromagnetic compatibility Part 2: Environment Section 5: Classification of electromagnetic environments
IEC61000-2-6	Electromagnetic compatibility Part 2: Environment Section 6: Assessment of the emission levels in the power supply of industrial plants as regards low-frequency conducted disturbances
IEC61000-2-7	Electromagnetic compatibility Part 2: environment Section 7: Low frequency magnetic fields in various environment
IEC61000-2-9	Electromagnetic Compatibility Part 2: environment Section 9 Description of HEMP environment- radiated disturbance
IEC61000-2-10	Electromagnetic Compatibility Part 2 - 10 environment - description of HEMP environment- conducted disturbance
IEC61000-3-2	Electromagnetic compatibility Part 3: Limits Section 2: Limits for harmonic current emissions

IEC61000-3-3	Electromagnetic compatibility Part 3: Limits Section 2: Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current- 16A
IEC61000-3-5	Electromagnetic compatibility Part 3: Limits Section 5: Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 16A
IEC61000-3-6	Electromagnetic compatibility Part 3: Limits Section 6: Limitation of emission of harmonic currents for equipment connected to medium and high voltage power supply systems
IEC61000-3-7	Electromagnetic compatibility Part 3: Limits Section 7: assessment of emission limits for fluctuating loads in MV and HV power systems
IEC61000-3-8	Electromagnetic compatibility Part 3: Limits Section 8: Signaling on low voltage installations – emission levels, frequency bands and electromagnetic disturbance levels
IEC61000-4-1	Electromagnetic Compatibility Part 4: Testing and measuring techniques Section 1: Overview of immunity tests
IEC61000-4-2	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 2: Electrostatic discharge immunity test
IEC61000-4-3	Electromagnetic compatibility Part 4: - Testing an measuring techniques Section 3: Radiated radio frequency electromagnetic field -immunity test
IEC61000-4-4:	Electromagnetic compatibility Part 4 Measuring techniques Section 4: transient/burst immunity test Testing Electrical
IEC61000-4-5	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 5: Surge immunity test
IEC61000-4-6	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 6: Immunity to conducted disturbances, induced by radio frequency fields
IEC61000-4-7	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 7: General guide on harmonics and inter-

	harmonics measurements and instrumentation, for power supply systems and equipment connected there to
IEC61000-4-8	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 8: Power frequency magnetic fields immunity test
IEC61000-4-9	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 9: Pulse magnetic field immunity test
IEC61000-4-10	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 10: Damped oscillatory magnetic field immunity test
IEC61000-4-11	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 11: Voltage dips, short interruptions and voltage variations immunity test
IEC61000-4-12	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 12: Oscillatory waves immunity test
IEC61000-4-15	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 15 flicker meter -functional and design specification
IEC61000-4-16d	Electromagnetic compatibility Part 4-16: Testing an measuring techniques - test for immunity to conducted, common mode disturbances in the frequency range 0Hz to 150kHz
IEC61000-4-24	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 24 Test methods for protective devices for HEMP conducted disturbance
IEC61000-5-1d	Electromagnetic compatibility Part 5: Installation an mitigation guidelines Section 1: General considerations
IEC61000-5-2	Electromagnetic compatibility Part 5: Installation and mitigation guidelines Section 2: Earth and cabling
IEC61000-5-5	Electromagnetic compatibility Part 5: Installation and mitigation guidelines Section 5 Specification of protective devices for HEMP conducted disturbance

14.2 American Standards

IEEE48 (1996)	IEEE Standard test procedures and requirements for high-voltage alternating current cable terminations.
IEEE80	IEEE Guide for Safety in AC Sub-Station Grounding.
IEEE383	Standard for type-test of Class E electrical cables, field splices and connections for nuclear power generating stations.
IEEE404 (1993)	Cable and joints for use with extruded dielectric cable rated 5000 V to 13800V and cable joints for use with laminated dielectric cable rated 2500V to 50,000V (50kV)
MIL-STD-880C	Military standard system safety program requirements (VSA)
NFPA70	National electrical code
NFPA70E (1988)	Standard for electrical safety requirements for employee workplaces
NFPA130	Standard for fixed guide way transit systems
NFPA258	Standard research test method for determining smoke generation of solid materials
SS299	Standard for fixed guide way transit systems
ANSI C3716 (1988)	Relays and low voltage power circuit breakers and AC power Circuits protectors
ASTM D 2863	Method for measuring the minimum oxygen concentration to support candle like combustion of plastic (oxygen index)
ASTM B 173-64	Specification for rope lay-stranded copper conductors having concentric members, for electrical conductors

14.3 British Standards

BS88	Specification for cartridge fuses for voltages up to and including 1000VAC and 1500VDC
BS142	Information and requirements for all protection relays
BS159	Bus bars and bus bar connection
BS729	Specification for hot-dip galvanized coatings on iron and steel articles.

BS731	Flexible steel conduit and adapters for the protection of electric cable.
BS951	Specification for clamps for earthing and bonding purposes
BS2692	Fuses for voltages exceeding 1000VAC
BS4444	Guide to electrical earth monitoring and protective conductor provision.
BS4568	Specification for steel conduit and fittings with metric threads of ISO from for electric installation
BS5372	Specification for dimensions of cable terminations for 3- core and 4-core polymeric insulated cables of rated voltages 600/100V and 1900/3300 V having aluminum conductors
BS5472	Specification for low voltage switchgear and control gear for industrial use. Terminal marking and distinctive number, general rules.
BS5493	Code of practice for protective coating of iron and steel structures against corrosion
BS6231	Specification for PVC insulated cables for switchgear and control gear wiring
BS6290	Lead-acid stationary cells and batteries
BS6360	Specification for conductors in insulated cables and cords
BS7430	Code of Practice for earthing
BSEN 6012994	Specification for alternating current disconnectors and earthing switches

14.4 European Standards (CENELEC)

EN50052	Standards for pressure vessel construction
EN50122-1	Railway Applications, Fixed Installations, Protective Provisions relating to electric safety and earthing

14.5 Others

IS01459	Metallic Coatings-Protection against corrosion by hot dip galvanizing- Guiding principles

1501460	Metallic Coatings-Hot dip galvanized coatings of ferrous materials -Gravimetric determination of the mass per unit area.
IS01461	Hot dip Galvanized Coating on fabricated ferrous products specification
IS02064	Metallic and other non-organic coatings definitions and conventions concern the measurement of thickness.
IS02177	Metallic Coatings measurements of coating thickness - coulometer method by anodic dissolution.
IS02178	Non-magnetic on magnetic substrates - measurements of coating thickness- magnetic method
IS02859	Sampling procedures and tables for inspection by attributes
UL94	Tests for flammability of plastic materials for parts in devices and appliances
UL508	Industrial control equipment
UL746C	Polymeric materials used in electrical equipment evaluations
VDE 0115 Part 1	Traction systems general construction and safety
EMC	International Standards are as follows:
BSEN 50082-1	Electromagnetic compatibility - Generic immunity standard Part 1: Residential, commercial and light industry.
EN 50082-2	Electromagnetic compatibility - Generic Immunity Part 2: Industrial environment.
DD ENV50121-1	Railway applications- Electromagnetic Compatibility Part 1: General
DD ENV50121-2	Railway applications- Electromagnetic Compatibility Part 2: Emission of the whole railway system to the outside world.
DD ENV50121-3-1	Railway applications - Electromagnetic Compatibility Part 3-1: Rolling Stock – Train and complete vehicle – limits for emission and immunity
DD ENV50121-3-2	Railway applications - Electromagnetic Compatibility Part 3-2: Rolling Stock - Emission and immunity of apparatus.

DD ENV50121-4	Railway applications - Electromagnetic Compatibility Part 4 ·Emission and immunity of the signaling and telecommunications apparatus.
DD ENV50121-5	Railway applications- Electromagnetic Compatibility Part 5: Emission and immunity of railway fixed power supply installations.
EN50155	Railway applications - Electronic equipment used on rolling stock
CAN/CSA-C22.3 No. 8-M91	

15. DEFINITIONS AND ABBREVIATIONS

15.1 Definitions

15.1.1 In this PS, the following defined terms shall have the meanings ascribed to them below:

Standard Terminology	In general definitions applied to traction power and protective relay function conforms to the British Standards (BS), American National Standards (ANSI), International Electromechanical Commission(IEC) Standards or European Norm Standards (EN).
Contact wire	25kV electric conductor of an overhead current collection system with which the train pantographs (current collectors) make contact.
Feeder Wire	Negative 25kV electric feeder conductor of the overhead feeder system (in the AT configuration)
Cross-bonding	The term used to describe cables used to electrically link parallel sets of running rails forming the traction return system together, to reduce voltage drop and leakage currents in an ac electrified traction system.
Earthing	Synonymous with grounding. The connection of equipment enclosures and non-current carrying metal parts to earth to provide safety to personnel, public and to the equipment.
Earth	Means the Conducting mass of the earth or any conductor in direct electrical connection there with.
Earth Mat	A system of bare conductors and/or bare driven conductor rods/pipes usually installed as a totally interconnected grid

	and buried in the earth to provide a low impedance and high current capacity connection to the earth.
Earth Bus	An un-insulated electrical conductor to intentionally provide multiple low resistance connections from the equipment enclosure(s) to earth.
High Voltage	Any voltage over 1kV phase to phase. As applied to this Contract, the high voltage is 69kV or 115kV, 2X25kV, 25kV or 22 kV three phase.
Interrupting Capacity	This is the capability to interrupt a maximum rated short circuit or fault current at a rated maximum voltage. Thus, it is usually expressed in volt-amperes, kilovolt amperes, or megavolt amperes.
Low Voltage	As applied to this Contract, low voltage refers to voltage not exceeding 1000 VAC between conductors.
	PCU (Protection and PCU is an intelligent microprocessor based self-
Control Unit)	diagnostic, protection and control and metering unit. The PCU consists of protection relay module, control module and metering module functioning as a complete unit for continuous controlling, monitoring, metering and protection of the system.
Return Conductor	Means a conductor that carries return current from the tracks to the sub-station.
Rail Bond	Means an electrical Connection across a joint in or between adjacent lengths of running rail.
Switchgear	Means isolator switches, circuit breakers, interrupters, cut-outs and other apparatus used for the operation, regulation and control of electrical circuits.
Withstand Capability	Rated capability of equipment to survive without damage the mechanical forces of a short circuit or the thermal effects of a short circuit downstream from the equipment. Also, the rated capability to withstand without damage for a short

	time, a specified power frequency over voltage and/or a specified voltage surge or impulse.
System	Electric Power System including, traction and auxiliary power supply systems and control system for the NTBR Rail Link.

15.1.2 The following definitions are applicable to the OCS

Autotransformers	The transformers utilized to convert the 50kV system voltage to the 25kV traction power contact system.
Auto-Tensioned Equipment	OCS equipment provided with counter weight or spring tensioning devices to maintain constant tension over a specified range of temperature by compensating for conductor thermal elongation or contraction.
Blow-off	Lateral displacement of a conductor due to wind.
Bolted Base Mast	Mast with a base plate for use on foundations with anchor bolts as opposed to plain masts that are either planted or embedded.
Bond	An electrical connection between metal c equalizes the voltage difference.
Cantilever	A hinged tubular frame assembly that supports and registers the OCS conductors and allows for along track movement for the conductors under temperature variation.
Cantilever Offset	A long track distance measured from the position where the cantilever is perpendicular to the track and the position where the cantilever is displaced due to heating or cooling of the conductors. The offset is a function of the position of the cantilever in the tension length.
Cantilever-Type Support	A structure consisting of a cantilever assembly Structure attached to a mast.
Contact Wire	A solid grooved conductor that forms the current collection interface between the OCS equipment and the pantograph.
Contact Wire Pre-sag	The design sag introduced into the auto tensioned contact wire to provide superior pantograph dynamic performance.

Crossover	A section of OCS equipment installed between two running lines to facilitate the smooth transition of the pantograph from one line to the other.
Dropper	A flexible cable suspended from the messenger wire that supports the contact wire.
Jumper	A conductor that provides a current path for traction current between the messenger wire and the contact wire of the OCS equipment.
Messenger Wire	The longitudinal wire or cable of a catenary system from which the contact wire is suspended, either directly or indirectly.
Midpoint Anchor	The structure approximately midway between two counterweights of a tension section where the messenger wire is anchored to stabilize the system. In addition to messenger wire, the contact wire should also be anchored if it is terminated separately from messenger wire.
Mid-span Offset	The deviation of a static contact wire at mid-span from the center line of a static pantograph under still air conditions.

Overhead Line Equipment The contact wire, messenger wire, AEW, feeder wires and the associated droppers and jumpers and other accessories to provide the means of distributing the power to the trains.

Open Route Sections	All areas not enclosed by civil structure
Overlap Section	The portion of OCS equipment where two mechanically separate contact wires run parallel to each other to form a continuous electrical path for the pantograph.
Overlap Span	The length of OCS equipment between adjacent overlap structures.
Pantograph	A current collecting device mounted on the roof of train.
Pantograph Sway	Lateral displacement of the pantograph with respect to the track induced by rail and lateral loads.
Passing Clearance	"Passing" clearance is defined as the clearance required when the pantograph exerts an upward force (dynamic uplift) or short duration static uplift at stations or signal.

Portal Structure	A structure consisting of a transverse beam together with two vertical columns located at both sides of the tracks that supports and registers a number of OCS equipment's.
Pull Off/Push Off	The registration towards or away from centre line of track in relation to the mast.
Registration	Lateral constraint of the conductors.
Removable Conductor Rail	Conductor rail system for use in the depot workshop that is movable. The system permits trains to motor into and out of the workshop under their own power but also to provide unhindered access for maintenance personnel to safely work on the roof of the train and use overhead cranes.
Sag	The height of the conductor with respect to the rail at its support point, less height with respect to the rail at the lowest point in the span.
Scott Transformer	A design of transformer designed to give a single-phase output from a three-phase input.
Section Insulator	A device in the OCS through which a train can pass drawing full power and without loss of power, but which isolates adjacent portions of the line when sectionalized.
Simple Catenary System	A support system with one or more contact wires suspended beneath a messenger wire on droppers.
Span Length	The horizontal distance between two adjacent supporting points of a conductor
Stagger	The horizontal displacement of the contact wire from the projected center line of the track (including design super elevation where present).
Static Clearance	'Static' clearance is defined as the clearance required to any earthed equipment or any equipment not at traction potential when the OCS system is not subjected to any dynamic forces (uplift) from the pantograph. This includes static uplift in sidings and depot areas where trains may be 'stabled' for long periods of time.

Steady Arm	A method of registering the contact wires which enables the registration assembly to be uplifted by a forced exerted from a pantograph.
System Height	The vertical distance between the underside of the contact wires to the center line of the messenger wire at the registration point.

15.2 Abbreviations

15.2.1 In this Section, the following abbreviations are used:

A or Amp	Ampere
AC or ac	Alternating Current
ANSI	American National Standards Institute
ASS	Auxiliary Sub-station
ASTM	American Society for Testing and Materials
AT	Auto-transformer
AWG	American Wire Gauge
BIT	Built in Test Diagnostics
BWA	Balance Weight Assembly
Cm2	Square Centimeter
CD ROM	Compact Disk Read Only Memory
CT	Current Transformer
OBA	Decibels (A Scale)
DC or dc	Direct Current
DP	Double Pole
DPCS	Digital Protection Control System
EEPROM	Erasable Programmable Read Only Memory
EMI	Electro Magnetic Interference
EMC	Electro Magnetic Compatibility
EN	European Norm (Standard)
ETS	Emergency Trip System
FRLSOH	Fire Retardant Low Smoke Zero Halogen
g/m2	Grams per metre squared

GS/4	Limits for Harmonics in the United Kingdom Electricity Supply System.
GI	Galvanized Iron
Hr	Hour
HT	High Tension
Hz	Hertz
IRJ	Insulated Rail Joints
kA	Kilo Amperes
Kg	Kilograms
Kgf	Kilogram force
Km	Kilometer
Km/h	Kilometers per hour
kPa	Kilo Pascal
kV	Kilovolt
kVA	Kilovolt Ampere
kVAR	Kilovolt Ampere Reactive
kVp	Kilovolt pulse (peak)
kW	Kilowatt
LAN	Local Area Network
LBS	Load Break Switch Local Area Network
LED	Light Emitting Diode
LSOH	Low Smoke Zero Halogen
LT	Low Tension
M	Meter
m/s/s	Meters per second per second
m/s/s/s	Meters per second per second per second
MBCC	Microprocessor Based Communication Controller
MC	Motor Coach
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
MDP	Main Distribution Panel
MEA	Municipal Electric Authority (of Bangkok)

Mm	Millimeter
Ms	Millisecond
MRT	Mass Rapid Transit
MRTS	Mass Rapid Transport System
MS	Mild Steel
mV	Millivolt
MVA	Mega volt Ampere
MW	Megawatt
N	Newton
NC	Normally Closed
NDTs	Non-Destructive Tests
NO	Normally Open
^{o}c	Degree Celsius
O&M	Operation and Maintenance
OCC	Operations Control Centre
ONAF	Oil-Immersed Forced Air Circulation Cooled
OVPD	Over Voltage Protection device
PCU	Protection and Control Unit
P.E	Professional Engineer
Ph	Phase
PLC	Programmable Logic Controller
PRF	Pulse Repetition Frequency
PT	Potential Transformer
QRA	Qualified Risk Assessment
RAMS	Reliability, Availability, Maintainability and Safety
RCC	Reinforced Cast Concrete
RDSO	Research Design Standards Organization (IR)
RF	Radio Frequency
rms	Root Mean Square
RRSW	Running Rail Sectionalizing Switch
RSS	Receiving Sub-station

S	Second
SCADA	Supervisory Control and Data Acquisition System
SCB	Shunt Capacitor Bank
SCR	Station Control Room
SE	System Earth
SEM	Structural Electrical and Mechanical Drawings
SF6	Sulphur Hexafluoride
SPS	Small Steel Parts
Sq m	Square meter
Sq mm	Square millimeter
SRU	Shop Replacement Unit
SVC	Static Volt Ampere Reactive Compensator
TC	Trailer Coach TEFC Totally Enclosed Fan Cooled
TP	Triple Pole
TSS	Traction Sub-station
μsec	Micro second
V	Volt
VA	Volt Ampere
VDU	Visual Display Unit
VT	Voltage Transformer
VVVF	Variable Voltage Variable Frequency
XLPE	Cross-linked polyethylene

15.2.2 The following abbreviations are used in the OCS:

AEW	Aerial Earth Wire
AT	Auto-transformer
ATE	Auto Tensioned Equipment
BWA	Balance Weight Assembly
FTE	Fixed Tension Equipment
HPRL	Highest Possible Rail Level
MCS	Main Control System

MPA	Mid-Point Anchor
MSO	Mid Span Offset
SI	Section Insulator

VOLUME 3 : OUTLINE SPECIFICATIONS
VOLUME 3/1 : THE RAIL-RELATED WORKS OF THE PROJECT
PART 3 – OUTLINE SPECIFICATIONS FOR RAILWAY SYSTEMS
SECTION 4 - SIGNALLING SYSTEM

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SECTION 4
SIGNALLING SYSTEMS

1 GLOSSARY

1.1 Terms

ACKNOWLEDGEMENT	Confirmation by an entity that it has received information
ACKNOWLEDGEMENT, DRIVER	Confirmation by the driver that he/she has taken into account information received through the DMI
AUTHENTICATION	The process of determining whether someone or something is who or what it is declared to be.
AUTHENTICATION KEY	Cryptographic key (KMAC) used to establish a safe connection according to the EURORADIO protocol.
AUTOMATIC TRAIN PROTECTION	A safety system that enforces either compliance with or observation of speed restrictions and signal aspects by trains.
AVAILABILITY	The ability of a product to be in a state to perform a required function under given conditions at a given instant in time or over a given time interval assuming that the required external resources are provided. Definitions for other availability related terms are given in reference 3
BASELINE	A baseline is defined by a stable kernel in terms of system functionality, performance and other non-functional characteristics.
BASELINE RELEASE	A baseline release is defined by a specific version of each of the CCS TSI annex A documents that are relevant for the system
BLOCK	A method of controlling the separation between trains by dividing the line into sections with, normally, no more than one train in each section. The block can either be a fixed block or a moving block.

BRAKING CURVE	Prediction of the train speed decrease versus distance by the on-board equipment, from a mathematical model of the train braking dynamics and of the track characteristics ahead.
BRAKING DISTANCE, EMERGENCY	The distance in which a train is capable of stopping with the emergency brake applied. Dependent upon train speed, train type, braking characteristics, train weight and gradient.
BRAKING DISTANCE, SERVICE	The distance in which a train is capable of stopping, with the full service brake applied. Dependent upon train speed, train type, braking characteristics, train weight and gradient.
CAB	The space in the power unit or driving unit of the train containing the operating controls and providing shelter and seats for the driver or engine crew.
CAB, ACTIVE	The active cab is the cab associated with an on- board equipment, from which the traction is controlled
CLEAR (A SIGNAL)	To change a signal aspect from its most restrictive aspect to a less restrictive aspect.
COMMON-MODE FAULT	Fault common to items which are intended to be independent.
CONDITIONAL LEVEL TRANSITION ORDER	A Conditional Level Transition Order is a spot check of the on- board operated level. This may cause a level transition if the on-board does not operate one of the allowed levels.
CONDITIONS, MAINTENANCE	The maintenance criteria adopted for maintaining the system referred to its Operating Conditions.
CONDITIONS, OPERATING	The rated performance required of the system.
CONDITIONS, SYSTEM	The conditions under which the system is called to operate, including: environmental conditions; operating conditions; maintenance conditions.
CONFIGURATION	The structuring and interconnecting of the hardware and software of a system for its intended application.

CONFIGURATION MANAGEMENT	A discipline applying technical and administrative direction and surveillance to identify and document the functional and physical characteristics of a configuration item, control change to those characteristics, record and report change processing and implementation status and verify compliance with specified requirements.
CONFLICTING MOVEMENTS	Movements that would require trains to occupy the same portion of track over all or part of their length.
CONTACT LENGTH	The distance between the place where a train becomes able to communicate with a device to the place where communication becomes impossible.
CONTINOUS DATA TRANSMISSION	Track-to-train or train-to-track transmission that can take place continuously, independent of location (e.g. by radio).
CONTROL CENTRE	A centralised control system that controls the train movements in a large territory.
CRITICALITY	The point at which a failure or a number of failures renders the system unusable and/or unsafe.
CROSS-ACCEPTANCE	The status achieved by a product that has been accepted by one Authority to the relevant European Standards and is acceptable to other Authorities without the necessity for further assessment.
CURRENT POSITION	The position of a train measured at a certain moment using defined system co-ordinates.
DANGER (ASPECT)	An indication given by a signal to stop.
DANGER POINT	The location beyond the End of Movement Authority that can be reached by the front of the train without creating a hazardous situation.
DATA INTEGRITY	The property that a message has not been modified or destroyed.
DECELERATION DATA	Data that relates to the braking performance of the train.

DESK	Inside a cab, the set of operating controls, which is dedicated to preferred movements in a given direction (i.e. forward movements, in which visibility from the cab is provided to the driver). Exception: some single cab locomotives are fitted with one single desk, allowing normal movements in both directions.
DIVERSITY	A means of achieving all or part of the specified requirements in more than one independent and dissimilar manner.
DRIVER IDENTITY	Unique code which identifies a train driver.
DRIVER MACHINE INTERFACE	The interface to enable direct communication between the on-board equipment and the driver.
DRIVING ON SIGHT	The driver driving at a speed that allows him to stop the train to avoid obstacles on the track.
DUAL CAB ENGINE	Rolling Stock unit fitted with two driving cabs and one single on-board equipment.
DYNAMIC SPEED PROFILE	The speed / distance profile that a train may follow without violating the static speed profile and/or the EOA/LOA.
EMERGENCY BRAKING	Application of a predefined brake force in the shortest time in order to stop the train with a defined level of brake performance.
END OF AUTHORITY	Location to which the train is permitted to proceed and where target speed = zero.
END OF MOVEMENT AUTHORITY	Location to which the train is permitted to proceed according to an MA. When transmitting an MA, it is the end of the last section given in the MA.

ENGINE	Association of one or two driving cab(s) of a Rolling Stock unit with one single on-board equipment. When a driving cab of the engine is used to lead a train/shunting consist, the on-board equipment supervises the movement of the train/shunting consist the engine belongs to. Each driving cab of an engine allows the driver communicating with the on-board equipment through the DMI.
ENTRANCE SIGNAL	A main signal, intended for trains entering a station.
ESTIMATED SPEED	The speed the odometer estimates the train is running at, with the highest probability according to the physical characteristics of the train and to the odometer working conditions
ESTIMATED POSITION	The position the on-board equipment estimates the train front is at, with the highest probability according to the physical characteristics of the train and to the odometer working conditions. It is expressed as a distance from a location reference detected by the on-board.
EXIT SIGNAL	A main signal that is intended for trains leaving a station.
FAIL-SAFE	A design philosophy which results in any expected failure maintaining or placing the equipment in a safe state.
FAILURE	Effect of an error on the intended service.
FAULT	An abnormal condition that could lead to an error in a system. A fault can be random or systematic.
FAULT DETECTION TIME	Time span that begins at the instant when a fault occurs and ends when the existence of the fault is detected.
FAULT NEGATION TIME	Time span that begins when the existence of a fault is detected and ends when a safe state is enforced.

FIXED BLOCK	A block in which the extremities of the block sections are at fixed locations. The signalling allows a train to move from one block to the next, normally only when the block ahead is clear.
FOULING POINT	The place where a vehicle standing on a converging line would come into contact with a vehicle on the other line.
FULL SUPERVISION MODE	on-board equipment mode giving full protection against overspeed and overrun.
HOME KMC	The KMC in a KM domain to which trackside and on-board entities belonging to that domain refer for key management.
IMMEDIATE LEVEL TRANSITION ORDER	An Immediate Level Transition Order means both a level transition ordered “now” and a level transition ordered at null distance not in relation with in-fill.
INDEPENDENCE, TECHNICAL	Freedom from any mechanism which can affect the correct operation of more than one item.
INFILL INFORMATION	Trackside data, referred to a main signal, which is transmitted at locations in rear of the main signal. Provides, for example, the ability to inform a train that the signal ahead has cleared.
INFILL LOOP	A loop which is installed at a place (e.g. in rear of a signal) to avoid unnecessary delay by transmitting in fill information advising the train at once when the signal ahead clears.
INTERLOCKING	A general term applied to the controlling of the setting and releasing of “signals” and “points” to prevent unsafe conditions arising, and equipment which performs this function.
INTERMITTENT TRANSMISSION	A term that encompasses “SPOT TRANSMISSION” and “SEMI- CONTINUOUS TRANSMISSION”.

INTEROPERABILITY	Interoperability means the ability to allow the safe and uninterrupted movement of trains that accomplish the specified levels of performance.
INTEROPERABILITY CONSTITUENT	Any elementary component, group of components, subassembly or complete assembly of equipment incorporated or intended to be incorporated into a subsystem, upon which the interoperability of the rail system depends either directly or indirectly. The concept of a constituent covers both tangible objects and intangible objects such as software.
INTEROPERABILITY, OPERATIONAL	The set of harmonized operating rules that enables interoperability.
INTEROPERABILITY, TECHNICAL	The set of harmonized technical requirements that enables interoperability.
ISOLATION MODE	When the on-board equipment is disconnected from the vehicle braking system. Isolation is indicated to the driver.
JURIDICAL DATA	Data to record all actions and exchanges relating to the movement of trains sufficient for off line analysis of all events leading to an incident.
KEY	A predefined component or information necessary to be able to encrypt data or interpret encrypted data.
KEY MANAGEMENT	The generation, storage, secure distribution, deletion, archiving and application of key entries in accordance with the security policy in a KM domain.
KEY MANAGEMENT CENTRE	The entity responsible for key management functions in a KM domain.
KEY MANAGEMENT SYSTEM	The set of entities and operational procedures taking part in the key distribution system.
KEY VALIDITY PERIOD	The specific timespan during which a key is valid.
KM DOMAIN	One KMC (Home KMC) and all the on-boards, RBCs and RIUs using that KMC for key management purposes.

LAST RELEVANT BALISE GROUP	The LRBG is used as a common location reference between the on-board and trackside equipment in levels 2 & 3
LEADING ENGINE	The engine in which a driving cab is used to control the movement of a train/shunting consist, under the supervision of the on-board equipment associated with the driving cab.
LIFECYCLE COST (SYSTEM)	The sum of the costs sustained or to be sustained for performing and appropriately supporting the activities occurring in the context of the operational parts of the System Lifecycle.
LIFECYCLE (SYSTEM)	The activities occurring during a period of time that starts when a system is conceived and ends at decommissioning when the system is no longer available for use.
LIMIT OF AUTHORITY	The place beyond which the train has no information but to which the train is authorised to run with a defined target speed higher than zero. The train is expected to receive new information before passing the Limit of Authority.
LINE	A continuous section of railway track.
LINE SIDE ELECTRONIC UNIT	A device for communicating variable signalling data to switchable balises.
LINE SIDE EQUIPMENT	see Trackside Equipment.
LOCAL TIME	The time for ordinary transactions in a locality, which is likely to be shown on station clocks.
MAIN SIGNAL	A fixed signal intended for train movements capable of showing a 'danger aspect' and one or more 'proceed aspects'. In some cases main signals at danger are valid for shunt movements.

MAINTAINABILITY	The probability that a given active maintenance action, for an item under given conditions of use can be carried out within a stated time interval when the maintenance is performed under stated conditions and using stated procedures and resources.
MALFUNCTION	A deviation from the specified performance causing the system to work incorrectly. This is normally due to an error or fault in the system.
MOVEMENT AUTHORITY	Permission for a train to run to a specific location within the constraints of the infrastructure.
MOVING BLOCK	A block whose length is defined by the position of the train occupying the section of track ahead. The minimum block length would be from the rear most part of the occupying train to a point on the track where, if the train braked from its current speed, the front of the occupying train would be when the train came to a stand.
MULTIPLE UNITS	Two or more traction units in service, mechanically, pneumatically and electrically coupled, which are operated by one driver.
NON-EQUIPPED LINE	A line without operational trackside Automatic Train Protection system.
NON-VITAL	A description applied to those parts of the signalling system whose failure or non-availability does not directly endanger rail traffic or reduce the integrity of the signalling system.
OCCUPIED	A track section having any part of a train present upon it.
ODOMETER ACCURACY	The extent to which the odometer might make underestimation/overestimation in measuring the movement of the train.

ODOMETRY	The process of measuring the train's movement along the track. Used for speed measurement and distance measurement.
ODOMETRY REFERENCE LOCATION	The reference location to which refers the train based odometer distance reading.
OFF-LINE KMS	KMS where distribution, deletion or updating of key entries requires staff intervention on the target device.
ON-BOARD EQUIPMENT	The equipment carried on the train with the aim of supervising vehicle operation.
ON-BOARD RECORDING DEVICE	A device (outside the on-board equipment) that records and stores data for subsequent analysis (e.g. further to a train accident).
ON-BOARD UNIT	See ON-BOARD EQUIPMENT.
ON-LINE KMS	KMS allowing remote distribution, deletion or updating of key entries in the target device.
ON SIGHT MODE	on-board equipment mode that gives the driver partial responsibility for the safe control of his train. In this mode the train possesses a movement authority but the track ahead might be occupied by another train.

OPERATED SYSTEM VERSION	For both trackside and on-board, to operate a system version means to comply with the requirements from all TSI annex A documents, which are applicable to this system version and to the concerned subsystem. The operated system version is ordered by trackside; however, to operate a system version number X within a delimited trackside area only means that an on-board equipment running on this area shall behave according to the set of requirements applicable to the system version number X.Y where X is the one ordered by trackside and Y is the system version number Y (which may be different from the one ordered by trackside) operated by the on-board within this version X.
OVERLAP	The section of line in advance of a stop signal that must be unoccupied and, where necessary, locked before and during a signalled running movement to the rear of the signal to avoid an accident if the train brakes do not perform as well as expected and the train passes the END OF MOVEMENT AUTHORITY.
PACKET	Packets are multiple variables grouped into a single unit with a defined internal structure. Packets are part of telegrams and messages.
PANTOGRAPH	Device for transmitting power from the overhead catenary to the train.
PERMISSIVE SIGNAL	A signal aspect or a signal identification, which enables a main signal to be passed at danger under special conditions, without specific permission from the signalman.
PERMITTED SPEED	The speed limit at which a train is allowed to proceed without warning and / or intervention.
POINT	A section of track equipped so that train routes may converge or diverge.

POSSESSION, OF SIGNALLING EQUIPMENT	The disconnection or restriction of use of signalling equipment agreed between maintenance and operations staff to enable work to be carried out on the equipment.
PROCEED ASPECT	Any signal aspect which permits the driver to pass the signal.
PROTECTED WRONG SIDE FAILURE	A wrong side failure where another part of the signalling system provides an acceptable level of protection.
PUBLIC KEY INFRASTRUCTURE (PKI)	Set of hardware, software, people, policies, and procedures needed to create, manage, distribute, use, store, and revoke digital certificates and manage public key encryption with the purpose to facilitate the secure transfer of information for a range of network activities.
RADIO BLOCK CENTRE	A centralised safety unit that receives train position information via radio and sends movement authorities via radio to trains.
RADIO HOLE	A known area where it is not possible to establish or maintain a reliable radio connection.
RADIO INFILL UNIT	A unit which provides a semi-continuous infill function
RBC AREA	Trackside area which is supervised by one RBC.
RBC/RBC BORDER	The border location between two areas supervised by two different RBCs.
RBC/RBC HANDOVER	The process of passing the supervision of a train between two Radio Block Centres.
RBC/RBC TRANSITION	Alternative term to RBC/RBC handover
RECOMMENDED	Not fulfilling the requirement will not have any impact on the technical interoperability of the equipment or of the system but it could be fulfilled to facilitate implementation or to enhance performances.

REDUNDANCY	The provision of one or more additional elements to achieve or maintain availability of a functionality if one or more of those elements "malfunctions".
REFERENCE LOCATION	A location on the track used as a reference for the information sent from trackside or for the train position
RELIABILITY	The probability that an item can perform a required function under given conditions for a given time interval.
REVERSING MODE	on-board equipment mode that allows the driver to change the direction of movement of the train whilst controlling the train from the same cab.
REVERSE MOVEMENT	A train movement in which the driver is situated in the leading engine but the train is moved in the opposite direction to the train orientation.
REVOCATION OF MOVEMENT AUTHORITY	Cancellation of a previously given permission to move a train to a given location.
RIGHT SIDE FAILURE	A failure that does not result in the level of protection normally provided by the signalling system being reduced.
RISK	The combination of the frequency, probability, and the consequence of a specified hazardous event.
ROLL AWAY	An unintended and non-powered movement of the train in a direction, which conflicts with the current position of the direction controller in the active desk.
ROUTE	The particular section or sections of track, from a starting point to a point of destination, prepared for train operation
ROUTE RELEASE	The release of route locking.
ROUTE SUITABILITY DATA	Data transmitted to the on-board equipment to allow it to check its ability to run on the track as indicated by the movement authority. It includes data related to loading gauge, traction system and axle load category.

SAFE DECELERATION	The deceleration the train is assumed to achieve with a certain confidence level
SAFE STATE	A condition which continues to preserve safety.
SAFETY	Freedom from an unacceptable risk of harm. Definitions for other safety related terms are given in reference 3.
SECTION	A part of the movement authority.
SECTION TIMER	The timer associated with a section as part of the movement authority. When the timer reaches a value defined by the trackside equipment the section is no longer available and the movement authority for the train is reduced accordingly.
SECURITY	The protection resulting from all measures, also administrative ones, to prevent accidental or malicious modification or disclosure of data; for key management, the protection generally guarantees confidentiality, authenticity and integrity of keys.
SEMI-CONTINUOUS TRANSMISSION	Transmission taking place over a defined distance.
SERVICE BRAKE COMMAND	The service brake command results in the train applying the full service braking effort.
SERVICE BRAKING	Application of an adjustable brake force in order to control the speed of the train, including stop and temporary immobilisation.
SESSION, COMMUNICATION	The process of initiating and terminating an applicative dialogue between trackside and on-board via radio.
SET SPEED	This is an input received from a function external to display to the driver. It represents the speed value to which the train speed is regulated by an external device (e.g. by a cruise control system).
SHUNTING MODE	on-board equipment operating mode which allows the train to move in shunting, without available train data.

SHUNTING MOVEMENT	The movement of trains or vehicles other than normal passage along running lines. When vehicles are moved without train data available.
SHUNTING SIGNAL	A signal provided for shunting movements only. A fixed signal intended for shunting movements. In some cases Shunting signals at danger are valid also for train movements.
SIGNAL	A visual display device that conveys instructions or provides advance warning of instructions regarding the driver's authority to proceed.
SIGNAL LOCATION	The geographical location of a signal.
SIGNALLING SYSTEM	Particular kind of system used on a railway to control and protect the operation of trains.
SLAVE ENGINE	Any engine that is not the leading Rolling Stock unit of a train or shunting consist. The on-board equipment of the slave engine runs in one of the modes in which it is not controlling the movement of the train/shunting consist (non leading mode, sleeping mode, passive shunting mode).
STATIC SPEED PROFILE	The description of the fixed speed restrictions of a given line. The speed restrictions can be related to such items as maximum line speed, curves, points, tunnel profiles, bridges.
STATION	A place where trains stop, or where loading and unloading occurs, and where assistance may be available. Where there can be points (facing or trailing) that makes it possible for the train to use different routes.
STOP SIGNAL	Any main signal capable of showing a stop danger aspect or indication. Position, from where no movement authority is given to a train. It is not necessarily a fixed signal.

SUB-SYSTEM	A combination of equipment, units, assemblies, etc., which performs an operational function and is a major subdivision of the system.
SYSTEM	A composite of equipment, skills, and techniques capable of performing or supporting an operational role, or both. A complete system includes all equipment, related facilities, material, software, services and personnel required for its operation and support to the degree that it can be considered a self-sufficient unit in its intended operational environment.
SYSTEM FAILURE MODE	on-board equipment mode entered when a fatal failure which could affect safety is found.
SYSTEMATIC FAULT	An inherent fault in the specification, design, construction, installation, operation or maintenance of a system, sub-system or equipment affecting multiple pieces of equipment under identical circumstances.
TANDEM	Two or more traction units mechanically but not electrically coupled together, used in the same train. Each traction unit requires a separate driver.
TARGET	Location where the train speed should be below the given target speed
TELEGRAM	A balise telegram contains one header and an identified and coherent set of packets. A balise group message maybe comprised of one or several telegrams.
TEMPORARY SPEED RESTRICTION	A planned speed restriction imposed for temporary conditions such as track maintenance.
TRACK CONDITION	Information transmitted to the on-board equipment to inform the driver and/or the train of conditions ahead. This information is dedicated to other functions than the speed and distance monitoring.

TRACK DESCRIPTION	Information complementing the Movement Authority and providing as a minimum the, static speed profile and gradient profile. Optionally, it can contain axle load profile, track conditions, route suitability data, areas where shunting is permitted, etc.
TRACK FREE	A route being detected clear of obstacles such that permission may be given for a train to enter that route.
TRACK GEOMETRY	The physical arrangement of the track in terms of curvature, gradient and cant.
TRACK OCCUPIED	An object in a route that prevents that route being offered to a train.
TRACKSIDE EQUIPMENT	The equipment with the aim of exchanging information with the vehicle for safely supervising train circulation.
TRACK-TO-TRAIN TRANSMISSION	The transmission of the messages from trackside equipment to the train via balise, loop or radio.
TRACTION UNIT	A powered vehicle able to move itself and other vehicles to which it may be coupled.
TRAIN	One or more railway vehicles hauled by one or more traction units, or one traction unit travelling alone, running under a given operational number from an initial fixed point to a terminal fixed point.
TRAIN DATA	Defined set of data which gives information about the train.
TRAIN DETECTION	The proof of the presence or absence of trains on a defined section of line.
TRAIN INTEGRITY	The level of belief in the train being complete and not having left coaches or wagons behind.
TRAIN INTERFACE UNIT	The unit, inside the on-board equipment, that provides the interface between the on-board equipment and the train.

TRAIN MOVEMENT	When vehicles are moved with train data available, as a rule from station to station, and as a rule under the authority of proceed aspects from main signals, or similar procedures.
TRAIN ORIENTATION	If there is an active cab, this one defines the orientation of the train, i.e. the side of the active cab is considered as the front of the train. If no cab is active, the train orientation is as when a cab was last active.
TRAIN RUNNING NUMBER	A number under which the train is operated.
TRAIN TRIP	Initiated when a train passes an EOA/LOA, excluding any occasion when a suppress facility is used, and causes an immediate application of the emergency brake.
TRAIN-TO-TRACK TRANSMISSION	The transmission of the messages from the train to trackside equipment via radio.
TRANSITIONS	The controlled changes between operating modes and / or levels
TRIP MODE	the on-board equipment mode (e.g. entered when passing an EOA), resulting in an application of the emergency brake that can only be revoked at standstill and with additional precautions.
VALIDATION	Confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use have been fulfilled.
VALIDATOR	The person or agent appointed to carry out validation.
VARIABLE	A set of bits, which are given a unique identity and meaning.
VERIFICATION	Confirmation, by examination and provision of objective evidence, that the specified requirements for the lifecycle phase have been fulfilled.
VERIFIER	The person or agent appointed to carry out verification.

VITAL	A description applied to equipment whose correct operation is essential to the integrity of the signalling system. Most vital equipment is designed to fail-safe principles - a wrong side failure of vital equipment could directly endanger rail traffic.
WARNING	Audible and/or visual indication to alert the driver to a condition which requires a positive action by the driver.
WHEELSLIDE	When a braked wheel loses adhesion with the rails and under rotates.
WHEELSLIP	When a traction-driven wheel loses adhesion with the rails and over rotates
WRONG SIDE FAILURE	An equipment failure tending to cause danger to rail traffic.

1.2 Abbreviations

ACK	Acknowledgement
ALE	Adaptation & redundancy management Layer Entity
APN	Access Point Name
ASP	Axle Load speed Profile
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
BCD	Binary Coded Decimal
BTM	Balise Transmission Module
CEN	Comité Européen de Normalisation
CENELEC	European Committee for Electrotechnical Standardisation (Comité Européen de Normalisation Electrotechnique)
CER	Community of European Railways
CRC	Cyclic Redundancy Code
CSM	Ceiling Speed Monitoring
CTCS	The Chinese Train Control System
Digital ATC	Digital Automatic Train Control
DMI	Driver Machine Interface
DNS	Domain Name Server
DP	Danger Point

DV	Difference Value between the Permitted Speed to e.g. DV_EBImin - Emergency Brake Intervention speed (minimum) DV_EBImax - Emergency Brake Intervention speed (maximum)
EB	Emergency Braking
EBCL	Emergency Brake Confidence Level
EBD	Emergency Brake Deceleration Curve
EBI	Emergency Brake Intervention supervision limit
EC	European Commission
EEIG	European Economic Interest Group.
EIRENE	European Integrated Radio Enhanced Network
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EN	European Norm
EOA	End of Authority
EOLM	End-of-Loop-Marker
Ep	Electro-pneumatic
ETSI	European Telecommunications Standards Institute
EU	European Union
EVC	European Vital Computer
FFFIS	Form-Fit Functional Interface Specification
FFFS	Form-Fit Functional Specification
FIS	Functional Interface Specification
FMEA	Failure Mode and Effects Analysis
FMECA	Failure Mode, Effect and Criticality Analysis
FRS	Functional Requirements Specification
FS	Full Supervision mode
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
GSM-R	Global System for Mobile Communications – Railways
GUI	Guidance curve
I	Indication supervision limit
I&A	Identification and Authentication
IEC	International Electro-technical Commission
IP	Internet Protocol
IS	Isolation mode

ISO	International Standardisation Organisation
KER	KVB, Ebicab, RSDD
KM	Key Management
KMAC	Authentication Key
KMC	Key Management Centre
KMS	Key Management System
KTRANS	Transport Key
LEU	Line side Electronic Unit
LOA	Limit of Authority
LS	Limited Supervision mode
LSSMA	Lowest Supervised Speed within the Movement Authority
LTM	Loop Transmission Module
LUC	Line Under Construction
LX	Level crossing
MA	Movement Authority
MAC	Message Authentication Code
MRDT	Most Relevant Displayed Target
MRSP	Most Restrictive Speed Profile
MORANE	Mobile Radio for Railway Networks in Europe
MTBF	Mean Time Between Failure
NL	Non Leading mode
NP	No Power mode
NTC	National Train Control
OBU	On-Board Unit
OL	Overlap
OS	On Sight mode
P	Permitted speed supervision limit
PBD SR	Permitted Braking Distance Speed Restriction
PKI	Public Key Infrastructure
PS	Passive Shunting mode
PT	Post Trip mode
RAM(S)	Reliability, Availability, Maintainability, (Safety)
RAP	Roll Away Protection
RBC	Radio Block Centre
RIU	Radio In-fill Unit

RMP	Reverse Movement Protection
RSM	Release Speed Monitoring
RU	Railway Undertaking
RV	Reversing mode
SB	Service Brake or in the context of modes, Stand By mode
SBD	Service Brake Deceleration Curve
SBI	Service Brake Intervention supervision limit
SF	System Failure mode
SH	Shunting mode
SIL	Safety Integrity Level
SL	Sleeping mode
SN	System National mode
SoM	Start of Mission
SR	Staff Responsible mode
SRS	System Requirements Specification
SSP	Static Speed Profile
STM	Specific Transmission Module
TCO	Traction Cut Off
TCP	Transmission Control Protocol
TTI	Time to Indication
SvL	Supervised Location
TI	Train Interface
TETRA	Digital Radio System : Terrestrial Trunked Radio equates to GSM-R
TIU	Train Interface Unit
TR	Trip mode
TSI	Technical Specification for Interoperability
TRK	Trackside
TSM	Target Speed Monitoring
TSR	Temporary Speed Restriction
UIC	Union Internationale des Chemins de Fer
UN	Unfitted mode
UTC	Universal Time Co-ordinated
V&V	Verification and Validation
VBC	Virtual Balise Cover
W	Warning supervision limit

WSF Wrong Side Failure

2 APPLICABLE STANDARDS

2.1 General

The equipment shall have the supporting documentation required by European Norms including:

- European Commission (EC) Declaration of conformity for EMC.
- EC Declaration of conformity for TSI.
- Evidence of assessment of conformity as required by CR CCS TSI 2006/679/EC or later versions for Operations.
- Further the following table lists applicable standards to be used throughout. :

Standard	Title
TIS	Thai Industrial Standards
NFPA 130	Standard for Fixed Guideway Transit and Passenger Rail System
JIS	Japanese Industrial Standards
EN 50121	Railway Application – Electromagnetic Compatibility
EN 50122-1	Railway Application – Fixed installations, Electrical Safety, Earthing and Return Current
EN 50122-2	Railway Application – Fixed Installations, Electrical Safety, Earthing and the Return Circuits,- Part 2: Provision against the effects of stray currents caused by D.C. Traction Systems
EN 50122-3	Railway Application – Fixed Installations, Electrical Safety, Earthing and the Return Circuits –Part 3: Mutual Interaction of a A.C. and D.C. Traction Systems
EN 50124-1	Railway Application- Insulation Coordination- Part 1: Basic Requirements- Clearance and Creepage Distance for all Electrical and Electronic Equipment
EN 50124-4	Railway Application – Electromagnetic Compatibility – Part 4: Emission and Immunity of the Signaling and Telecommunications Apparatus.
EN 50126	Railway Applications – Specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)
EN 50128	Railway Application – Communications, Signalling and Processing Systems – Software for Railway Control and Protection Systems
EN 50129	Railway Application - Communications, Signalling and Processing Systems – Safety related electronic Systems for Signalling
EN 50163	Railway Application – Supply Voltages of Traction Systems
IEC 60044	Instrument Transformers
IEC 60071	Insulation Co-ordination

IEC 60076	Power Transformers
IEC 60146	Semiconductors Converters – General Requirements and Line commutated Converters
IEC 60376	Specification of technical grade sculpture hexafluoride (SF6) for use in electrical equipment
IEC 60480	Guidelines for the checking and treatment of sculpture hexafluoride (SF6) taken from electrical equipment and specification for its re-use.
IEC 60 622	Secondary Cells and batteries containing alkaline or other no-acid electrolytes – Sealed nickel –cadmium prismatic rechargeable cells
IEC 60 623	Secondary Cells and batteries containing alkaline or other no-acid electrolytes – Vented nickel-cadmium prismatic rechargeable single cells
IEC 61000-4-2	Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test.
IEC 61000-4-4	Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrical fast transient/burst immunity test
IEC 61000-4-5	Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques –Surge Immunity test
IEC 61508-2	Functional safety of electrical/electronic/programmable electronic safety related systems- Part 2: Requirements for electrical/electronic/ programmable electronic safety related systems
BS 6346	Electric cables. PVC insulated, armored cables for voltages of 600/1000 v and 1900/33000 V
BS 6746	Specification for PVC insulation and sheath of electric cables
BS 6360	Specification for conductors in insulated cables and cords.
ITU-T-G.652	The construction and properties of metal armored loose tube fiber optic cable (Single Mode Optical Cable)

3 SCOPE OF WORKS

3.1 General

The Works comprise all signalling Works specified herein.

The Private Party shall be responsible for all Works and everything necessary (whether specifically mentioned in this specification or not) including all small parts, items etc. to ensure the successful implementation and proper operation of the Works in accordance with the Specifications and Contract Documents.

The Works shall include detailed design, manufacture, supply, delivery, installation, setting to work, testing, commissioning and dismantling and recovery from site of all materials and equipment made redundant by the Works.

The Works shall also include provision of spare parts, special tools and equipment, training and facilities for factory witnessing and testing by the Engineer's Representative.

3.2 Signalling Works

Signalling Works shall be provided throughout the Project Area as detailed on the schematic Draft Line Diagram attached

The schematic Draft Line Diagram shows general arrangements only. The Private Party shall design all final arrangements in accordance with relevant specification criteria taking into account detailed field surveys, final civil and track designs, signal sighting surveys. Such final design shall include appropriate numbering of signalling functions as required.

Signal structures, gantries, repeater signals, provision of all signals actually required, including standard posts, long posts, gantries, cantilevers etc., based on site conditions, final track intervals, sighting requirements etc. are the Private Party responsibility and all such signals and structures shall be deemed to be included in the Contract.

Further the supply and installation of a train detection system, point machines, power supply systems including UPS requirements for all signalling provisions and equipping the depot(s), yards with signalling facilities shall be considered.

3.3 Train Control System

The Private Party shall supply an ATP system that is an open interoperable state of the art high speed signaling system **according to** the European Control System(ETCS), The Chinese Train Control System(CTCS) or the Japanese Train Control System (Digital ATC)

The Train Control Area would be designated as follows:

1) Area between U-Tapao to SVB and Latkrabang : Train detection and train integrity supervision are performed by the trackside equipment. Movement Authority (by radio) with continous speed control profile such as ETCS – Level 2, CTCS Level 3, Digital ATC

2)Area between Lat Krabang to Phaya Thai : Train detection and train integrity supervision are performed by the trackside equipment. Movement Authority is transmitted always at the group of Balise close to the relevant main signal with the end of authority such as ETCS – Level 1 or 2, CTCS Level 2 or 3, Digital ATC. The Existing airport link signalling 's system have to compatible with the new signalling system and seamless cross all border.

3) Area between Phaya Thai to Don Mueang : Train detection and train integrity supervision are performed by the trackside equipment. Movement Authority is transmitted always at the group of Balise close to the relevant main signal with the end of authority such as ETCS – Level 1 or 2, CTCS Level 2 or 3, Digital ATC.

The Private Party shall design and install the Train Control onboard (Trainborne) Equipment in all new Rolling Stock equipment.

The Private Party shall ensure that the Works are fully and completely integrated, that all design and construction interface issues are properly identified, addressed and resolved.

3.4 Local / CTC Control – Operators Workstation

a) Local Operators Workstation comprising VDU arrangements shall be provided, together with facilities for transfer of control between Local Workstations and CTC where such CTC arrangements are provided.

b) The most efficient and cost effective method for dealing with replacement of local control arrangement -if required - shall be provided.

3.5 Interlocking

All new stations shall be provided with a Computer Based Interlocking (CBI) system, all existing CBI Stations (Airport Link) shall be open and interfaced with the new highspeed system. In accordance the European Control System (ETCS), The Chinese Train Control System(CTCS) or the Japanese Train Control System (Digital ATC)

3.6 Point Crank Handles

Point crank handles for manual operation of Point machines shall be provided at all new stations.

3.7 Planning and Execution of Work

The Signalling works shall be planned, coordinated and integrated with civil engineering and trackwork such that :

- Work is carried out in a safe and secure manner
- Any effects on Employer ET’s train operations are minimised
- The need for temporary signalling works shall be eliminated as far as possible
- Work is progressed expeditiously
- Activities are correctly sequenced
- Progress is under continuous monitoring and review

- Planning is modified as necessary to take account of progress of dependent Civil Engineering activities.

3.8 Interfaces

The Signalling Systems shall be designed and installed to interface with existing signalling installations (Airportlink).

3.9 Signaling Equipment Rooms

Existing Signalling Equipment (Airportlink) rooms shall be re-used provided they are suitable and spacing requirements are fully adhered to.

Where new stations are being constructed by others, the station buildings will include a Signalling equipment room, air conditioning units, battery room and Standby generator room.

3.10 Immunisation of Signalling Equipment

It is the intention of Employer to adopt electric traction at 25 kV, single phase, 50 Hz as provided for the Airport Link.

It is therefore required that as much protection against electro-magnetic effects shall be built into the design as is economically viable.

4 SIGNALLING GENERAL REQUIREMENTS

4.1 Signalling System General

The signalling system shall be based on a three aspect system employing colour light signals displaying Red or Yellow or Green with an aspect sequence to control train movements on a signal to signal basis in conjunction with the Train Control System.

The main running signals shall be supplemented by additional signals such as Junction Indicators for diverging routes, call-on signals and shunt-ahead signals and speed indication boards.

The Yellow warning aspect shall provide a minimum warning distance of 1000m to the Red stop signal, this may be extended to suit particular conditions up to a maximum of 1500m.

Warning distance may exceed 1500m through station layouts subject to the approval of the Engineer’s Representative for each case.

Where particularly difficult sighting conditions occur, an advance indication of the state of the signal ahead shall be provided by a Repeater Signal.

Shunting movements shall be controlled by subsidiary main signals, or ground shunting signals or hand signals in conjunction with Limit of Shunt Boards and other fixed signals.

4.2 Signal Aspects Code

Red - Stop.

Yellow - Proceed on straight route prepared to stop at next signal at Red.

Yellow with Junction Indicator - Proceed through junction or junctions - regulating the train speed through the junction to limit given by the speed board - prepare to stop at next signal at Red

Green - Proceed on straight route, next signal at Yellow or Green.

Main Red Aspect with Subsidiary Emergency Call-On Signal - draw ahead to next signal and be prepared to stop short of any obstruction.

4.3 Signal Aspects - Displays Main Running Signals

Red and/or Yellow and/or Green aspects according to the format required and with the aspects arranged in a vertical row, Green above Yellow above Red and provided with a long range lens.

4.3.1 Junction Indicators

Five lunar white lights displayed at an angle of 45 degrees to left or right of the vertical. In the case of multiple routes to the left, or to the right, only one Junction Indicator shall be provided to indicate all routes diverging to .the left, and one indicator to indicate all routes diverging to the right.

In the case of routes diverging to both left and right, the indicator shall consist of one pivot light, plus 4 lights for the diverging indication to left and right.

4.3.2 Emergency Call-On Signal

Three lunar white lights in a triangular arrangement with main signal at red.

Flashing Red Aspect (for Inner Home Signals)

4.3.3 Shunt Ahead Signal

Three lunar white lights in an inverted triangular arrangement with main signal at Red.

4.3.4 Ground Shunt Signal

Horizontal Line of two Red lights - Stop.

Diagonal Line of two lunar white fights (45 degrees) - Shunt ahead

4.3.5 Repeater Signal- Main Running Signals

Five lunar white lights arranged to display either three horizontal fights or three diagonal (45 degrees) lights.

4.3.6 Horizontal - Signal Ahead at Stop (Red)

Horizontal Flashing - Signal Ahead at Caution (Yellow) Diagonal Signal Ahead Clear (Green).

4.3.7 Limit of Shunt Board (L.O.S.)

A black and white post in accordance with consented Working Drawings and shall be located to indicate limit of train movements taking place without the clearance of the main running signal.

4.4 Indication of Signals

All controlled signals, intermediate automatic signals and warner signals shall be indicated at Workstations VDUs - but the indications shall essentially consist of a red indication when the signals and its controls are "on", and a yellow or green indication when the signal and its controls are "off'. Intermediate automatic signals shall be indicated generally, at the Workstation VDU to which a train approaching the signal would be heading. Separate indications shall be provided for Junction Indicator Signals, subsidiary Call-on Signals or Shunt Ahead Signals Repeater Signals and Ground Shunt Signals.

The indications shall, in addition to the signal control relays, be controlled by the Lamp Proving relay such that the indication is extinguished when the signal is not illuminated.

4.5 LED Failure System

All main running signal aspect units shall be fitted with a LED failure system.

Failure of the LED in a signal aspect shall be indicated.

4.6 Identification of Signals

4.6.1 Signal Number Plates

All signals shall be identified by a number. A new number plate shall be provided for all new and existing signals throughout the contract area, and shall include a station code where applicable.

Controlled signals shall be designated by a number referring to the number of the controlling function on the Workstation VDU. The number shall be preceded by a two or three letter code of the station name which controls the signal.

4.6.2 Local Operators Workstations

4.6.2.1 General

Local Operators Workstations shall be installed in the Station Masters Office, signal cabin or other designated space.

Access to Workstations shall be password protected.

Workstations shall consist of Visual Display Units (VDUs), which will show the status of the Interlocking displayed on a track mimic layout with graphical Symbols. The layout symbols and text shall be adequately sized consistent with providing clear information and readability from the normal operating position by an operator with normal vision in normal ambient lighting conditions. The layout shall be in the same orientation as the external railway and although not to scale shall have track circuits signals, points, and other indicators in a reasonably correct relationship. Windows of controlled command and alarm message shall be shown on the same screen also.

The system shall be controlled with a mouse and keyboard and shall include: -

- Route setting
- Point Control
- Alarm acknowledge
- Blocking control
- Emergency control
- Attendance/Non -attendance control
- Day/Night control
- CTC/Local control

The content, style and presentation of visual and audible information shall be in accordance with SRT's current principals and practice.

All safety related indications shall be:

- Laid out logically.
- Grouped together where appropriate.
- Grouped in relation to the equipment controlled or supervised.
- Clearly labelled

Displays shall include significant geographical features affecting the safe operation of the railway (e.g. station platforms, bridges, viaducts etc.) and distances, where necessary, to assist correct judgment.

It shall not be necessary to show all available information all the time. The ability to progressively suppress items of fixed information, to achieve better clarity, is required. It shall be possible to display certain fixed Information on demand, separately or in any combination , including:

- Signal Identities
- Point Identities
- Track Circuit Identities

Adjacent to all lettering in English there shall be the equivalent in Thai script. The interpretation of the English to the Thai script will be added to the drawings by the Engineer’s Representative when the Private Party submits drawings for review. Numbers shall only be in English and shall be included on the drawings before the drawings are submitted to the Engineer’s Representative for approval.

All commands, controls etc. shall be affected from a seated Workstation position which shall be fitted out with all the necessary operator interfaces including VDU's, mouse, Keyboards etc.

The user of any VDU shall be able to adjust the brightness, contrast and color saturation to suit. The user shall be capable of making the required adjustment from the normal operating position.

Command inputs and operation of controls etc. shall be by "on-screen" cursor setting methods controlled by mouse. The number of operator actions required to execute a function shall be kept to a minimum but shall be consistent with clear, logical and coherent execution of functions.

Safety critical commands, e.g. emergency route release, emergency point operation, call- on route setting, removal of "blocking" controls etc. shall be controlled by operation of a screen password.

Independent back-up control facilities shall be available from an associated 'QWERTY' style keyboard. Custom designed keyboards are not permitted.

Clock/Time displays shall be provided. The clocks shall be synchronised to a common controlling source within a given installation, together with the train control and communications equipment and the data recording equipment, and shall show the time corresponding to a recognised National Time signal.

A fully redundant system configuration shall be provided; employing duplication of computers, second computer shall be controlled suddenly after switching without any obstruction, associated hardware, communications links etc., and shall be integrated with the associated redundant CBI system.

A static layout of the interlocking area shall be provided to supplement the Local Operators Workstation showing all tracks, signals, points, platforms and stations and all other signalling equipment. This shall be mounted in a frame at a location approved by the Engineer’s Representative such as it does not cause an obstruction.

The size shall be such that it is clearly readable from the position of the Workstation operator.

Overhead lighting shall be provided in the SM office above the Local Workstation to provide adequate illumination of the writing area. This facility shall be fed from the secure signalling power supply system. All terminals and exposed connectors at mains voltage will be covered and labeled.

4.6.2.2 Route Setting

Routes shall be set from an entrance signal to an exit signal or exit location. It shall be possible to set "long routes" within an interlocking by selection of an entrance to one route and an exit to a subsequent route ahead. All routes in between shall then set. Cancellation of long routes shall only be possible by cancelling each individual route in turn.

Oversetting by main routes shall be provided over ground shunting signals which occur in the line of route, and also for through traffic passing through stations on the main line.

The status of the routes shall be clearly indicated.

Generally the colour of the track mimic on the VDU, between entrance signal and exit signal or exit location shall reflect the status of the route.

The track mimic over those portions of track containing power-operated points shall indicate the direction of the route.

In the event of a track circuit (axle counter) failure (other than the points track circuit) the route, if otherwise available, shall set but the signal shall not clear.

The colour of the track mimic shall progressively revert back to its quiescent state as the route is normalised in conjunction with sectional route releasing.

4.6.2.3 Clearing of Signals

After a route has been set and locked the signal leading over that route shall automatically clear to the appropriate aspect, except in the case of approach released signals and call- on indicated signals.

If the home signal does not clear because of the failure of a track circuit in the route, or its overlap, or a failure of the LEDs of main signal , setting the "CALL ON" route at the Workstation shall clear the "CALL ON" signal and cause the "CALL ON COUNTER" to increment by one. The "CALL ON" command shall be set by operation of a secure function by password.

The "CALL ON" signal shall be normalised by the route releasing circuit or, if inoperative, by the "EMERGENCY ROUTE RELEASE" function that shall be released by operation of a secure function by password.

4.6.2.4 Cancellation of Route

Passage of a train shall automatically restore the signal to red. The route shall be sectionally released by the passage of the train. Points shall remain in their last operated position.

If, following the passage of the train the route does not release, operation of the "EMERGENCY ROUTE RELEASE" function shall release the route after a preset time of maximum of 5 minutes.

This operation shall be released with a secure function by password and indicated in a distinctive and graphic manner and shall advance the "EMERGENCY ROUTE RELEASE COUNTER" one step. If, following the setting of a route, the signals have cleared but the track circuits are not dropped ie: a train has not passed the signal, operation of the "SIGNAL CANCEL" function shall change the signal to red.

If the approach locking is not engaged the route shall normalise immediately; if the approach locking is engaged the preset time delay must expire before the route is normalised. During the time-out period the individual Signal Lock indication shall flash.

The time delay shall be nominally 2 min. but shall be adjustable for any period between 30 sec. and 5 min.

4.6.2.5 Signal Dimming & Point Indicator Lighting (Day/Night Switch)

Signal dimming and point indicator lighting functions shall be provided at the Workstation. The signal indication dimming function shall dim the lighting of main signal aspects, call-on and shunting signals but shall not dim junction indicators.

4.7 Operation of Power Points

4.7.1 By Route Setting

When track circuits (axle counter) free and condition of route setting is available, points shall be set and locked by the operation of the route setting system.

Where a route contains more than one set of points, these shall be set in sequence:-

1) As detailed in the control tables to satisfy interlocking conditions.

   In order to prevent point machine switch-on surges over loading point power supplies points shall be called sequentially, separated by an adequate time interval.

2) A maximum of 2 machines at each end of the station may be switched on together at any one time.

4.7.2 Individual Operation

Individual operation and individual locking of a set of points shall be available from the Workstation. This operation shall cause the points to assume the opposite position. This operation shall be possible when the points track circuit is clear, no route is set over them and the points are not "Blocked".

4.7.3 Emergency Operation of Points

If the points track circuit has failed, points may be thrown individually by operation of the "POINTS EMERGENCY" function. This operation shall be set with a secure function by password and cause the "EMERGENCY ROUTE RELEASE COUNTER" to increment by one indicated in a distinctive and graphic manner and shall cause the POINTS EMERGENCY COUNTER to be advanced one step.

4.7.4 Point Crank Handles

Crank Handles for the manual operation of point machines shall be provided and shall be normally housed in an interlocked circuit controller mounted on a wall at the Workstation location.

When the handle is removed signals reading over the points shall be prevented from clearing or shall be replaced, the points shall be prevented from operating electrically and the points detection shall be interrupted

4.8 Automatic Block Operation

The automatic block operation shall be in accordance with the Train Control System requirements.

4.9 Key-Locks for Hand Operated Points/Derailers

The key is required for the use of operating staff to unlock hand-operated points or derailers for shunting.

The construction of the key and construction and operation of the key lock shall be in all essential respects identical to the details described for the "Occupation Key" except that the key and key lock shall be engraved with the station name and the points/derailer number to which they apply.

4.10 Electric Points Emergency Crank Handle Controller

In case of electrical failure of a points machine the points will be manually operated by crank handle.

The crank handle will normally be housed in a circuit controller located in the Station

Masters Office.

The points crank handle shall be configured with an index such that it is only possible to insert the handle into the correct point machine and return it into the correct circuit controller at the station to which it applies.

The crank handle shall be engraved with the station name to which it belongs and additionally with the number(s) of the points to which it applies.

The crank handle shall normally be retained in a circuit controller which shall be wall mounted in the Station Masters Office.

The circuit controller shall be configured to accept only the correct crank handle, and shall be engraved with the station name and the points number to which it applies.

The circuit controller shall have a minimum of two sets of electrical proving contacts which are closed only if the crank handle is present in the controller and turned to the "locked" position .

Removal of the crank handle from the controller shall not be possible without rotation to an "unlocked" position. Rotation of the crank handle from the "locked" position shall positively drive the proving contacts open and they shall remain open until the crank handle is rotated back to the locked position.

The electrical contacts shall be robust and be manufactured of corrosive resistive material, and the contacts shall impart a self-cleaning wiping action.

The circuit controller case shall be in a dust-proof steel or cast housing or similar material such as alloy with a removable, sealed and lockable cover.

4.11 Event Recording and Playback Facility

Event Recording and Playback Facilities shall be provided at each local Interlocking and also at the CTC.

All control, command, indication, alarm and fault etc activity and system information shall be recorded.

The event record shall include date & time tag, event description, object name, priority, class, interlocking, operator etc.

Outputs shall be available as hardcopy, screen displays, playback etc. It shall be possible to filter outputs by time span, activity type, event priority etc.

The Playback System shall record events and pictures for later viewing. Operators shall be able to select starting points, playback speed (typically 0.1, 0.5, x1, x2, x10, x100), pause, reverse etc.

On line data storage of one month shall be provided, enabling users to access and browse the previous 30 days record at any time. The system shall also store records in a suitable manner to pemit transfer of each month's records to external processors or onto suitable media for archival storage. The following factors shall be taken into account: -

- Separate physical media units required for each month's records.
- A simple means of retrieval and display of the archival information is required.
- Sufficient media for at least 12 months records shall be provided.

The prime storage media shall be duplicated and the system shall be incorporated into the associated fully redundant systems.

4.12 Interlockings - Computer Based Interlocking (CBI)

4.12.1 General

Each station or interlocking area as defined shall be provided with a computer based route setting interlocking (CBI) which shall be controlled from Local/CTC Operators Workstations as specified in the Scope of Works. A distributed interlocking system shall be provided with individual local CBls installed at each station.

Computer based interlockings shall be of a type which are well established within the profession, they shall be well proven, tried and tested and have a substantial successful service history on other recognised major passenger railways worldwide, including service in locations with a similar climate to Thailand.

CBls, in the type and form proposed, shall have achieved certification, by independent competent authority, of successful completion of formal validation and type approval processes.

Full and complete technical and operational information and details shall be provided for all major components.

Submittals for review by the Engineer’s Representative shall include comprehensive details of such systems including the following:-

- safety philosophy utilised
- international standards applicable
- hardware, software and operational descriptions
- availability strategy and expectation
- system architecture
- evidence of formal validation, type approval and acceptance, by competent authority, for use on other recognised major passenger railways worldwide.
- service history including locations in use, length of service, references etc.

The description shall also define how the system caters for the following:-

- Interfacing to the CTC system.
- Software interpretation of interlocking principles.
- Data preparation and data modification.
- Interfacing to signals, points and track circuits.
- Testing using simulators.
- Technician terminal facilities.
- Maintainability and fault diagnosis.
- System self monitoring and activity recording.
- Training requirements.

Processing speed shall be such that, to an operator, actions and associated responses shall appear to be virtually instantaneous making due allowance for operational times of external equipment. In any case, the "major cycle time" for each individual CBI shall not exceed 1.3 sec. within which time all status, interlocking, interface and ancillary functions applicable to the CBI shall be properly processed, including cross-boundary route functions in cases where an interlocking area is made up of a number of CBI units. The system shall incorporate means to permit the monitoring and display of worse case "major cycle time". Allocation of processor systems within interlocking areas shall be designed accordingly.

A Red aspect-retaining feature shall be employed for signals which shall ensure a RED aspect is maintained under failure conditions or where incomplete or corrupted data is received.

A fully redundant system configuration shall be provided employing duplication of computers, hardware, communication links etc. and operating in hot standby mode, to ensure that any single malfunction, hardware failure, disconnection, etc. shall not shut down an interlocking or any major portion of an interlocking. A Secondary system shall be controlled and indicated suddenly after switching without any obstruction. Electronic field units shall be installed in the same room as CBI only which shall be subject to the specific approval of the Engineer's Representative.

Relevant railway industry standards, including those applicable to the following, shall be strictly and rigorously applied:-

- protection against hardware conditions creating unsafe operation
- software configuration, production, validation and version control
- independent, or evidence of independent, safety verification

Compliance is required with the following requirements for SIL 4 with CENELEC EN50126, 50128 and 50129.

4.12.2 Local Maintenance Workstation (Technic Terminal)

Visual Display Unit (VDU) colour monitor with mouse, Keyboard (QWERTY) and all necessary software for operation. Routes and signals would not be able to be set but it is to provide a Comprehensive event logging, recording and replay system.

To be located in the Station Equipment Room to enable maintenance personnel to see the state of the interlockings on a track-layout plan display. To show track circuits, points, signals and other equipment. Typically to include:

- Inhibiting and blocking functions.
- Log all internal or external change of state.
- Log all interlocking faults.
- Log selected and identifiable external failures.
- Real time display of graphical events.
- Replay graphical events between times nominated by user at slow, real time and fast speeds. To include start, stop, pause, fast forward, fast reverse facilities.
- Display and replay other states in text.
- Display and replay selected items.
- Display and replay all or selected changes of state.
- Keep log files for access purposes.
- Replay of log tiles.
- Printer to copy displayed data.
- Counters to show on the VDU the readings for operations of the following.
- Emergency route release; Points emergency; Call on; Points trailed; Block cancel up side and Block cancel down side.
- Station Name
- Time
- Windows of controlled command
- Windows of alarm messages

A static layout of the interlocking area showing all tracks, signals, points, platforms and station and all other signalling equipment shall be provided in the vicinity of the Maintenance Workstation. This shall be mounted in a frame at a location approved by the Engineer’s Representative such as it does not cause an obstruction. The size to be such that it is clearly readable.

4.12.3 Remote Diagnostic/Monitoring

Remote Diagnostic/Monitoring graphic display and recording tool for maintenance use. Typically to include the following functions:

- Real-time display of system status.
- Track plan displays.
- System fault messages.
- To be able to log all system events.

- Replay of logged data in graphic form.
- Remote access
- To be able to display multiple interlockings

4.13 Interlocking Control Tables

The Private Party shall prepare full and complete Interlocking Control Tables for all stations, including block controls.

All Interlocking Control Tables shall be submitted for approval in accordance with an agreed schedule.

All interlocking and control functions shall be in accordance with accepted railway signalling safety principles.

4.14 Power Failure

System design shall ensure that no additional or unwanted locking is applied after the restoration of power after power failure, and the design or other special provisions shall ensure that no route which has been set but not yet occupied shall become unlocked or be cancelled as a result of power failure or power interruption, and that no route that is set and is being traversed by a train shall become unlocked as a result of a power failure or resumption of supply after a power failure.

4.15 Train Detection System

4.15.1 General

Train detection and train integrity supervision shall be performed by the track side equipment of the underlying signaling system (interlocking, track circuits etc.)

Therefore a train detection system shall be provided identifying the location of the trains.

The system to be proposed shall cover conventional Track Circuits necessitating insulated rail joints, Audio Frequency Track Circuits and/ or Axle Counters.

4.15.2 Track Circuits

Conventional Track Circuits shall be provided in station areas as well as in the depot- and yard area. The design of the track circuits shall be carried out by the Signalling Contractor, whereas the installation shall be done by the Track Work Contractor.

4.16 Signalling Power Supply

4.16.1 Basic Power Supply Configuration

Signalling Power Supply shall be fed at the Power Equipment Room of all new stations and the Depot to be provided by the Power Supply Subsystem.

Incoming power shall be isolated by transformers from the auxiliary power system. The signalling power supply system shall be earth free and its feeders equipped with earth leakage detectors, to provide alarm in case of an earth fault detection.

4.16.2 Backup Power Supply

A combined arrangement of auxiliary supply of UPS and Diesel Standby shall be provided.

In the event of an incoming power failure the no-break type UPS standby system shall take over and its batteries shall maintain power to the signaling system (except of point machines) for a minimum period of 1 hours.

The Diesel Generators provided by the Power Supply Subsystem shall sustain a minimum of 24 hours operation time to the essential consumers of the station building including the Signalling System.

4.17 Point Machines

Both, the main line shall be provided with non-trailable and the Depot shall be provided with trailable electro-mechanical type of point machines.

All point machines shall be equipped with an associated point indicator to indicate to the train driver the position of the turnout (either straight or diverge direction) in day and night time.

4.18 Depot/Yard Signalling

The following systems shall be provided in the Depot:

1. Computer based Interlocking (CBI)
2. CTC I/F
3. Train Detection System (Track Circuits)
4. Point Machines incl. Point Indicators
5. Derailers
6. Ground Shunt Signals
7. Wayside Signals

Workstations for the Controller shall be provided at the OCC.

5 ENVIRONMENTAL CONDITIONS

5.1 General

This Clause sets out details of environmental conditions in which railway signalling equipment may be stored, transported or operated.

Equipment shall operate satisfactorily and in accordance with the specification under year round environmental and climatic conditions experienced in Thailand including, but not limited to: -

- Temperature & Humidity
- Pollution
- Near Shore Saltwater Atmosphere
- Solar Radiation
- Lightning
- Vibration Wind & Rain
- Reptile, Insect and Rodent Attack.

All equipment data shall include details of the various ranges of environmental conditions and which the equipment and systems will continue to function satisfactorily in accordance with the specification.

5.2 Environmental Categories and Definitions

Equipment may be stored and operated under a wide rage of conditions. The categories described below cover this range. The paragraphs of this Clause define the environmental conditions for the different categories again using the reference letters to identify them. An equipment will be required by its Individual specification to conform to one of these categories which will be referred to by its reference letter.

Equipment Housing	Category
Internal air conditioned and continuously manned	A
Internal may, or may not, be air conditioned and/or continuously manned	B
Line side Apparatus Cabinets	c
Apparatus exposed to prevailing weather conditions, (not track mounted)	D
Apparatus exposed to prevailing weather conditions, (track mounted)	E
Portable Apparatus	p

Definitions

The following definitions apply: -

Track Mounted Equipment : Equipment mounted, either directly or indirectly, on sleepers (transverse or longitudinal), slab track, ballast or underline bridges or equipment supported either directly or indirectly from the rail.

Shall Operate Correctly: Shall be so designed and constructed that operating parameters do not lie outside those values laid down in the individual equipment specifications. The individual specification for an equipment may lay down the way in which it shall behave under failure conditions (i.e. it may be required to be "fail-safe"). If so, and if the equipment fails to a specified failure mode for no other reason than the effects of environmental conditions under which it is required to operate then it shall not be considered as having operated correctly.

Permanent Damage: Environmentally provoked deviations from the specified parameters which are not corrected when there is a return to normal working environmental conditions.

5.3 Electromagnetic Environment

This Clause applies to all Categories of equipment. Equipment must be provided with its own noise-free enclosure where necessary to ensure correct operation and avoid permanent degradation.

Transformers, electronic equipment and electromagnetic relays used in railway signaling systems result in other equipment housed in the same building or enclosure being subject to:

a) Stray magnetic fields

b) Electrical interference conducted along power supply, input and output connections.

c) Radiated electrical interference.

Additionally such interference may also be derived from AC electric traction systems.

Where protection is required against surges due to induction form lightning this will generally be provided external to the equipment. Typically 3 pole arrestors are used on track circuit and line circuits. The usual configuration is connection between each line and earth and between each line.

5.4 Temperature and Humidity

Equipment in each category shall operate correctly under the temperature and humidity conditions set out for that category in the Table.

No equipment shall suffer permanent damage by storage for an indefinite period or transport at ambient temperatures in the rage - 10 degrees C to 70 degrees C and relative humidity up to 100%.

All temperatures quoted are ambient temperatures assuming that no heat is produced within the enclosure. In practice the temperature within a small enclosure such as an unventilated line side apparatus case may rise to a higher value due to heat given off by the equipment itself. Design, construction and test procedures must be such that equipment will operate correctly under these conditions.

The temperature and humidity conditions are such that, in combination, condensation may occur on and within equipment which shall operate correctly under such conditions.

5.5 Mechanical Environment

Equipment in all categories with the exception of thermionic devices shall not suffer permanent damage by a shock equivalent to a free drop of 250 mm on to a solid surface. This solid surface shall be rigid, shall not itself deform under the Impact and shall be sensibly flat.

For equipment in categories D and E this requirement applies to equipment in working condition but when packed or arranged for transport the requirement is modified in that the free drop shall be 500mm.

Equipment in each category shall operate correctly under the vibration conditions set out for that category in the Table. No equipment shall suffer permanent damage either by storage for an indefinite period under the vibration conditions specified for the working of Category C equipment or by transport by rail or road vehicle.

Category P equipment will include such items as measuring and recording instruments and while satisfying the vibration requirements for category C equipment under operating conditions E must not suffer permanent damage by continual transport in rail or road vehicles.

In all cases the vibration amplitudes quoted in the Table are maximum. Since the vibration will usually be caused by passing trains it will be intermittent. The variation of vibration with time which the equipment must be designed for and which it must withstand on test is as follows:

a) from zero the amplitude increases to maximum at a uniform rate over a period of 30 seconds ,

b) the amplitude remains at the maximum value for 60 seconds,

c) from maximum the amplitude decreases to zero at a uniform rate over a period of 30 seconds,

d) the amplitude remains at zero for 9seconds,

e) a further cycle of variation of amplitude commences.

This variation applies throughout the frequency range 0 to 100 Hz.

5.6 Pollution

Equipment will be in contact with the atmosphere which will generally be polluted. Pollutants may be wither chemically active or inert such as dust.

All equipment must operate correctly in a dust laden atmosphere. Means must be provided to prevent either ingress of pollutants or their direct or indirect effects preventing correct operation or causing permanent damage during transport or storage.

Chemically active pollutants may occur in the atmosphere near sea water or in industrial areas. In the latter case gases may dissolve in condensation or themselves condense in or on equipment. Equipment shall be protected against the effects of such corrosive substances.

Equipment in categories D and E must be resistant to attack by detergents, sewage, toxic substances such as weed killer and lubricating and fuel oils.

5.7 Packaging to meet Transport and Storage Requirement

The requirements for transport and storage may be more economically met by providing temporary packaging, to be removed in installation only, as an alternative to meeting the requirements of the design and construction of the equipment itself.

If equipment is offered on this basis the temporary packaging must comply will all the relevant requirements for the equipment as specified both in this specification and the individual equipment specification. The temporary packaging must be offered for type approval with the equipment.

The temporary packaging shall additionally comply with the following requirements.

Full details of the equipment, as shown on the equipment label, must be given on the outside of the packaging.

It must be possible to remove and replace the temporary packaging without ·reducing its effectiveness.

Labels are to incorporate a distinctive colour either as the background or or the lettering and shall be provided adjacent to each and every means by which the package may be opened or removed. The wording on these labels shall read:

"PROTECTIVE PACKAGING. ONLY TO BE REMOVED IMMEDIATELY BEFORE INSTALLATION"

The lettering for this label shall be at least as large as the largest lettering on the other parts of the packaging.

Table 1 - Environmental Ranges etc.

Category	Ambient Temperature Range		Maximum Relative Humidity (not considering)	Ingress Protection to Cenelec EN 60529 Standard	Maximum Vibration Amplitudes (MM)	
	Min	Max			0-50 Hz	50-100 Hz
A	0°C	+45°C	95%	IP code 52	0.05	0.01
B	0°C	+45°C	95%	IP code 52	0.125	0.025
C	0°C	+70°C	99%	IP code 54	0.125	0.025
D	0°C	+70°C	99%	IP code 54	0.125	0.025
					0-9 I9-25 I25-50 Hz I Hz l Hz	
E	0°C	+70°C	99%	IP code 54	20 I 10 I 2	0.5
p *1	0°C	+70°C	99%	IP code 54	REFER TEXT	0.5

*1 - To be Ruggedised

6 CTC GENERAL REQUIREMENTS

6.1 General

A fully redundant system configuration shall be provided employing duplication of computers, hardware, communication links etc. and operating in hot standby mode, to ensure that any single malfunction, hardware failure, disconnection, etc. shall not shut down the CTC or any major portion of the CTC or its associated systems.

Systems shall be capable of supporting various interlocking interfaces and protocols including CBI and shall allow the addition of new specific interlocking interfaces and protocols as required.

System faults and alarms shall be recorded.

Each station on the SRT network has a unique three-character identification code, which shall be incorporated into CTC systems as appropriate. A current list can be provided by SRT.

6.2 CTC Workstations

The number of Operator's Workstations, Chief Controller's Workstations and Remote Workstations etc. required for a particular CTC controlled area shall be specified under Scope of Works.

Facilities and system requirements, as specified for Local Workstations, shall be applicable to CTC Workstations subject to adaptation and enhancement of such facilities etc. to suit CTC operation.

Dynamic color displays of the whole of the CTC control and supervision areas are required. Use of pan and zoom techniques to pan seamlessly along the total system picture or to view selectable areas is preferred.

The limits of each signalling interlocking shall be depicted.

The following functions shall not be available under CTC control :-

- Call-On Routes
- Emergency Route Release
- Emergency Point Operation

Repeats of "call-on control" counters, "point trailed" counters, Emergency Point" counters and Emergency Route Release" counters, for each interlocking individually, shall be included in the CTC indications.

Inhibit or Blocking functions, when initiated by the CTC, shall be maintained as vital functions in the field in the event of a transmission failure.

Alarms & Indications for each Interlocking shall be provided at the CTC. Audible warnings shall not sound at the CTC for stations which are in Local Control.

Other alarms & indications to be provided at the CTC are:-

- Station in Local Control
- CTC Central Equipment Failed - Urgent Alarm
- CTC Transmission I Field Equipment Failed (for each Interlocking) - Urgent Alarm

It shall be possible to place certain signaled routes into "Fleeting Mode" such that, on passage of a train, route normalisation is inhibited and such signals are allowed to re-clear when conditions ahead permit. This facility shall be provided for through straight routes.

All controls shall be affected from seated Workstation positions which shall be fitted out with all the necessary operator interfaces including VDU's, Keyboards and other control devices in respect of all. CTC functions and operations including signalling control, communications, train describers, timetable systems, automatic train reporting, automatic route setting etc. Workstation position arrangements shall employ fully integrated systems with the minimum number of operator interface units, VDU's, Keyboards etc. consistent with efficient operation of all systems and facilities.

Workstations including furniture etc. shall take into account the color schemes and finishes employed in the CTC operations room as a whole.

Control areas and Workstations allocation shall be flexible to permit manning of the CTC to be varied to match traffic density over a 24-hour period. It shall be possible to control the whole, or any portion, of the CTC control area from any one or more of the Workstations.

Allocation of control areas to Workstations and transfer of control areas between Workstations shall be by secure means under the control of the Chief Controller.

Secure means shall be provided to ·ensure that, once a control area is allocated to a specific Workstation then such an area cannot be accessed by any other Workstation.

Allocation of control areas to Workstations shall be clearly indicated on system screens.

The limits of indications at the extremities of the CTC control area shall be such that all trains are indicated that are within sighting of the outermost signal aspects that can be caused to change from the CTC and that all trains which are between the CTC and the adjacent control facility shall be indicated at one facility or the other.

VDU picture displays shall contain sufficient information to enable Operators to carry out all train regulation and control functions.

There shall be sufficient VDU units at each Workstation position to enable the operator to view his whole area of control simultaneously whilst operating control functions from his fixed seated position. This shall be achieved by use of Overview pictures.

Such Overview pictures shall contain information consistent with that required to set main routes and effect train regulation including, in correct geographical relationship:-

a) geographical track layout together with major geographical features including. stations, halts, tunnels , viaducts etc.

b) main controlled signal symbols together with ON/OFF indication and signal identity

c) automatic signal symbols together with ON/OFF indications and identities

d) route set indications

e) track circuit (axle counter) indications

f) in-line point status indications

g) block direction Indications

h) train descriptions for all trains in the area of control

i) automatic working (fleeting) facilities

j) blocking facilities

Overview pictures shall be supplemented by "Detailed pictures". Such Detailed pictures shall be capable of facilitating the operation of all control functions and be capable of showing all indications specified.

Sufficient Detailed and Overview pictures shall be available to cover the whole area of CTC control.

The design of Overview and Detailed pictures shall be subject to the specific approval of the Engineer’s Representative.

The arrangements shall be versatile such that it shall be possible for operators to call up any display on any VDU screen.

Alarms and warnings shall be alerted to Operators irrespective of which displays are in operation .

Alarm, fault and diagnostic etc. information may be given on a separate screen display.

All text shall be capable of being displayed in Thai language and in English (Bi - Language). In the interests of clarity Thai and English need not be displayed simultaneously.

Other Alarms and Indications

The CTC Panel and Diagram shall include indications which will indicate alarms and failure indications from each station.

Separate Indications from each station shall be provided and indicated on the CC. diagram to indicate.

- Station in Local Control.
- Mains Supply Available.
- AVR Status Warning.
- Standby Generator Running.
- Standby Generator Low Fuel Warning
- Standby Supply Not Available.
- UPS Failed.
- Signalling Equipment Failed.
- CTC Equipment Failed.
- Telecommunication Equipment Failed.
- Signal Lamp (LED) Failed.
- Points Trailed.
- Intruder Alarm.

All alarm indications shall be flashing when requiring immediate attention and steady if less urgent attention is necessary.

Signal Dimming

A Signal lamp (LED) dimming control shall be provided which when operated shall operate the dimming switching device at all local panels/interlockings within the C.T.C. area of control and independent of the individual station selection.

6.3 Train Describer System (TDS)

6.3.1 General

The purpose of the TDS is to store and display the unique identity and location of all trains in the CTC area.

The train describer system shall be capable of dealing with train descriptions (TDs) consisting of six (6) characters of any combination of letters or numbers.

Train descriptions shall generally be subject to the following 6 character criteria:-

a) A letter followed by 4 numbers

b) A directional arrow positioned at the beginning or end of the TD as appropriate.

Dynamic TD displays shall be presented on screens which shall follow the progress of the trains throughout the CTC area. The description shall be displayed by replacement of a short section of track mimic with the TD at the location concerned, which shall then revert to normal track mimic as the TD moves on. Displays of empty 'TD berths" are not required.

The TDS shall be capable of dealing with joining and separation of trains, more than one train occupying a track circuit etc.

Comprehensive command facilities ·shall be provided including: -

a) Enter, delete, replace or move TDs

b) Edit manually and system generated TD queues

c) Search for the location of a specific TD

d) Identify the TD at a specific location.

The TDS shall continue to operate under degraded and/or unusual input conditions eg:-

a) Track circuit failures, spurious and bobbing track circuit indications

b) Point indication failures

c) Trains passing Red signals

d) Several trains on the same track section

6.3.2 Unidentified Trains

When the system detects the presence of an unknown train on a track circuit (which is not blocked), it shall firstly allocate a system generated description to the train, and then generate a prompt for the operator.

The system generated train description shall be carried along with any movement of the train until the operator responds to the unknown train prompt, or otherwise alters the train number.

Where a track, which is blocked becomes occupied, the unidentified train facility shall be suppressed.

6.3.3 System Borders

The TDS shall interface with adjacent TD systems to facilitate automatic transfer of TDs between CTC systems. Sufficient early transfer and display queuing of TDs for approaching trains is required to assist train regulation etc.

At borders with non-equipped sections, or in other areas where trains enter the CTC area, TDs shall be entered manually or automatically via a Timetable Management system with appropriate confirmation by the Operator. Where manual entry is required manual train queue display facilities shall be provided to automate assigning of TDs as trains enter the area.

6.4 System Transmission & Response Times

Each field interlocking shall be controlled by a CTC field station, which shall be periodically scanned. A fault or failure or disconnection of one or more field stations shall not affect the operation of the remainder of the system.

It is required that once a control is initiated by the CTC Operator that the field equipment receives the command and responds to it with minimum delay. The maximum time between activation of a control at the CTC Centre and the field interlocking responding shall be 500 ms.

Indications shall be transmitted back to the CTC Centre with minimum delay. The maximum time between a change of state in the field and the corresponding indication being displayed at the CTC Center shall be 1 second.

Up to 1000 objects shall be capable of being changed in this time scale.

When a new graphic picture is called up for display on a colour VDU, the response time from the finish of the entry of the command requesting the display until the conclusion of the drawing of the display, including all data items, must not exceed 4 seconds. Where a number of pictures are called simultaneously, then the maximum response must not be greater than 8 seconds for five (5) displays. These displays may be either identical or different in content.

Where text Information is called, the screen shall start writing within 2 seconds from the entry of the command, and be completed with a screen containing 1000 characters including blanks in not more than 4 seconds. Again, multiple screen requests are possible and this shall be such that all. screens complete writing within 8 seconds.

The maximum propagation & response times specified shall be achieved under worst case system loading conditions.

Synchronous communication circuits are available for CTC equipment operations. Direct digital interfaces between CTC equipment and SDH equipment are preferred provided electrical isolation conforming to the relevant Telecom standards is maintained.

6.5 Remote Workstations

Workstations provided for remote locations shall be identical to the CTC Operators Workstations but shall be limited to display functions and to enquiry facilities relating to the location, description, and running times of trains.

6.6 Maintenance Terminals & Facilities

Fault finding alarms shall be provided within the equipment and be available to the technician to aid in fault identification. Diagnostic indications considered necessary for ease of fault identification shall also be provided.

The following equipment and facilities shall be provided for maintenance personnel to access information and to assist in the testing of hardware and software operation under various conditions:-

a) Two (2) Maintenance Terminals, unless specified otherwise in Scope of Works.

b) Two (2) hardcopy reporting terminals complete with keyboards, unless specified otherwise in Scope of Works.

c) Facilities to display and/or record controls to, and indications from, a field station on a single bit or station basis.

d) Facilities to display and/or record, the contents of one or more words of storage:

e) Facilities to produce dynamic displays equivalent to CTC Workstation displays but without control, acknowledge etc functions.

f) Facilities to divert messages and reports from one device to another in the event of equipment failure.

g) Facilities associated with the Recording & Playback system. (Replay Workstation) shall be supported at a minimum of more than 1 year.

6.7 System Generated Warning Messages & Prompts

6.7.1 General

By suitable processing of the indication information being received from field locations, the CTC system shall be able to detect fault conditions, illegal train movements, and various other conditions likely to affect traffic operations in the field, and shall generate appropriate warning messages and prompts for display to the operator(s).

Each system generated message shall be timed and stored for display in either an urgent or non urgent message queue appropriate to an operator's position depending on the division of responsibility current at the time. When either queue contains a message for the operator an audible alarm shall be sounded in the appropriate VDU at regular intervals. On command from an operator one such message shall be displayed, with the order of preference being own urgent queue, own non-urgent queue.

All urgent messages shall be logged on the hardcopy report unit.

6.7.2 Warning Messages

Warning messages shall indicate a significant condition to be brought to the attention of the operator(s) and shall be classed as urgent messages. These messages shall Include warnings of, at least:-

a) An incorrect sequence of operation of track circuits

b) A train movement past a red signal.

c) A signal indicated at clear without the corresponding control being transmitted, except when in local control.

d) An indication that a signal has restored to red in the face of a train without the corresponding control being transmitted, except when in local control.

e) Failure to receive any response from a field station address for more than 30 secs (it shall be possible to suppress this warning during testing etc. which shall cause the CTC fault indication to flash).

In general, warning messages will not require any immediate keyboard response.

The format and text of these system-generated messages will depend on the nature of the warning and shall be in as near plain English as is practical. Each warning message shall contain relevant details of location, train, signal, etc., as applicable, and shall include the time of occurrence, not the time of display.

6.7.3 Prompts

Actionable advice messages, or operator prompts, shall be generated for display when the system determines that a train.is approaching or standing at a signal which is not being called to clear, or when the system determines that a slot or release operation is required of the operator because of a changed indication from the field.

When such a prompt is displayed the system shall accept, as a response, a simplified form of operator command indicating the action to be taken if any.

On command, operator prompts shall be displayed in a precise and unambiguous form. At least the following shall produce operator prompts:-

a) A running train in a station berth with the applicable starting signal not called to "Clear" when the section ahead clears.

b) A running train departing from a station passing an entry signal with the next controlled signal in advance not called to clear.

c) A running train occupying the berth track of any controlled signal not called to clear.

d) After. a shunting operation has commenced at a station (by the operator clearing a specific shunt signal}, and the shunt signal replacement track clears after being occupied. This prompt will normally be issued after each clearing of the points track.

e) When a slot for a signal is given by an external officer (Local SM, Signalman or other Controller).

6.8 CTC Control

6.8.1 General

Control of all signalling functions and their indications shall be available to the CTC Centre and to the local Workstation, so that the complete signalling system within the CTC area is under the control of the CTC operator, and during failure of the CTC system or during such other periods that are necessary, full signalling system control can be maintained by local Workstation Operation.

All Emergency Release functions and delay timers shall be proved to have reset before "switching out" changeover takes effect, and shall be proved de-energised before the "Switching In" changeover takes effect.

The operation of the CTC system and the Local Workstations shall enable the signaling system to be controlled and the block system to operate in any combination of stations which are under local Control or CTC control, thus a Local Workstation shall be able to operate to stations on either side or both sides which may be under local or CTC control.

6.8.2 Local Control

The Local Workstation shall be switched in or out by operation of a secure password locked switching function. Local or CTC control shall be indicated accordingly.

The Local Workstation shall be free to switch In or out, but shall only be switched by the authority of the CTC Operator.

When the Local Workstation is switching in, controls shall be automatically transferred to the Local Workstation, controls for the station from the CTC Centre shall be ineffective. Indications shall continue to operate normally at the CTC Centre

The action of SWITCHING IN shall take place automatically following the operation of the "Switch In" (local control) function and control shall be transferred from the CTC. This shall not cause any change of state in the field including aspect bobbing, state of routes set or not set, blocks set or not set, point controls or other locking.

All controls from the Local Workstation shall then be effective immediately.

Simultaneously local communications circuits shall be switched from the CTC Centre to the Local Workstation.

The action of SWITCHING OUT shall take place automatically following the operation of the "Switch out" (GTC control) function and control shall be transferred to the CTC providing that "Emergency Route Release functions and associated time delays are proved normal.

Simultaneously local communications circuits shall be switched through to the CTC Centre.

The action of switching out shall not cause any change of state in the field including aspect bobbing, state of routes set or not set, point controls or other locking etc.

6.8.3 Attendance / Non-Attendance Function

The Local Workstation shall be switched to Attendance / Non-Attendance mode by operation of a secure password locked switching function. Attendance I Non-Attendance mode shall be indicated accordingly.

The purpose of this function is to control the status of the Workstation and the communications circuits when the local operator is in attendance but not necessarily controlling the train movements, which may be under CTC control, and to secure the Workstation from unauthorised operation when the Workstation is unmanned during low traffic periods or when the Workstation is in local control but when the local operator is temporarily absent from the control office attending to other duties.

In the "non-attendance" mode the telecommunications circuits shall be switched through to the CTC Operator and the control functions shall be ineffective.

In the "Attendance" mode, even if the Workstation is under CTC control, the local telecommunications circuits shall be switched to the local operator/station master who will then deal with all local telephone communications. When in the "Attendance" mode signalling controls at the local Workstation shall only be effective when the local Workstation is under "Local Control".

6.9 Timetable Management System (TMS)

Timetables shall be the primary source of information for other systems typically automatic train reporting, automatic route setting, automatic train regulation systems and certain features of train description systems.

The Timetable Management System (TMS) shall provide for the basic preparation, building, storage, editing, loading etc. of Base and Operational timetables.

The system shall cater for seasonal, weekend, holiday and exceptional effects and shall enable operators to edit and modify timetable information both off-line and on-line.

Timetable data shall include train identity, type, class, time profile, stopping pattern, routing information etc.

Means shall be provided for the loading, activation, editing etc of appropriate daily operational timetables.

6.10 Automatic Train Reporting System (ATR)

The principal functions of the Automatic Train Reporting (ATR) system shall be:-

a) To monitor current train running performance against timetable.

b) To provide statistical data for analysis and timetable preparation.

As trains progress through the system their actual progress shall be monitored and compared with the operational timetable data.

For the purpose of monitoring station stops, the arrival time at a station is the time when the track circuit preceding _the loop line or passing road is occupied and then cleared (usually a points track). The departure time from the station is the time when the first track beyond the loop line or passing road is occupied (usually a points track).

System outputs shall be in the form of VDU displays, hardcopies and storage devices in respect of: -

a) Train Graphs

b) Train Run Reports, Schedules etc

c) Stored ATR data

Train graphs shall be of a form and type equivalent to those produced manually by SRT.

Displays of Train Graphs shall incorporate pan and zoom techniques in both axes.

ATR outputs shall contain information in respect of train running which is planned, actual, future and predictive and each shall be shown in a distinctive manner.

Outputs shall be available on a routine basis and also on demand. Operators shall be able to call up information by exception by the use of selection criteria. This shall include the ability to select the extent of variance from the timetable for specific reports.

The system shall interlink with the TDS such that TD displays are able to highlight extent of delay, ie variance from the timetable. Delay criteria and form of display shall be subject to the specific approval of the Engineer’s Representative.

On line data storage of one year shall be provided, enabling users to access and browse the previous one year record at any time. The system shall also store records in a suitable manner to permit transfer of each month's records to external processors or onto suitable media for archival storage.

6.11 Automatic Route Setting System (ARS) (if applicable)

6.11.1 General

The ARS system shall automatically set routes throughout the controlled area and shall provide the following facilities:-

a) Be capable of operating any booked service to its planned path from the point of Inception to the point of termination.

b) Be capable of automatically changing a TD where a train has completed one booked path and is about to embark on another booked path.

c) Be able to regulate path clashes that arise from perturbed running of booked services, minimizing the overall delay.

The ARS system shall be sub-divided into "Districts" which shall generally relate to interlocking areas. It shall be possible for operators to either enable or dis-enable ARS for each District separately. An indication of the status of each District shall be given to the operator.

The train service data for the ARS system will be derived from the TMS.

The ARS system shall be provided with the identity and location of each train by the Train Describer System.

The ARS system shall be capable of performing route setting and train regulation for the whole area under control of the CTC.

Route setting shall match the planned timetable when all trains are running as scheduled. When train services are disrupted the ARS system shall make decisions to regulate the service to achieve minimum overall delay to trains. Means shall be provided to enable such ARS decisions to be automatically referred to the operator for vetting and acknowledgement prior to implementation.

When it is not within the ARS system's capability to keep trains moving to achieve an optimum solution it shall keep them running in line with the general timetable plan or contingency plan.

ARS action shall be taken on the basis that trains shall only have routes set for them once they have been recognized by the ARS system and are included in the timetable data.

When the ARS system is enabled, manual route setting shall also be available and shall always take priority over automatic operation.

The operator shall be able to switch off the ARS system at any time.

Should communication to one or more interlocking be unavailable, ARS shall continue to operate in all areas not affected by failure.

Alarms shall be provided for any conditions affecting normal operation of the ARS system.

6.11.2 Operator Interface

The operator shall be able to:-

a) Operate the ARS system and receive information from it.

b) Selectively signal individual trains by ARS or manual means and be able to determine by which method each train is operated.

c) Determine where ARS will next route a train.

d) Ascertain the booked timetable of each train under ARS control.

e) Engage and disengage ARS Districts.

The system shall be interlinked with the TDS such that display of TDs for ARS and non-ARS trains shall be clearly distinguishable by use of distinctive colours.

6.11.3 Regulation Performance

The ARS system must regulate at least to, but preferably better than, the standard of a competent and experienced Operator. The system shall resolve all day to day regulation conflicts between trains whose route setting is under ARS control.

Regulation will include:-

a) Conflicts at points of convergence

b) Conflicts between following trains including the recessing of those with lower priority to allow those of higher priority to pass.

c) Conflicts over single line sections between opposing trains including sections of single line working in respect of booked maintenance work.

Calculations must take into account all trains affected by a predictable regulation.

Regulation of trains shall be based on the following princlples:-

a) When all trains are running to time they will be sequenced as defined in the timetable.

b) When running out of course the ARS system must minimise delay to all trains affected (eg where two trains are approaching a point of conflict in one direction the delay experienced by the second train as a result of ARS regulation must be factored into the delay calculation}.

c) Each train's delay shall be weighted according to priority utilizing an appropriate weighting system.

d) Timetable order shall be maintained where the weighted delays incurred in doing so are minimal.

The ARS system must regulate according to actual events and the operational timetable required.

6.11.4 Route Setting Requirements

Automatic route setting performance shall be efficient and timely and shall be at least equal to, or preferably better than, that of a competent and experienced Operator. Trains must not be unnecessarily delayed through lack of attention by the ARS system.

The ARS system must at all times route correctly described trains to their correct destinations.

Manual route setting, and cancellation, shall be available in parallel with ARS and shall" cause no additional activity to the operator as a result of the ARS being present.

Routes set by ARS shall be displayed in an identical manner to those set manually. ARS must permit trains to run with the least possible restriction wherever possible. Routes may only be set by ARS when all of the following are satisfied:-

a) The train is approaching a point where route setting is required.

b) The train has an entry in the timetable or is running to a standard pattern.

c) The train is progressing along a scheduled route or a permitted alternative route.

d) The next route required is designated as requiring setting by the ARS strategies.

e) The train is a designated ARS train.

Commands to set a route shall only be sent to an interlocking by ARS where such a route:-

a) is available to be set.

b) is an ARS route

c) lies in a District which is enabled for ARS operation.

Oversetting of routes shall not be permitted by the ARS system even where this facility is available manually.

ARS may only perform where routes are response automatically by the passage of trains.

In the event of any of the following occurring within an ARS District, then such a District shall immediately be dis-enabled and shall revert to manual control:-

a) manual cancellation of a route

b) detection of an incorrect sequence of track circuit operation .

c) initiation of Local Workstation control

ARS working may only then be re-established by the operator.

The ARS system shall set routes ahead of train movements to the following criteria:-

a) Routes shall be set far enough ahead of train movements so as to ensure that drivers do not receive restrictive signals unnecessarily.

b) Routes shall not be set to far ahead such that optimum train regulation is jeopardized.

6.11.5 Alarms

Suitable ARS alarms shall be generated for each of the following circumstances:-

a) Changes of state of the ARS system or of any District within it becoming either available or unavailable

b) The inability to correlate train descriptions in the timetable with those of trains in the train descriptions system.

c) Trains being run to a path not prescribed to them in the timetable.

d) The inability to set a route for any particular train.

e) Trains which have had a route set for them and fail to move within 5 minutes.

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SECTION 5 - TELECOMMUNICATION SYSTEMS & SCADA

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SECTION 5

TELECOMMUNICATION SYSTEMS & SCADA

1 GENERAL REQUIREMENTS

1.1 Relevant documents

This Outline Specification shall be read in conjunction with the Contract, the accepted proposal of the Private Party and other documents forming part of the Contract.

1.2 Technology standard

A state-of-the-art integrated and comprehensive Communications Systems shall be provided to avoid obsolescence of the technology and equipment as far as possible and to ensure efficient, cost effective and flexible operation of the HSR system.

The engineering details shall be provided based on the Specification and proven engineering practises and calculations. The Private Party shall propose systems that have been used in other railroads for at least 2 years in revenue service operating condition.

1.3 RAMS

It is a prime requirement that the COM & SCADA Systems, including each individual item of associated equipment, shall be designed, for high availability & reliability, low lifecycle cost, proven serviceability, and environment friendly. The COM & SCADA Systems shall be a balance between a configuration of mature, field proven hardware and software and conformance to the latest industry standards.

1.4 Open standards

All Communication Systems shall be based as far as practical on “Open Standard” technologies, protocols and interfaces. Furthermore the implemented systems shall maximize the use of IP/MPLS or TCP/IP and Ethernet interfaces on both internaly and inter-connected systems such as to provide a common single integrated overall system platform. The Communication System shall support concept of through operation with single central control room (OCC) for the whole HSR Line.

1.5 Environment

The Design shall take into account the configuration of the whole HSR Line and shall be fully coordinated with all other disciplines, operational strategies and procedures necessary for efficient operation. The design shall provide interfaces or shall integrate in the existing COM systems of the Airport Rail Link and the Red Line, the Private Party shall propose the level of COM & SCADA systems integration to the Engineer’s Representative.

1.6 Scope of Works

The communications systems shall include:

- **Backbone Transmission Network (BTN)**

  Secure, redundant & fast transportation of all data between all systems of the HSR rail system. The BTN shall not cause any functional or performance degradation of other systems and shall be designed to cope with futrue expansions.

- **Master Clock System (MCS);**

  Effortless visibility of time information for passengers, and operational staff , provision of reliable time reference for other systems.

- **Radio Communications System (DRS);**

  Main voice communication system for operations and data support for signalling system.

- **Passenger Information System (PIS);**

  Information system for train data and other information as well as advertising platform,

- **Public Address (PAS) System**

  Announcement system for passengers and operational staff.

- **Telephone System (TEL);**

  Telephone communication for operational staff, and emergency communication outlet for passenger.

- **Closed Circuit Television (CCTV) System;**

  Video surveilance system to visually monitor and survey the operation of the HSR line. Assist operations to prevent and investigate situations that potentially could lead to an emergency or other critically event.

- Office Automation and Information Technology (IT) System; Data network for administration and operational purpose.

- **Board Band Radio System (BBRS);**

  Data & voice communication between trains and operation control as well as become the carrier for up-to-date media advertisement and passenger WIFI

- **Controlled Access Security System (CASS);**

  Secure and controlled access to operational and technical areas and rooms.

- **Train Communication System (TCS);**

Communication system for passengers travelling in the train with operational staff.

- **Failure reporting, analysis, and corrective action system (FRACAS);**

  Maintenance system to record and analyse system faults and problems.

2 BACKBONE TRANSMISSION NETWORK (BTN)

2.1 General

Under this Contract the Private Party shall supply a resilient Backbone Transmission Network (BTN) consisting of a redundant FO cable, network nodes and management system and distribution switches. The BTN shall be capable to transport newer technologies coupled with the mix of legacy protocols over a packet-oriented transport network that shall have similar deterministic connections like SDH/SONET. The BTN system shall have the capability to use the MPLS-TP protocol which is the industry standard, defined by IETF and ITU-T. The transport capacity of the BTN shall be no less than 10GB and the system design shall provide full redundancy of the data backbone.

The BTN shall provide the following data performances and interface functions on stations and on trains:

2.2 BTN Functionality

The BTN shall be based on open standard technologies and protocols and shall provide security measures to ensure segregation and segmentation between the supported systems through a scalable architecture.

2.2.1 Layer 2 and 3 connectivity between all stations and systems of the HSR

2.2.2 Path protection mechanism

2.2.3 10 Gbps transmission capability between the nodes

2.2.4 VLAN with guaranteed bandwidth, each VLAN segment shall provide the assigned bandwidth all the time.

2.2.5 Data / voice network connectivity for Telephone, SCADA, AFC, Master Clock, PAS, PIS, DRS, BBRS, SMS, CASS and OA/IT systems.

2.2.6 Distribution switches shall support and include all OA/IT requirements in addition to the connectivity of other systems.

2.2.7 Dedicated fiber cores and patch panels for Signalling system fiber.

2.2.8 Interface with all required local communication circuits, all communication links between systems on different locations shall be established through the BTN.

2.2.9 20% spare capacity shall be provided at each node and each location of distribution switches, based on the number of installed ports at that location.

2.2.10 Remote management, performance reporting and configuration of nodes and switches.

2.3 Scope of works

The Scope of Works (SOW) for the Backbone Transmission Network (BTN) shall include all required works to plan, design, implement and test the BTN functionality as described in the Specification. In detail the SOW shall include, but is not limited to:

2.3.1 SOW details

a. Traffic & capacity analyses per station and system. The results of that analysis shall be used as the foundation of the BTN design.

b. Installation of cable, nodes and distribution switches and power supplies.

c. Commissioning and testing of FAT and acceptance testing.

d. Closed loop redundant 96 core fibre optic rings including all splicing arrangements, optical distribution panels and jumper / patch panels.

e. Patch panels at stations, depot and interconnection locations.

f. Provision of network nodes, add / drop out nodes, patch panels and distribution switches.

g. Provision of network management system.

h. LAN cable between the nodes and the distribution switches.

i. All LAN cabling and wall outlets required for the OA/IT network on stations, Depot and other buildings.

j. Provision of power supply, accessories and bracketry.

k. Router, firewall and other LAN security equipment.

l. Provision of fiber optic testing equipment incl. an OTDR.

2.4 BTN Requirements

2.4.1 Ring switchover after disconnection within 50ms

2.4.2 Under no circumstances shall a break or disconnection of the fiber optic ring cause that a station is isolated from the BTN.

2.4.3 Network wide management system, all nodes and switches are manageable

2.4.4 FO links to the service substations shall have 12 cores

2.4.5 Network latency shall not limit the performance of any connected systems

2.5 Applicable Standards

IEC 11801	The standard defines several link/channel classes and cabling categories of

	twisted-pair copper interconnects, which differ in the maximum frequency for which a certain channel performance is required:
ANSI/TIA-568	ANSI/TIA-568 defines structured cabling system standards for commercial buildings, and between buildings in campus environments. The bulk of the standards define cabling types, distances, connectors, cable system architectures, cable termination standards and performance characteristics, cable installation requirements and methods of testing installed cable
IEEE 802.1	Group of networking protocols that is providing the standards of connecting devices to an Ethernet network.

2.6 RAMS

2.6.1 The Private Party shall undertake comprehensive RAMS analyses to confirm the predicted RAMS figures.

2.6.2 The Backbone Transmission Network system shall comply to an MTBF better than 90000 hrs (10 years)

2.6.3 The design life of the BTN shall be 15 years

2.6.4 The availability of the BTN shall be better than 99.99 %

2.6.5 The MTTR of the BTN shall not exceed three (3) hours, including mobilization during operational hours, on average.

3 MASTER CLOCK SYSTEM

3.1 General

Under this Contract the Private Party shall supply a Master Clock System (MCS), for accurate time determination and provision as reference time source for the railway system. The MCS shall comprise all items of control equipment, software, equipment power supplies, control units, interfaces, equipment cabinets and enclosures, master clock unit, slave clocks, data output ports, antennae, central master computer for staff attendance time logging, all cabling between respective items and all cabling to the interfaces with other systems.

The MCS shall provide the following data performances and interface functions on stations and on trains:

3.2 MCS Functionality

The master clock system shall be capable to control and synchronize the slave clocks based on the IRIG-B formats such as IEEE 1344 or AFNOR NF. The features shall include as a minimum GPS synchronization, bridging of GPS synchronization failure, high free running accuracy and redundant power supplies.

3.2.1 Master clock to provide the reference time signal and synchronizes all slave clocks and connected systems.

3.2.2 Slave clock to receive the time reference signal from the master clock and synchronises all analogue and digital clocks

3.2.3 GPS receiver shall display the decoded GPS time reference and the signal strength.

3.2.4 Analogue and digital clocks shall be automatic adjusted to the current date and time after reset or power interruption.

3.2.5 Analogue and digital clocks shall be maintenance free.

3.3 Scope of works

The Scope of Works (SOW) for the Master Clock System (MCS) shall include all required works to plan, design, implement and test the MCS functionality as described in the Specification. In detail the SOW shall include, but is not limited to:

3.3.1 SOW details (provision, installation, testing, training, documentation)

a. MCS design to provide aesthetic time information for passengers throughout the passenger area.

b. GPS antenna and receiver

c. Master clock at Depot / OCC CER

d. Interfaces

e. Slave clock every station CER

f. Analogue round clock double sided, illuminated

g. Analogue round clock single sided, illuminated

h. Digital clocks in operational areas such as SOR

i. Cable and conduits

j. Bracketry

3.4 MCS Requirements

3.4.1 Clocks

a. Station entrance clocks shall be single sided 600 mm analogue clocks with an IP 55 rating

b. Concourse clocks shall be single or double sided 300 mm analogue clocks with an IP 44 rating, quantity and location shall be agreed with the Engineer’s Representative.

c. Platform clocks shall be double sided 600 mm analogue clocks with an IP 55 rating, 2 double sided clocks per platform side.

d. Non-public areas can be of the analogue or digital type with the size that matches the legibility design.

3.5 RAMS

3.5.1. The Master Clock system shall comply to an MTBF better than 45000 hrs (5 years)

3.5.2. The design life of the MCS shall be 15 years

3.5.3. The availability of the MCS shall be better than 99,9 %

3.5.4. The MTTR of the MCS shall not exceed three (3) hours on average

4 DIGITAL RADIO SYSTEM (DRS)

4.1 General

Under this Contract the Private Party shall supply a Digital Radio System (DRS) based on TErrestrial Tunked Radio (TETRA) standards and technology. This radio system shall be suitable to be used for secure & safe communication between all operational employees of the rail operator and to support ECTS level 2 main line train control equipment. The Private Party shall propose how the radio design meets a traffic model of 2% or better Grade of Service based on the Erlangen method for all users on normal, peak and emergency situations.

The DRS shall provide the following voice & data performances and interface functions on stations and on trains:

4.2 DRS Functionality

4.2.1. Base Station System (BSS) Fall-back

Each BSS has to be equipped with a dedicated Fall-back controller. For the case that a BSS is losing connection to the network, respectively to the switch, it will move automatically into fall-back operation and ensures a wide range of functions on a cellular basis.

4.2.2. BSS Expansion

Each BSS can be easily upgraded for future extensions and is capable for a total number of up to 16 Carriers per Site, in meaning of per antenna system.

4.2.3. BSS Redundancy

The BSS shall have a fully redundant configuration. All active components have to doubled and will back up each other in case of any module failure. Aside of the above stated Transceiver redundancy due to the 2 Carrier configuration, the following modules in particular are redundant:

a. BSS IP-switch

b. Synchronization unit

c. Fall-back Side Controller

d. Power Supply Unit

4.3 Network Management System Solution

The Network Management Station (NMS) provides the interface to the network, which allows the network manager to configure, control, monitor, authorize and maintain the network and its subscribers.

The NMS server platform is integrated in the Tetra system, and is accessed by a network management station. The NMS shall provide 5 (five) management categories under ISO model which defines network management tasks using the FCAPS model (Fault, Configuration, Accounting, Performance and Security).

4.3.1 Access

Access to the different NMS functions shall be determined on the basis of access rights and user licenses. It shall be possible to make certain functions available to specialized personnel only in order to prevent unauthorized access to certain services.

4.3.2 Fault Management

The system shall monitor & manage Hardware Failures, Line Failure and External alarms such as sensor inputs (temperature, seismic, wind speed)

4.3.3 Supported protocols

The NMS shall support protocols for access and integration with other systems such as: TCP/IP, HTTP and SNMP.

4.3.4 Dispatcher CAD

The CAD of the radio system shall be based on touch screens and a graphical user interface (GUI) that allows the operator to establish a communication channel with a one click or touch action on the icon of the dispatcher screen.

The Dispatcher shall be capable for monitoring of multiple groups by cooperating teams (pools) of dispatchers. The application shall be designed for ease of use, offering an intuitive user interface whereby all tasks can be completed with a minimum amount of user interactions. Activity in groups and progress of calls shall be shown in real-time, including the indication of talking party number and name alias, and priority level.

4.3.5 Instant talk back

Instant talk back on any group is possible by just clicking the Push to Talk area for that group, even allowing overruling talking users in the group.

4.3.6 Emergency

In emergency situations, the dispatcher can make calls with high priority to pre-empt other calls in order to take-over busy channels or to reach busy subscribers.

4.3.7 CAD Workstation features

22” Touch screen, multi-channel audio, pedal for foot switch and comfortable headset.

4.3.8 GUI

The CAD GUI shall be based on the geographical location of the HSR and shall show the track, the train, the stations, the depot, side tracks, wayside cameras, crossings and turnouts. The CAD GUI for the Depot controller shall show only the depot tracks. The controls for on board CCTV and voice communication shall be fully integrated in the CAD GUI

4.3.9 Call Functions

The following call functions shall be available in the proposed system

- Individual call (duplex/simplex)
- Group call
- Broadcast call
- PABX, PSTN, ISDN call incl. DTMF over dialing

4.4 Scope of works

The Scope of Works (SOW) for the Digital Radio System (DRS) shall include all required works to plan, design, implement and test the DRS functionality as described in the Specification. In detail the SOW shall include, but is not limited to:

4.4.1 SOW details, items to be provided, installed & commissioned.

a. Control equipment, a fully redundant Central Switching Unit at the OCC and a geo-redundant switch at the backup center location
b. Software & licenses
c. Coverage and traffic prediction & analyses report.
d. Equipment power supplies
e. Control units & interfaces, including NMS.
f. 5 CAD radio workstations with 21” touch screen monitors.
g. Equipment cabinets and enclosures
h. Radio base stations & repeaters installed on every station and the Depot. Additional number of base stations and repeaters will depend on achieving the 2% GOS and coverage requirements at all locations and sections.
i. Digital voice recorder (DVRS) for recording all radio conversations.
j. 22 Train radios incl. 19” rack, ruggedized handset and control head.
k. 300 Hand portable radios
l. Digital radio test set
m. 10 Desktop radio for OCC
n. Antenna tower, self-supporting structure, maintenance platform suitable for 2 workers and appropriate foundation.
o. Directional outdoor antenna suitable for the environment.
p. Leaky feeder antenna
q. All cabling between respective items and all cabling to the interfaces to other systems

4.5 DRS Requirements

4.5.1 Central switching unit (CSU)

The CSU shall be based on “state-of-the-art” soft-switch IP technology. The architecture of the CSU shall be inherently dual/multiple – redundant - in every aspect from the power supplies to the shelf management.

4.5.2 Redundancy

The CSU rack has to be designed to provide integrated redundancy capable of achieving five-9’s (99.999%) availability. All components in the rack and shelfs have to be duplicated and operating in Hot-Standby mode/

4.5.3 Geographic Redundancy

The third CSU shall be provided at a different geographic location than the first CSU rack and shall operate in standby mode. This CSU shall become automatically the active CSU whenever the first and second CSU become unavailable. The database for the fall-back CSU shall be always the same as the database for the first and second CSU's to enable the fall-back CSU to become active without delay and human interaction.

4.5.4 Hot-plug

Any card in any rack and shelf can be removed or inserted without any user-precautions for power on/off or other preparation procedures.

4.5.5 Thermal management

Each slot in the CSU shall be designed to dissipate up to 200W power. The high efficiency cooling shall improve the reliability of components by keeping temperatures low.

4.5.6 Configuration management

Card compatibility shall be checked at insertion. If necessary, the configuration is then copied to the new card. The card is then allowed to start up. Any card shall be removed or inserted without any user-precautions for power on/off, hot-plug functionality.

4.5.7 Radio Coverage

The radio coverage shall include all levels of the stations and buildings, a zone of 100m around the station, the Depot and adjacent buildings & yards, the track and a area of 50m around the track. On all these areas the signal level shall be at least 100dBm, 95% of all areas need to achieve the coverage values. The measuring shall be done in blocks of 100 square meters.

4.5.8 Radio coverage monitoring

The TETRA Radio System shall be able to continuously check the performance of base stations, including cabling, RF distribution systems and antennas. In addition, the performance of TETRA repeaters and segments of radiating cable shall be monitored by the coverage monitoring function.

4.6 RAMS

4.6.1. The DRS shall comply to an MTBF better than 45000 hrs (5 years)

4.6.2. The design life of the DRS shall be 15 years

4.6.3. The availability of the DRS shall be equal or better than 99,99 %

4.6.4. The MTTR of the DRS shall not exceed three (3) hours on average.

4.7 Applicable Standards

Standard	Description
ETSI 300 392 1-18	General design, air interface, gateway, security
ETSI 300 394	Conformance testing
ETSI 300 396 1-10	Network design, security
BS EN 50128	Railway applications
BS EN 50122	Railway applications - Electromagnetic compability
BS EN 50155	Railway applications

5 BROAD BAND RADIO SYSTEM (BBRS)

5.1 General

Under this Contract the Private Party shall supply a Broad Band Radio System (BBRS) that enables the operator in the OCC and the SOR to receive train performance data, train status information and train maintenance data from any location of train along the route and the depot. The BBRS shall also provide video surveillance data from the passenger compartments to organise help and assistance for emergency situations while the train is traveling.

The Private Party shall also offer a priced option and business model of Wi-Fi provisions for passengers that can be provided by the same architecture but with a higher bandwidth.

The BBRS shall provide the following data performances and interface functions on stations and on trains:

5.2 BBRS Functionality

5.2.1 The Broadband Radio System (BBRS) shall be an IEEE 802.11 based bidirectional point to multipoint system that shall provide mobile wireless broadband connectivity to the trains. Open standards shall be adopted where possible.

5.2.2 The BBRS wireless Access Points (AP) should support wireless LAN meshing and shall act as a transition point from the wireless network to the wired network and also function as a range extender to provide additional wireless coverage. The Mesh connection must be compliant to 802.11s.

5.2.3 The BBRS wireless mesh connection shall be in the 5.8 GHz unlicensed band.

5.2.4 The BBRS base stations shall be based on a fully synchronized network that operate on a common time base for all base stations, avoiding potential radio interferences.

5.2.5 The Private Party shall propose a proven equivalent solution for the BBRS solution. This solution shall be operational in at least one other mass transportation railroad that provides wireless LAN services to their passengers.

5.2.6 The BBRS shall provide a communication interface with the on-board CCTV surveillance and Passenger Information Display System (PIDS), to the trains, stations and the OCC.

5.2.7 The BBRS shall allow the transmission of the train borne CCTV cameras video stream for real-time monitoring during normal operations, assistance and emergencies. In addition, shall provide the interface with the train PIDS to allow ad-hoc on-board text/visual announcements from the existing OCC and ad-hoc transmission of multi-media content to the train PIDS.

5.2.8 The BBRS shall provide low and fixed latency and jitter which is essential for applications such as video and VOIP.

5.2.9 The Private Party shall design, provide and implement the end-to-end BBRS with all the necessary equipment and interfaces for the train borne and ground system. The BBRS shall comply with railway standards including EN50155

5.2.10 The BBRS transmission equipment shall be provided in each train driver cab to be connected to the train LAN.

5.2.11 The trackside access points (AP) and/or base stations shall be designed for outdoor all weather environments and shall be have a IP67 enclosure.

5.3 Scope of works

The Scope of Works (SOW) for the Broadband Radio System (BBRS) shall include all required works to plan, design, implement and test the BBRS functionality as described in the Specification. In detail the SOW shall include, but is not limited to:

5.3.1 SOW details, items to be provided, installed & commissioned.

a. Data requirements study and plan
b. System, radio coverage and cable design
c. Route design for antenna and base station
d. On-board equipment design & coordination with the SRT
e. Interface design & coordination
f. BBRS main server
g. BBRS NMS
h. BBRS controller & workstations
i. BBRS power supply

j. Equipment bracketry and fixings

k. Connectors, adapters, interfaces and accessories

5.4 BBRS Requirements

5.4.1 Distributed architecture

a. No single point of failure

b. No central controller

5.4.2 Real time monitoring

a. Data rate per train

b. Data rate per car

c. Data rate per section of the route

5.4.3 Interfacing requirements

a. Rolling stock interface for train data

b. Data interface to train communication system

c. Ethernet interface to the back-bone transmission system

5.4.4 Base station handover

a. Seamless handover >= 50ms

b. Train speed up to 250 Km/h

5.4.5 Security

a. The Wireless Mesh Access Points shall support end-to-end encryption with WEP, WPA (TKIP) and WPA2 (CCMP/AES, 802.11i) for client encryption; and secure mesh with AES for mesh encryption. It shall also support 802.1X (infrastructure/Client) and MAC address hardware authentication.

5.4.6 Coverage

a. The BBRS shall provide complete track coverage along the whole main line and in the existing depot for continuous broadband data link between trains and fixed infrastructures.

b. The BBRS shall assure smooth and efficient handover between the access points (AP). During the handovers, there shall be no impact such as freeze or lost video signal and internet connection.

c. The BBRS shall guarantee seamless handover <50ms between the base stations along the route.

5.5 RAMS

5.5.1 The BBR system shall comply to an MTBF better than 45000 hrs (5 years)

5.5.2 The design life of the BBRS shall be 15 years

5.5.3 The availability of the BBRS shall be better than 99,9 %

5.5.4 The MTTR of the BBRS shall not exceed three (3) hours on average.

5.6 Applicable standards

EN 50155	Electronic equipment used on rolling stock for railway applications
EN 50121	Railway applications - Electromagnetic compatibility
EN 61373	Rolling stock equipment. Shock and vibration
IEC 60571	Electronic equipment used on rolling stock

6 PUBLIC ADDRESS SYSTEM (PAS)

6.1 General

Under this Contract the Private Party shall supply a Public Announcement System (PAS) that enables the operator to address the passengers, the public and employees clearly understandable voice messages on all areas of the rail system without disturbing the general public unreasonably.

The PAS shall provide the following audio and interface functions on stations and on trains:

6.2 PAS Functionality

6.2.1 Facilitate live and recorded announcements from remote and local positions.

6.2.2 Prioritisation of announcements according to the operational guide book.

6.2.3 Provide safe and reliable interfaces for emergency announcement and evacuations.

6.2.4 PAS control stations shall be provided at SOR's in the OCC / FBOCC and on platforms.

6.2.5 The announcements shall be selectable by zones.

6.2.6 Announcements need to achieve a speech intelligibly that enables the audience to clearly understand the announcement.

6.2.7 Train and informational announcements shall be synchronized with the PIDS in the same area and zone.

6.2.8 Prioritisation of announcements shall be based on the type of announcements and the source of announcement.

6.3 Scope of works

The Scope of Works (SOW) for the Public Address System (PAS) shall include all required works to plan, design, implement and test the PAS functionality as described in the Specification. In detail the SOW shall include, but is not limited to:

6.3.1 SOW details, items to be provided, installed & commissioned.

a. Acoustics study prior to final design

b. System, coverage and cable design

c. Cable route design and implementation

d. Loudspeaker procurement and installation

e. Interface design & coordination

f. PAS amplifier

g. PAS NMS to manage all PAS equipment

h. PAS controller & workstations

i. PAS power supply

j. Equipment bracketry and fixings

k. Connectors, adapters, interfaces and accessories

6.4 PAS Requirements

a. The Private Party shall propose the zoning arrangement to the Engineer's Representative for approval, the announcement zones shall include:

b. Station entrances and exit areas

c. Station concourse and intermediate levels

d. Station platform levels

e. Car park areas

f. Substations and crossings.

g. Depot area including stabling yard

h. Administration buildings

i. Zones shall be individual and multiple selectable.

6.4.1 PAS workstation computer

a. The Private Party shall provide for each SOR a PAS workstation computer with the following functions:

b. Touch screen operation of the MMI GUI

c. MMI GUI shall provide a clear concise layout of all PA zones

d. A clear differentiation in shape and colour for different functions

e. Recording of announcements and modifying recorded announcements

6.4.2 PAS speaker

Various types of speaker shall be installed throughout the railway line, the type and charactereristic of the speaker shall match the installation location. The types of speaker shall include:

a. Ceiling mount speaker

b. Column speaker

c. Sound projector

d. Horn speaker

6.4.3 PAS paging station

a. The Private Party shall provide for each SOR and OCC controller position a PAS paging station with the following functions:

b. Goose neck microphone with PTT button, VU meter and integrated preview loudspeaker

c. Integrated ruggedized handset

d. Integrated LCD touch screen with programmable GUI for zone selection

6.4.4 PAS amplifier

a. The amplifier shall be of the 100V, 250-watt class D audio amplifier type

b. Integrated digital voice announcements

c. Integrated DSP, EQ, Delays and dynamics functions

d. Speaker bus health monitoring

e. Ambient noise compensation

f. Induction loop outputs

g. Fault protection mechanism

h. Web-based management

i. Auto configuration

j. Fiber and copper Ethernet interfaces

k. Provision of alternating A/B principle connection to the speakers to ensure continuous functionality if one path is not available.

6.4.5 Health monitoring

a. Amplifier over-current / short circuit

b. Thermal overloading

c. Microphone / Speaker faults

6.4.6 Interfacing requirements

a. Signalling interface for arrival, departure, pass through and related announcements

b. Emergency and alarm announcements initiated from BMS

c. SIP interface for radio and telephony announcements

d. Ethernet interface to the back-bone transmission system

6.4.7 Acoustics

a. The Private Party shall conduct acoustical modelling with tools such as EASE, ODEON or similar and present the results to the Engineer's Representative for approval.

b. The PA system shall achieve a RASTI level of 0.5 in 90% of the areas

c. The sound pressure level (SPL) shall not vary more than +- 3dB (A) in a zone

d. The SPL of announcements shall be between 8 to 15 dB (A) above the ambient noise level (measured at approx. 1,5m above ground / floor)

e. The harmonic distortion shall not exceed 3% of the design output.

6.4.8 Cabling

a. Dual cable path shall be used to feed the speaker to ensure PA coverage if equipment or cable failure occurs.

b. The cable need to be of fire retardant LSOH type and meet the standards for audio evacuation systems such as BS7443.

c. The cabling shall be suitable to provide enough power to the speaker on every location.

6.5 RAMS

6.5.1 The PA system shall comply to an MTBF better than 45000 hrs (5 years)

6.5.2 The PAS loudspeaker shall comply to an MTBF better than 90000 hrs (10 years)

6.5.3 The design life of the PAS shall be 15 years

6.5.4 The availability of the PAS shall be better than 99,9 %

6.5.5 The MTTR of the PAS shall not exceed three (3) hours on average.

6.6 Applicable standards for PAS

Standard	Description
BS 6259	Code of practice design,& testing sound systems
BS 5839	Fire detection & alarm system for buildings
BS 7443	Sound systems for emergency purpose
EN 50130	Electromagnetic compatibility
EN 60065	Audio video safety requirements
IEC 60849	Sound systems for emergency purposes
IEC 268-16	Part 16 speech intelligibility by speech transmission index

7 CLOSED CIRCUIT TELEVISION (CCTV)

7.1 General

Under this Contract the Private Party shall supply a state of the art CCTV system which shall provide video coverage for all public and non-public area of the rail line with a decentralized recording capacity of 168 hrs at 30 frames per second and 336 hrs at a 7 frames per second.

The CCTV shall provide the following data performances and interface functions on stations and on trains.

7.2 CCTV Functionality

The general guideline for the video resolution in areas is to display a 1.8m tall person (standing upright) on a 19-inch monitor with an image height of not less than 52mm, within the CCTV camera coverage area identified as “recognition area”, for both fixed lens and zoom lens cameras at the shortest focal length.

7.2.1 The video coverage area shall minimize the blind spots to a max of 5% per area or level.

7.2.2 Glare free, non-distorted and non-pixelated video images from all CCTV cameras.

7.2.3 Easy and user friendly access to stored video files.

7.2.4 Synchronized incident playback and export of video files.

7.2.5 24 hours 7-day recording.

7.2.6 Alarm management for areas, doors or external interfaces.

7.2.7 16 simultaneous video streams from different locations per workstation.

7.3 Scope of works

The Scope of Works (SOW) for the Closed Circuit Television (CCTV) shall include all required works such as control equipment, software, equipment power supplies, control units, interfaces, equipment cabinets and enclosures, video recorders, monitors, cameras, all cabling to and between respective items and all cabling to the interface terminations with other systems. The Private Party shall plan, design, implement and test the CCTV functionality as described in the Specification, in detail the SOW shall include, but is not limited to:

7.3.1 SOW details, items to be provided, installed & commissioned.

a. CCTV coverage plan for all areas that defines the areas where the CCTV video will permit the operator to:
   - Detect a person or an object
   - Recognition of a known person
   - Identification of an unknown person

b. Decentralized video storage as specified.

c. CCTV Server to manage the recording disk array for storage and playback

d. CCTV NMS to manage all IP components of the CCTV system.

e. CCTV control workstation with touchscreen (21”) at SOR, OCC and FBOCC

f. Video cameras including bracketry as specified.

g. Video monitors as specified.

7.4 CCTV Requirements

7.4.1 CCTV cameras

The cameras used for the coverage have to be fixed focus cameras and shall cover the designated area with “glare free” and “not distorted” video streams. PTZ cameras need to be deployed to investigate areas of interest that have been identified by the video coverage of the fixed lens cameras.

The minimum technical specification shall include:

a. Video stream resolution 1980*1020, 4K Ultra HD at 30 fps.

b. One high-resolution video stream and one low resolution video stream.

c. Compact vandal- and dust-resistant design that is fit to cope with environmental conditions of the project.

d. The cameras provide video images that a free from barrel and any other distortion.

e. The cameras provide video streams & images that a free from pixilation, the data backbone system has to be designed to meet the CCTV requirements.

f. Network access control IEEE 802.1X support

g. Day and night functionality that is able to compensate strong light sources such as direct sun light and provide illumination on areas that need to be monitored at night and are not illuminated by other light sources.

h. Power over Ethernet according to IEEE 802.3at-2009[7]PoE standard also known as PoE+ or PoE plus, provides up to 25.5 W of power for "Type 2" devices

i. Operating condition -30 to +50 °C

j. Housing rated to IP 66

k. Vandal rating IK10

7.4.2 CCTV monitors

The CCTV monitors shall provide as a minimum requirement:

a. Screen size of 21” (minimum)

b. Screen resolution of 1920x1080 (minimum)

c. Video inputs of HDMI, DVI and optional VGA through adapter if necessary.

d. Pixel response time of 5 ms grey to grey.

7.4.3 CCTV storage

The CCTV system shall be capable to store all video streams on an architecture that is based on a SAN topology with Serial Attached iSCSI (SAS) controllers that can control iSCSI and SATA drives. The video streams shall be recorded directly to the disk array whereby every camera “knows” the designated disk for recording.

a. 16 video streams in highest resolution of live cameras or stored video files, shall be visible at each of the controller positions in the OOC.

b. The high-resolution video (1920*1020, 30fps) shall be available for 7 days before it is automatically overwritten.

c. The low-resolution video (1920*1020, 7fps) shall be available for 14 days before it is automatically overwritten.

7.4.4 CCTV workstation

The CCTV workstation computer shall be capable to monitor, retrieve and export video streams from the CCTV system. The workstation shall include:

a. Operating system Windows 7 Professional 64 (available through downgrade rights from Windows 10 Pro) or similar operating systems that provide a user friendly GUI.

b. CCTV system client software and required licenses.

c. Intel® Core™ i7 processor or better

d. 8 GB memory or better

e. 1 TB HDD storage or better

f. NVIDIA® Quadro® K620 (2 GB) or better.

g. 24” touchscreen monitor

h. Wired mouse and keyboard

7.5 RAMS

7.5.1 The CCTV system shall comply to an MTBF better than 45000 hrs (5 years)

7.5.2 The design life of the CCTV shall be 15 years

7.5.3 The availability of the CCTV shall be better than 99,9 %

7.5.4 The MTTR of the CCTV shall not exceed three (3) hours on average.

7.6 Applicable Standards

CE	Conformity EU
EN609950	Insulation
EN55022	EMC transmission class C
EN55021	EMC immunity
IEC 60529	Enclosure protection
IEC 62262	Impact restistance rating
H.264	Video compression
4K Ultra HD	Video image quality
BS 8495	Code of practise image export for evidence

8 FAILURE REPORTING, ANALYSIS AND CORRECTIVE ACTION SYSTEM (FRACAS)

8.1 General

Under this Contract the Private Party shall supply a Failure Reporting, Analysis and Corrective Action system to be used to address the characteristics of hardware failures, process failures or software failures. These analysis shall be helpful to determine the root causes of failures and establishing guidelines to prevent hard- and software failures as well as improving related processes.

The FRACAS shall provide the following performances to manage infrastructure and operational processes:

8.2 FRACAS Functionality

8.2.1 Definition of failures

The system shall permit the definition of failure condition for all infrastructure items and processes.

8.2.2 Performance values

For all infrastructure items and processes managed through FRACAS, performance values such as MTBF, availability and MTTR shall be integrated in the FRACAS system.

8.2.3 Classification

The system shall be able to provide classification for failure, performance and other related status conditions.

8.2.4 Reporting

The system shall be able to design, modify and delete reports for actual statuses, KPI's, history and trending failure and performance information. The reporting system shall be able to generate adhoc, manual and scheduled reports printed on paper and saved as pdf files.

8.3 Scope of works, items to be provided, installed & commissioned

The Scope of Works (SOW) for the FRACAS shall include all required works to plan, design, implement and test the FRACAS functionality as described in the Specification. In detail the SOW shall include, but is not limited to:

8.3.1 SOW details

a. Server with monitor and sufficient hard disk storage and processing power.

b. 2 workstation computer with 21” monitor

c. 2 Color laser printer

d. FRACAS application including database

e. 6 FRACAS user licenses

f. Interface application to collect automatic data from SCADA

g. 4 weeks of training or workshop for general FRACAS principles

8.4 FRACAS Requirements

8.4.1 Failure definition shall include:

- Failure symptom
- Failure effect
- Failure mode

- Failure mechanism
- Failure cause

8.4.2 Failure classification shall include:

- Failure relevant, same system, other system
- Failure train service, delay, information, safety, security.
- Failure accountability, warranty, liability, penalty.
- Failure pattern
- Failure multiple

8.4.3 Data sources

The FRACAS shall support the data input from these sources

- Reliability analysis
- Automated data input such as SCADA
- Log books and maintenance records
- Failure review processes
- RAMS data from infrastructure
- KPI targets

9 CONTROLLED ACCESS SECURITY SYSTEM (CASS)

9.1 General

Under this Contract the Private Party shall supply a state of the art secure access system with which the operator can manage and control the access to rooms and areas. The CASS system shall be fully integrated with the CCTV system to monitor and record the access to critical areas and rooms. The CASS card reader shall have the appropriate enclosure and vandal protection rating that is suitable for the installation location.

The CAS system shall provide the following access control and interface functions on stations and on buildings:

9.2 CASS Functionality

Access to operational and technical rooms shall be controlled by a Controlled Access Security System (CASS). The CAS System shall be operated by contactless smart cards that contain the information regarding the person that wants to have access and the access authority of that person.

9.2.1 Door locks

The door locks shall be of the electro mechanical type and accessible by the contactless CASS cards or by the master key system.

9.2.2 Hierarchical design

The CASS shall adopt the hierarchical distributed processing configuration, i.e. each subsystem shall be a self-contained system. Lower level subsystems shall receive access control data from the level above and shall store in their own memory for operation use. In case of malfunction of upper level system or communication network failure, the lower level subsystems shall still function as standalone systems.

9.2.3 Reader range

Reader should operate at a read range of 5 to 10mm.

9.2.4 Door controller

Network door controller should continue to operate if server or network fails and able to store at least 50,000 alarms and events

9.2.5 Network controller

Network controller database should hold at least 5,000 cardholders

9.2.6 Encryption

Data encryption between readers, controllers, network and server

9.2.7 Cards

System and Cards should support Mifare Desfire EV1 or EV2 (Mifare classic is not permitted because of breached code)

9.2.8 Integration

The system shall be integrated with the user and event database of the Airport Rail Link and the Red Line CASS.

9.3 Scope of works

The Scope of Works (SOW) for the Controlled Access Security System (CASS) shall include all required works to plan, design, implement and test the CASS functionality as described in this Specification.

In detail the SOW shall include, but is not limited to:

9.3.1 SOW details

a. Central CASS server, with redundant power supply.

b. Backup and restore application and external backup media.

c. CASS workstation with 21” touchscreen, card programmer

d. Decentralised door controller, 1 controller for max 4 doors.

e. Access cards 1200 cards

f. Access card printer including ink supply for 3 years

g. Network management server

h. External application to modify the door location graphic.

i. Report generator, incl. external report application to design, edit and modify report.

j. Electro mechanical door locks for all technical & control rooms, detailed quantity to be agreed by the Engineer's Representative.

k. Card reader detailed quantity to be agreed by the Engineer's Representative.

9.4 CASS Requirements

a. The card reader shall be able to read contactless smart cards to a distance of not more than 10cm.

b. The card reader shall have an IP 55 and minimum VK 3 rating.

c. The CASS needs to provide a fail-secure environment.

d. The CASS and the CCTV system need to be highly integrated.

e. CASS controller need to be operational even if the connection to the server is lost.

f. CASS controller shall be limited for the quantity of doors assigned.

9.5 RAMS

9.5.1 The CASS system shall comply to an MTBF better than 45000 hrs (5 years)

9.5.2 The design life of the CASS shall be 15 years

9.5.3 The availability of the CASS shall be better than 99,9 %

9.5.4 The MTTR of the CASS shall not exceed three (3) hours on average.

10. TRAIN COMMUNICATION SYSTEM (TCS)

10.1. General

The Private Party shall provide the following Train-borne Communications System (TCS) for the rolling stock cars.

The TCS shall provide the following audio, data and visual communications facilities on the trains:

10.2 TCS Functionality

10.2.1 One-way announcement from the Train Operator (TO) to the passengers using the train-borne PA system, including automatic next station arrival Visual text messages from the TO the passengers using the train-borne PIO including multi-media features

10.2.2 Two-way conversation between the TO and passengers using the Passenger Inter-communications (PIC) Unit

10.2.3 Three-way conversation between the TO, LC (OCC) and passengers using the Passenger Inter-communications(PIC) Unit, initiated from OCC.

10.2.4 Two-way conversation between the TO and the Traffic Controller (TC) in OCC using the train radio unit

10.2.5 Two-way conversation between the TO and the Depot Controller (OC) in the depot using the train radio unit.

10.2.6 One-way announcement from the Control Superintendent (CS) in OCC to the passengers- using the PAS.

10.2.7 Visual text messages from the CS in OCC to the passengers using the Train-borne PIS, together with the central PIS and the radio system (option)

10.2.8 Two-way conversation between the front and the rear cabs CCTV video monitoring and recording of the passenger cars and train operator cab

10.2.9 The train-borne PIO shall also be used to display automatic next station arrival interfaced with the signalling system, weather information, news headlines and the like for passenger interest. It shall also be used to display commercial advertisements

10.3 Scope of work

a) Coordinate the design with rolling stock manufacturer

b) Interface to DRS and BBRS

c) Design, install and commission of passenger intercom

d) Design, install and commission of video surveillance, 4 cameras per car

e) Design, install and commission of Digital Video Recorder, 1 DVR per car

f) Design, install and commission of cables and power supply

g) Design, install and commission of loudspeaker and amplifier

h) Design, install and commission of driver control console

i) Design, install and commission of information display

j) Design, install and commission of dynamic route map

10.4 Requirements

a) Mounting and installation method must fit into the overall train design

b) Camera resolution shall be 4K Ultra HD at 30 fps

c) 4 full HD (1080p) WDR cameras shall be provided for each passenger car and one camera in the driver cabin.

d) Cameras shall be of the PoE type and have intrusion & tamper detection the cameras shall be able to record audio.

e) Digital video recorder shall record 3 days continuously before overwrite.

f) Dynamic route displays above door with door open indicator

g) 4 double sided information display, size to fit the interior of the car

h) Passenger intercom has to be single button operation

i) Driver control includes display to show all cameras of a car

j) Driver control includes alarm and fault information of the train.

k) Information displays shall have a resolution of 1920*1024 pxl, brightness level of 450cd/m, viewing angle of ≥ 160° horizontal & vertical, dimension of 550*340*44 mm, contrast ratio 2000:1

l) The announcement control and amplification unit shall be remote configurable through an HTML interface and provide health monitoring for speaker, microphones and amplifier.

10.5 Applicable standards

EN 60549	EWIS
EN 50155	Rolling stock
EN 51373	Vibration
EN 50124	Immunity
EN 60950	Safety
EN 55015	Emissions

10.6 RAMS

10.6.1 The TCS system shall comply to an MTBF better than 45000 hrs (5 years)

10.6.2 The design life of the TCS shall be 15 years

10.6.3 The availability of the TCS shall be better than 99,9 %

10.6.4 The MTTR of the TCS shall not exceed three (3) hours on average.

11 PASSENGER INFORMATION SYSTEM (PIS)

11.1 General

Under this Contract the Private Party shall supply a Passenger Information System which shall permit the operational staff to make visual announcements to passengers on stations or on trains. The information for different zones and areas shall be individually or combined selectable depending on individual or central configurations. In addition to adhoc or pre-recorded visual announcements the PIS display shall also show the current time and provide display space for advertisements.

The PIS shall provide the following information & media performances and interface functions on stations and on trains:

11.2 PIS Functionality

PIS displays shall be provided in sufficient quatities and on locations where the passenger can effortless observe the provided information.

a) On the platform the displays shall be mounted to be visible for the passenger waiting on the platform waiting areas without the need to turn their back to the tracks.

b) Concourse displays shall be mounted to enable passengers to find their way to the correct platform.

c) Entrance area display shall be located to permit the passengers to obtain the required information effortless.

d) Train and operational information shall be displayed in alternating language of Thai and English.

e) Audio information related to announcements and advertisement shall be replayed by loudspeaker attached to the PIS display.

f) Audio announcements shall be synchronized to avoid echo caused by not-synchronized signal latency

11.3 Scope of works

The Scope of Works (SOW) for the Passenger Information Display System (PIDS) shall include all required works to plan, design, implement and test the PIDS functionality as described in the Specification.

In detail the SOW shall include, but is not limited to:

11.3.1 SOW details

a. Design the PIDS to enable passengers to obtain information throughout the passenger area.

b. Install & commission the PIDS server and media server

c. Install & commission the PIDS workstation at every SOR

d. Install & commission the PIDS displays at the stations

e. Install & commission the PIDS cabling

f. PIDS interface to signalling, PAS, BTN and MCS

11.4 PIDS Requirements

a. Train routes display information updated through schedule computer.

b. Train routes display information updated through OCC and or Station Master

c. The displays shall be based on LED technology, have diameter at least 47 "and have an IP 56 rating.

d. General information displayed automatically and manually

e. Emergency information displayed automatically and manually

f. PIS displays located at entrances, concourses and platforms

g. PIS display shall provide train information, advertising and date & time information.

11.5 RAMS

11.5.1 The PIDS system shall comply to an MTBF better than 45000 hrs (5 years)

11.5.2 The design life of the PIDS shall be 15 years

11.5.3 The availability of the PIDS shall be better than 99,9 %

11.5.4 The MTTR of the PIDS shall not exceed three (3) hours on average.

12 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)

12.1 General

Under this Contract the Private Party shall supply an electrical SCADA system that shall be used to monitor and control systems such as the High Voltage (HV) and Low Voltage (LV) electrical supply network for traction, station, communication and signal systems within the electrified area of the HSR network. The SCADA system shall be certified for Safety Integrity Level 2 (SIL 2) to meet the requirements of IEC 61508 for the reliability of the safety functions for traffic infrastructure & operational facilities.

The SCADA system shall provide the following monitor & controll performances and interface functions on stations and substations:

12.2 SCADA Functionality

The electrical SCADA system shall be used to monitor and control the High Voltage (HV) and Low Voltage (LV) electrical supply network for traction, station, and signal systems within the electrified area of the HSR network.

The SCADA system shall be based upon a multiplexed communication network with distributed processing capability. Data shall be capable of being transferred to and from any point in the SCADA network. Failure of any equipment element or node on the SCADA network shall not affect the operation of any selected equipment.

The system shall provide continuous, effective monitoring and/or control of selected equipment on the whole HSR system.

12.2.1 The central processing system shall consist of 2 redundant SCADA server that are operating in Hot-Standby mode, one wall mounted mimic display to show the status of all monitored and controlled devices.

12.2.2 Remote Terminal Units (RTUs).

All monitoring and control shall be performed through the RTUs interface to the electrical plant within a station's substation and other subsdtationds and monitor the status of the plant via digital and analogue inputs. This data is transferred to the local and central SCADA system simultaneously. The RTUs also provide for analogue and digital control outputs to switch a plant equipment such as circuit breakers and tap changers. The RTU shall be assembled from modular units, for example, power supply module, CPU and communications module, communication interface modules and modules for input/output purposes. I/O and serial cards shall be able to be arranged in the RTU rack in any order.

12.2.3 The SCADA system shall be divided into Safety Critical and non-Safety Critical systems, to ensure that the control and monitoring of such systems shall be kept functionally separate. The safety relevant part of the SCADA system shall have a SIL-2 certification.

12.2.4 The Manufacturer of the SCADA system must have a project experience that includes at least 5 successful SCADA projects of similar size & complexity.

12.2.5 The SCADA shall have a field-proven reliability and native fault tolerance.

12.2.6 System scalability shall be in excess of 1,000,000 data points, provable with a verifiable real-word case study or test system.

12.2.7 The system shall be fully customizable and of a modular architecture for maximum flexibility including data.

12.2.8 The SCADA system shall include components for display, monitoring, control, reporting, archive, and analysis functions.

12.2.9 In the event of a communications failure between a station and the equipment located in the OCC, FBOCC and PTR, the SCADA equipment and the connected selected equipment shall continue to function as normal in a standalone mode.

12.2.10 Comprehensive user management tools and definable areas of responsibility for SCADA operators and administrators.

12.2.11 Role-based authority for approvals appropriate for specific levels of control

12.2.12 Seamless integration of all wayside subsystems into a unified GUI.

12.2.13 Comprehensive communication protocol framework that is "OPC ready".

12.2.14 Human Factors design approach based on best practices for industrial automation developed by the Abnormal Situation Management consortium

12.2.15 Electrical flow path visualization

12.2.16 The SCADA system shall provide sufficient maintenance information to the maintenance database system, which shall be located in the Depot.

12.2.17 Customizable logic and calculation engine for development of specialized functionality.

12.2.18 The reporting system shall allow the operator to edit/modify, create, enable, disable and delete reports and report templates.

12.3 Scope of works

The Scope of Works (SOW) for the Supervisory Control And Data Acquisition System (SCADA) shall include all required works to plan, design, implement and test the SCADA functionality as described in the Specification. In detail the SOW shall include, but is not limited to:

12.3.1 SOW details (where not explicitly excluded the SOW works includes design, installation & commission)

a. Redundant server, powered by Intel i7 3.4 GHz processors or better, in hot standby mode at OCC CER.

b. Redundant server, powered by Intel I7 3.4 GHz processors or better, at stations and substations.

c. Dual redundant RTU CPU and COM modulesat stations and substations that connect directly via modular analogue I/O modules to the equipment and indirect via digital communication interface modules to the IED of the equipment.

d. Control room MIMIC wall display visualize the SCADA status & control information.

e. SCADA workstations including appropriate touchscreen, colour printer and necessary accessories, at each station and each OCC controller position of HSR line. The detailed amount and location of workstations and printers shall be proposed by the Private Party and agreed with the Engineer's Representative.

f. SCADA data network such as switches, firewalls, external links and connect to the BTN where required.

g. The Private Party shall coordinate the requirements for the CCR, DCC and PTR structures at the Depot and OCC with the CICs and other subsystems.

h. The Private Party shall coordinate the requirements for SCADA Input / Outputs in all locations including and elevated structures/stations, Depot, BSS with the CICs and other M&E subsystems and external parties such as the MEA.

i. The Private Party shall coordinate the SCADA Input / Outputs requirements with the Power Systems (M&E) and, according to the specific requirements of the MEA at the H.V Bulk Substation(s) as appropriate.

j. The Private Party shall coordinate the SCADA Input / Outputs requirements for all other M&E Systems and the M&E Power Systems.

k. The Private Party shall provide a SCADA training system in the PTR that emulate a "live" system using real data from past events as the active system.

l. The training system shall consist of a server with the same database as the active system, one RTU representing the same type of I/O's, 3 workstation, 3 printer.

m. The SCADA system shall provide monitoring and/or controlling of selected equipment forming part of the Works. Such selected equipment shall include, but not be limited to:

- high and medium voltage power distribution;
- traction power distribution;
- platform screen doors, if any;
- UPSs and battery backup systems for M&E Systems;
- LV systems in the Depot Buildings;
- environment control systems (air conditioning, ventilation and smoke extraction located in the Depot buildings);
- fire detection and suppression in the Depot buildings;
- water supply, pumping systems for drainage and sewage for the Depot Buildings
- other building services systems, and/or equipment (located in the Depot buildings) and general fault status of all M&E System equipment.
- Lifts & escalators

12.4 SCADA Requirements

a. Under no circumstances shall the control of equipment in any one area of the HSR Project be under the control of more than one SCADA workstation at any one time. However, parallel monitoring shall be possible

b. The SCADA system shall include a database facility that shall maintain and update records of alarms, events, controls and the status of all the selected equipment. This database shall be updated as a real time activity and shall be accessible by any SCADA workstation in the SCADA system.

c. The overall and detailed design of the SCADA system shall prevent "Data Avalanches" that could stall the system.

d. Historical data storage and software backup systems shall be provided, designed to ensure that stored data is retained in an efficient manner and permits the rapid searching against selectable criteria. The storage facilities shall also ensure that historical records can be reconstructed into a form of readable data.

e. The operating system shall be the actual supported version of MICROSOFT or Red Hat Linux.

12.5 Required interface capabilities

Protocol	Transport	Mode	Interfaces
OPC UA	TCP	Server / Client	OPC
HPOMS	TCP	Initiator/respond	SCADA
ATC	TCP	Responder	ATC server
SIP	TCP	Initiator	Audio
BACnet	TCP	Initiator	RTU, PLC. IED
Modbus	TCP, serial	Initiator	RTU, PLC. IED
IEC 60870-5	TCP, serial	Initiator	RTU, PLC. IED
SNMP	TCP	Controller	Network

12.6 RAMS

12.6.1 The SCADA system shall comply to an MTBF better than 45000 hrs (5 years)

12.6.2 The design life of the SCADA shall be 15 years

12.6.3 The availability of the SCADA shall be better than 99,998 %, the Private Party shall provide simple calculations to show how this is achievable with the proposed system architecture.

12.6.4 The MTTR of the SCADA shall not exceed three (3) hours on average.

12.7 Acronyms

AC	Alternating Current

ATM	Asynchronous Transfer Mode
ARL	Airport Rail Link
CMMS	Computerized Maintenance Management
CMS	Central Monitoring System
CPU	Central Processing Unit
CTC	Central Traffic Control
FBOCC	Fall Back Operations Control Center
IED	Intelligent Electronic Device
I/O	Input/ Output
HSR	High Speed Rail Bangkok- U-Tapao
MTTR	Mean Time To repair
Modbus	A communication protocol
NMS	Network management System
OCC	Operations Control Center
OCS	Overhead Catenary System
PLC	Programmable Logic Circuit
PTR	Playback and Training Room
RAMS	Reliability Accessibility Maintainability Serviceability
SCADA	Supervisory Control and Data Acquisition
SIP	A communication protocol
UDP	User (or Universal) Datagram Protocol
VOIP	A communication protocol

VOLUME 3 : OUTLINE SPECIFICATIONS

VOLUME 3/1 : THE RAIL-RELATED WORKS OF THE PROJECT

PART 3 – OUTLINE SPECIFICATIONS FOR RAILWAY SYSTEMS

SECTION 6 - AUTOMATIC FARE COLLECTION SYSTEM

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SECTION 6

AUTOMATIC FARE COLLECTION SYSTEM

1 SCOPE OF WORKS

1.1 General

The Automatic Fare Collection (AFC) System for the High Speed Project Bangkok – U-Tapao is to be engineered, manufactured, supplied, installed, tested, commissioned and maintained by the Private Party under the Contract.

The existing Automatic Fare Collection (AFC) System of the Airport Link requires to be considered, i.e. the new AFC-System shall be compatible to the AFC – System of the Airport Link.

1.2 Key Challenges

There are three overriding considerations, which are of the highest importance in the development of the base AFC System:

1.2.1 Devices that routinely interface with passengers shall be arranged to minimize their time in transit to and inconvenience. The availability of a device and the numbers provided at stations shall limit the queue lengths for a particular service (TVM's, gates, validators, etc.), to five customers during peak hours and four at all other times. Devices shall be provided to satisfy the peak period demand of their engineering throughput, excluding failed units.

1.2.2 The attainment of the reliability, availability, maintainability and safety requirements of the system will be verified by analysis, testing and system demonstrations as required in this Specification.

1.3 Summary of Works

1.3.1 The SRT intends to have an efficient ticketing and passenger control system for the High Speed Project Bangkok – U-Tapao. The AFC System shall have equipment located at Operation Control Centre (OCC) (or any other location as advised by the SRT), and at stations.

1.3.2 The base AFC system shall be for the use of contact-less smart card tickets (CSC) for multiple journeys.

1.3.3 Magnetic stripe paper tickets, recyclable magnetic plastic tickets or smart tokens (CST) for single journey.

1.3.4 The microchip used in contact less smart media shall be powered by a modulated radio frequency signal transmitted from read/write unit located at the entry to each gate at stations. On entry to the system, the ticket is validated before passengers enter the revenue area. A second validation is conducted prior to exit from the transit system.

1.3.5 Single journey tickets or tokens (CST) shall be encoded with the condition of the journey when issued from a Ticket Vending Machine (TVM) by payment in cash.

1.3.6 The equipment shall be reliable, efficient and of good quality. The engineering shall accommodate future expansion without any hindrance.

1.3.7 A Central Computer (CC) System shall collect and analyze information received from the station computers. It shall produce network-wide revenue and traffic data and monitor the performance of all AFC equipment. It shall also download to the Station Computer (SC) all fare tables, operating parameters, commands, and software upgrades for all AFC equipment at stations. The operator at the OCC shall be able to issue command to control and receive the real time status of every individual AFC, equipment at the CC console or terminals.

1.3.8 A SC, installed at each station, will act as a network server and perform data transfer unction for all AFC equipment in the station. It will also store at least two sets of fares.and control parameters of all equipment within the stations. In case the communications link with the Central Computer is not working, it shall be possible to switch over from one fare to another.

1.3.9 Ticket Office Machines (TOM) shall be installed in the Station Control Room (SCR) at station. It shall issue all types of tickets to passengers.

1.3.10 Ticket staff to check the validity of ticket and verify other data shall use Decoder encoded on a ticket.

1.3.11 Ticket Readers shall be installed at Don Mueang, BangSue, Makasan, SA Airport, Pattaya, and U-Tapao in the concourse and paid area. Passengers may use it to know the balance amount of ticket.

1.3.12 The Automatic Gates (AG) installed between the free and paid areas at the station shall check the validity of passenger ticket and on verification shall permit entry or exit from a station.

1.3.13 Bulk Initialization Machine shall encode large volumes of contact-less smart cards (CSC) and token tickets (CST) efficiently and shall sort them into several kinds of tickets and then stack them into suitable lots. These tickets shall be distributed to stations for sale.

1.3.14 The AFC system shall be capable of up grading for working with multiple operators. Detailed information by other operator upon request by the Private Party shall be provided.

1.3.15 All system clocks shall be synchronized to the Clock System.

1.3.16 The equipment shall comply with the Disabilities Laws of Thailand.

1.3.17 Ticket Vending Machines shall be provided at each station for the sale of single journey smart tokens or tickets

1.4 Schedule of Equipment

1.4.1 Systems and Equipment

The scope of supply shall include all necessary hardware, software, accessories, materials and documentation. The Private Party shall supply all equipment and facilities necessary to meet all requirements of this Outline Specification, including, but not limited to:

(1) All equipment associated with AFC system including;

(a) Central Computers;

(b) Station Computers;

(c) Ticket office machines;

(d) Network system, including Ethernet, station hub, router and bridge(e) Ticket Readers;

(e) Line Printers, laser Printers;

(f) Automatic Fare Collection Gates (Entry, Exit and Reversible);

(g) Gates for disabled persons/ Emergency;

(h) Communications equipment's like Multiplexer, Router, Station LAN;

(i) Ticket Vending Machine

(j) Power Supply System for AFC equipment power cable and distribution panel from the main power supply;

(k) Bulk Initialization machine for CSC ticket

(l) Magazine I ticket or cash container trolley

(2) All cables and cabling necessary for the Works;

(3) Enclosures and supporting brackets for housing and fixing equipment;

(4) All equipment associated with any interfaces is required to ensure the system operation;

(5) All special test equipment and tools,

(6) All application software and hardware required for the AFC system and the development system, also licenses for all proprietary and Operating System software;

(7) Computer furniture for all station and computers, ticket office machines;

(8) Storage cabinets for tickets, spares and record;

(9) A complete list of consumables for each unit of AFC equipment along with a recommended replacement cycle and purchase detail; and CSC Tickets and Tokens or magnetic Stripe ticket, sufficient for testing the AFC System.

1.4.2 Capacity

The Private Party shall engineer, install and put into revenue service only that equipment of the AFC system sufficient to satisfy the patronage forecast.

2 SYSTEM DESCRIPTION AND PERFORMANCE REQUIREMENTS

2.1 General

2.1.1 When implementing the operating requirements, the Private Party shall ensure that all associated security/ frauds problems are addressed.

2.1.2 The operating features of the system shall be fully parameterised to enable the changes at the CC and downloaded to the field equipment to be effective at a future date.

2.1.3 The AFC system shall be a closed system that requires validation of tickets at entry and exit gates. However, the system shall be capable of accommodating upgrading for integrated ticketing with other modes of transport at sometime in the future, at minimum cost and inconvenience.

2.1.4 The AFC system shall be able to support a fare structure based on zones, distance, time of day, special concessions staff passes and a combination of these and to facilitate their modification and upgrading.

2.1.5 The Private Party shall obtain the fare policy from the SRT during the engineering phase.

2.2 Exit/Entry Sequence

2.2.1 Entry and exit gates must be used in the correct sequence. Once an entry gate has processed the ticket, the passenger shall not be allowed to use the ticket at another entry gate.

2.2.2 Provision shall be incorporated at the TOM to upgrade tickets to comply with the above condition. Appropriate charges, if necessary, shall be levied for upgrading the tickets.

2.2.3 Should charges be levied on the passenger, the charges are to be downloaded parameters, 2.2.4 It shall also be possible to download commands to the gates at selected or all stations, from the CC to suspend the above check and reactivate the check through another command. These commands shall be executed automatically.

2.2.5 To be more specific, an anti-passback feature shall be build into the system. It shall allow some special ticket type e.g. staff ticket, for multiple entry or exit.

2.2.6 Minimum charges to be deducted from a ticket, if a passenger opts to exit the station after entering the paid area, without performing a journey.

2.3 Fares

2.3.1 Fares shall be station-to-station, specific zones, time of day or special concessions for each type of ticket. Each ticket type shall have its own fare tables.

2.3.2 The fare shall be derived from:

(1) Assigned fare for the particular journey

(2) Ticket type

(3) Time period

(4) Days of the week shall be classified into 3-day types, namely:

(a) Weekdays;

(b) Saturdays; and

(c) Sundays and public holidays.

2.3.2 For a fare table change, it shall be possible to download the new fare table from the CC ahead of the implementation date. The only requirement to activate the new fare table shall be a system-wide execution command from the CC, a local execution command from the maintenance terminal or an automatic control signal initiated by the fare gate. In case of failure to execute commands, request signal from gates shall be sent for a fresh input.

2.3.3 The total time required to download from the CC to all devices shall be specified such that it will not affect the normal operation. During the download the device shall be able to operate normally and the time elapse to switch to a new fare table shall not affect the normal operation.

2.4 Time in System Check

2.4.1 A time-in system check shall be incorporated whereby the time between entry and exit gate transactions is checked against a table of allowable station-to-station journey times.

2.4.2 Should a passenger "over-stay" in the system, the exit gate shall remain closed and direct the passengers to the Booking Office. The charge for "over-riding" the "Allowable Time-In-System" shall be defined by parameters at the CC.

2.4.3 The charges shall vary with ticket types. The station staff shall have the discretion to either:

(1) Request the passenger to use the TOM to deduct the excess charge due from the value of the ticket, provided the remaining value is adequate to pay for the excess fare. Where the deduction of the excess charge would cause insufficient

value in the stored value cards for the journey, the passenger shall be required to pay in cash.

(2) Collect or process the ticket by the TOM and the TOM shall generate a receipt for record purpose, unless suppressed.

2.4.4 Time check override

It shall be possible to suspend the time-in system check through downloading commands from the CC to the gates of either selected or all stations. Similarly, it shall be possible to reactivate the check from the CC.

2.5 Ticket Sales

2.5.1 CSC ticket may be purchased with up to 16 different maximum values. These shall be downloaded from the CC to the TOM. The passenger can purchase the CSC ticket from the TOM according to the selected price.

2.5.2 The fare buttons of the TOM are parameterised and downloaded from the CC. Each TOM shall have its own unique fare table in relationship with its station of origin.

2.5.3 It shall be possible to add value to CSC ticket that has already been issued. "Add value" facility shall be available at the TOM

2.5.4 "Add-value" services shall only be provided for CSC types. No further deposit shall be levied for the-add value function. During the add-value process, the security of the system shall not be compromised.

2.6 Concession and Staff Pass Monitoring

2.6.1 Concession fares will be permitted in the High Speed Railway Project System. Concession tickets shall be available in the AFC system software to introduce concessions at any time. Staff passes will be issued to the employees, the use of which should be monitored as per the requirement of the SRT.

2.6.2 It shall be possible to monitor the use of any existing ticket type. Parameters shall enable the gates to activate visual and audible alarms upon processing of such tickets, including Employee Passes.

2.7 Period of Validity

The period of validity for each ticket type shall be a parameter from the CC. It shall not be possible to use tickets that fall outside the validity period. Passengers shall be required to replace the ticket or add value before the ticket is used again.

2.8 Unique Ticket ID

Fail-safe features shall be incorporated to ensure that no duplicate ticket aids are created in the system, either through hardware or software failures. All tickets shall be numbered serially during manufacturing itself.

2.9 Black-listed Tickets

2.9.1 CC shall prepare a list of duplicate ticket and fraudulent ticket detected by system.

The CC shall also allow the operator to enter a list of blacklisted tickets.

2.9.2 Black-listed tickets IDs shall be downloaded to the AFC equipment at stations

2.9.3 Blacklisted tickets can be rejected at entry or exit gates depending on the downloaded parameters. Entry gate will reject the ticket and the exit gate will erase or block the ticket from any further use. The extended gate display at station control room shall discretely identify such tickets to the operator who will take the necessary action according to the procedures. TOMs shall not accept blacklisted tickets for add-value functions and display the reason to the operator.

2.9.4 Every detection of blacklisted tickets shall be recorded at the CC, which shall also be notified of such detection to AFC equipment at stations. Alarms can be provided at CC and the gates during detection.

2.10 Life of ticket

The life span of smart card tickets shall be five years (or 100,000 transactions). The Private Party shall demonstrate these figures during the Phase II - Operation & Maintenance Period (O&M).

2.10.1 Ticket capture

Single Journey recyclable Tickets (SJT) after completion of a journey shall be captured at exit gate. Should there be any positive remaining value on a SJT after the completion of the journey, the exit gate shall encode the remaining value to zero and capture these tickets regardless of the unused remaining value.

If the collecting bin is full, the gate shall be go into 'OUT OF SERVICE' mode. Gates shall give advance warning to station computer when its bin is 75% full

2.10.2 Tickets may be retained for the following reasons may retain tickets:

(1) Blacklisted;

(2) Failure to pay penalty charges;

(3) Failure to pay the amount due to insufficient fare; and

2.10.3 The Private Party shall propose user friendly, cost effective and efficient methodologies for capture of single journey tickets in gates. Exit gates shall validate and capture SJT in single presentation. In case ticket is not valid, the system shall reject it and shall return it to the passenger.

2.11 Lost Ticket

Should a passenger have lost his ticket, he will not be able to exit via the exit gate.

The passenger shall pay an administration charge and the fare, as prescribed by the Private Party. The charge shall be a parameterised value for each ticket type and journey traveled downloadable from the CC. This shall be recorded and the accounting system shall capture such occurrences and report it to the CC.

2.12 Underfare

2.12.1 In case of under fare the exit gates shall reject such tickets. Passengers shall pay the difference between the remaining value and the fare at the TOM. In addition to the difference, an underfare charge may apply which shall be parameterised from the CC. Each ticket type shall have its own underfare charge. It shall be possible to put the parameter to zero (0).

2.12.2 The TOM shall have a provision to upgrade such tickets for exit from the system after the required payment has been made and recorded. The accounting system shall capture such occurrence and report it to the CC.

2.13 Negative Value

No negative value shall be permitted in any type of tickets. Passengers will be asked to pay the difference before leaving the system.

2.14 Calendar and Operating Day

2.14.1 A distinction shall be made between the calendar day and the operating day. A calendar day extends from midnight to midnight. An operating day starts from a parameterized number of hours after midnight, and extends through 24 hours.

2.14.2 Hence, all expiry checks shall be done based on operating day to avoid inconvenience to passengers who enter the system before midnight and exit the following day.

2.14.3 When the train service is run overnight for consecutive dates, accounting data will also need to be divided into two operating days.

2.15 Train Service Disruption Mode

2.15.1 Should there be any disruption to the train service, a degraded mode of AFC operation called "Train Disruption Mode" shall be provided. The enabling and disabling of this mode shall be done by downloading commands from CC or SC to the gates of selected, or all, stations.

2.15.2 During service disruption, it shall be possible to stop sale of tickets and cancel ticket already sold and refund fare.

2.16 Emergency Mode

2.16.1 A facility shall be provided to place all gates in a station in emergency mode whereby the gates will be opened for passengers to enter or exit without use of tickets. The enabling and disabling of this mode shall be possible either through the CC or SC. The CC shall be able to apply this mode to a particular station, a range of stations, or system-wide.

2.16.2 At each station, there shall be an alternative means, provided by a mechanical button, to set all gates to emergency mode, which shall not depend on the availability of the CC or SC and/or the station to the CC and SC network connection, in accordance with NFPA.130 Guidelines. Display indicating 'enter'f do not enter' shall be set usually to 'enter' on the paid area side and 'do not enter' on the free area side.

2.17 Refund of Tickets

2.17.1 The system shall provide a means to refund unused tickets. The refund system shall be secured against fraud.

2.17.2 No refund shall be made for partially used single journey tickets.

2.17.3 An accounting system for the refund shall be provided. The refund of ticket shall be done at booking offices at stations.

3. TECHNICAL REQUIREMENTS

3.1 General

This specification shall cover functional requirement and technical specification of AFC equipment for the High Speed Project Bangkok - U-Tapao The base AFC system shall be engineered using contactless smart card for multi-trip journey and token embedded with chip to be used as single journeys ticket.

The Private Party may, however, propose a cost-effective alternative AFC system based on contactless smart card for multi-trip and magnetic recyclable paper or plastic ticket for single journeys. Other elements of the optional system shall remain as specified in the base system.

The compatibility of the new AFC System to the existing AFC System at the Airport Link shall be ensured.

The following sections are covered in this chapter:

(1) Station accounting system (SAS), Smart Media

(2) AFC system components

(3) Security in AFC system

(4) Option - magnetic recyclable single journey tickets

3.2 Station Accounting System (SAS)

3.2.1 Description

(1) Station accounting system enables the overall control and monitoring of each item of AFC equipment within the station and transfer of data to the CC. The station accounting system shall register and .transmit alarms and responses to emergency situations.

(2) The SAS shall include the power and data communication links to each item of AFC equipment, the SC, the Ticket Office Automation system and CC system interface.

(3) It shall enable printing of reports at stations. The reports shall include accounting and statistical information. It shall include any other reports required for AFC operation.

(4) The SAS shall be able to download data to the AFC machines individually or as groups. The SAS shall check the version of the software in AFC machines and initiate the download process if the version is not the same. The SAS shall also provide manual control for the operator to control a download of parameter files to AFC machines.

(5) The SAS shall receive maintenance data from AFC equipment and transmit the same o CC for monitoring and use of the same ·as an effective maintenance tools.

(6) The SAS shall be able to monitor certain critical functions of the AFC system and collect data for warnings and alarms. Suitable Man Machine Interface (MMI) shall be employed e.g. geographic layout of the station and relative position of the AFC machines. Machine icons shall be able to tell different operation mode or alarms of the equipment etc.

(7) Items included in Station Accounting System shall be:

(a) Station Computer (SC) with Printer

(b) AFC Local Area Network (LAN) (Ethernet shall be specified.)

(c) AFC Data Cable Distribution and Control

(d) AFC Power UPS

(e) Power Distribution Cable and Control

(f) Interfaces with the communications system

3.2.2 Equipment Control

(1) The normal method of control of the equipment shall be by the SC.

(2) The concourse will be in one of the three concourse operating modes

(a) Concourse Open Mode : Tums all equipment to in-service mode.

(b) Concourse Closed Mode Closes all entry gates. : Leaves Exit gates working normal.

(c) Concourse Emergency Mode Opens all gates in both directions.

(3) Control of Equipment - The SC shall control individual AFC equipment as follows:

(a) Equipment Operating Modes:

(i) Mode of operation of gates: and

(ii) Mode of operation of the TOM.

(b) Servicing Control - Servicing control shall enable servicing of the TOM, Ticket Reader and Gates; and

(c) When the SC instructs equipment to change mode it shall complete any transaction in process before changing the mode.

(4) Gate Operating Mode - When the Concourse Operating Mode is open, the gates shall be in one of following gate operating modes:

(a) Normal Mode (high security);

(b) Line Mode Override (TMO); or

(c) Incident Mode (good will mode).

(5) In the event of total loss of AFC power supply, the equipment will be in the powered off mode which shall be the same as Concourse Emergency Mode.

3.2.3 AFC Workshop Equipment

(1) The AFC workshop equipment shall be connected to a LAN and that shall interface to the SC and CC in the same manner as the Station Level AFC equipment unless alternative arrangements acceptable to the Engineer's Representative are proposed by the Private Party.

(2) The Private Party shall ensure that these interfaces do not create an opprtunity for fraudulent use of the AFC System.

3.2.4 Central Clearing House (CCH) System

(1) The AFC system shall be designed as a conventional four-tier closed system using contactless fare media for both single-journey (contactless token or CST) and multy-journey (Contactless smart card or CSC).

The four tiers are conventinally described as:

(a) Level 0 – Fare Media (CSC, CST)

(b) Level 1 – Media handling devices (TVM,AG, TOM etc.)

(c) Level 2 – Sation Computer System (SCS)

(d) Level 3 – Central Computer System (CCS)

A fourth tier (Level 4) shall be an external Central Clearing House (CCH)

(2) The Private Party shall ensure that the CC system shall be capable of providing relevant information to a separate CCH system and shall advise the SRT on the provisions made to guarantee adequacy, security, and auditability of such information.

(3) The Private Party shall provide a demonstration of how the proposed information shall be used for financial reconcillation where common fare media is used on three or more service providersand where integrated fares are applied to journeys between any two service providers. Similar demonstration shall be done by the Private Partys for integration with retailers.

(4) The Private Party shall provide all necessary data formats and communication protocol details required for interfacing to the CCH system.

3.2.5 Concourse Emergency Mode Switches

(1) In the event of loss of the central equipment or communication system, suitable backup arrangement may be provided in the station system to control AFC equipment at a station. The circuit of the backup shall be reliable and include manual overrides.

(2) These concourse Emergency Mode switches shall operate independently of the SC.

(3) The gates will automatically open if the control cable connection is broken.

For the flap gates, the flap shall be open (closed mode operation) by using UPS or battery power during emergency.

3.2.6 Power Failure Protection

(1) No transaction data shall be lost due to power failure

(2) Any transaction that has been started shall be completed, including the storage of transaction data, before a device shuts down in a controlled way.

3.2.7 Station Computer (SC)

(1) SC Function General

(a) The Station computer (SC) at each station shall control and monitor the AFC equipment status, including critical functions, and keep a record of machine registers. The SC shall communicate with the CC facility through the Data Transmission System (DTS) communication link;

(b) The SC shall receive operational data (including fare tables and security data (including black listed ticket) from the CC system and disseminate this data throughout the AFC system;

(c) The main function of the SC shall be to enable data to be securely transmitted between each item of AFC equipment on the AFCLAN and the CC;

(d) The SC shall read TOMs register and contents of each TOM at intervals of 15 minutes. In case SC fails, such 15-minute register readings shall be stored in a "first in first ouf' buffer of AFC equipment and retransmitted as soon as communications to the SC is ready again; and

(e) The SC shall also communicate with gates for efficient functioning of the AFC system.

(2) SC Features

(a) The SC shall collate, format and enable end of day and ad hoc reports to be printed from the data transmitted by the various AFC machines;

(b) The data for these reports shall be recorded on hard disk of SC so that in the event of a communication failure between the SC and CC, it may be transmitted to the CC when communication has been restored;

(c) The SC shall also be able to store report data on a CD-R disk or DVD Unit for transfer to the CC;

(d) The SC will enable periodic and ad-hoc cash reconciliation for the station;

(e) The SC shall be able to output reports in a spreadsheet. The format of the same shall be reviewed by the Engineer’s Representative;

(f) The SC configuration shall be submitted for review by the Engineer’s Representative;

(g) The SC shall include a VDU, keyboard and printer;

(h) The SC shall automatically re-boot after resumption of power in case of power failure;

(i) The SC shall enable station AFC equipment to be taken out of service, put back into service and initiated without the need for communication with CC;

(j) AFC station data shall be in files which will be selected for display via the Graphical User Interface in the Station Computer;

(k) The SC shall be capable of handling a minimum of 256 AFC equipment;

(l) There shall be one version of. the SC software for all stations. Stations shall automatically configure the software by tables according to their AFC configuration;

(m) The SC shall enable the station AFC system to operate normally in the event of loss of communication with the CC. In the event of failure, the SC shall utilise the most recent operational data received from the CC. The SC shall store data to be transmitted to the CC when communication is restored;

(n) If there is loss of communication between the SC and the AFC equipment (Gates, TOM etc.,) then the equipment shall operate in the stand-alone mode utilizing the most recent data from the SC;

(o) The failure of the SC shall not affect functioning of the TOMs including ticket Office equipment and the gates;

(p) Therefore, the SC shall be able to store up to five days' data in case of loss of communications with the CC. The data shall be divided into accounting days terminating at 24 hours each day. Should it be necessary to store more than five days' data, this may be transferred to CD-A or DVD unit; and

(q) Password hierarchy shall be set-up for different operator access level.

(3) Computer Hardware

(a) Central Processing Unit (CPU) VDU, keyboard and tracker ball- The CPU shall have sufficient processing power and main memory to drive the full hardware and software configuration of the AFC system, and to fulfill the workload and performance requirements of the system.

(b) Mass Storage - The mass storage shall have sufficient capacity to fulfill the workload and performance requirements.

(c) CD-A or DVD Unit - The drive shall be able to read with CD's with a capacity of 700 MB.

(d) Printer - The SC shall drive a printer support printing of minimum 600 lines per minute, continuous printing.

(4) Data Categories

(a) Data to be transmitted from AFC equipment to the SC shall be divided into the following categories:

(i) Transaction Data-Accounting and statistical data including cash accounting, ticket sales, passenger traffic, gate data, origin and destination data;

(ii) Audit Data: Details of audit data of each machine incJuding data of non-resettable registers;

(iii) Status Data: Status data including faults, maintenance alerts, mode of operation; and

(iv) Alarm Data.

(b) Data will also be downloaded from the CC facility to the SCs. This data will be operational and security data such as:

(i) Operational Data:

(ii) Fare tables;

(iii) date and time;

(iv) peak and off-peak; and

(v) promotional features and discounts.

This data shall include a time stamp on operational date and timed;

(i) Security Data. Security data will include security word for black listed tickets (i/c passes I CSC disallowed in the system); and

(ii) Any other data for AFC operation.

(5) Data Exchange

(a) Transaction data and audit data shall be sent to the CC facility. Status and control data shall be sent to the SC. Fault and maintenance data shall be sent to the SC.

(b) The data exchange shall include the following:

(i) Data from CC to SC and vice versa;

(ii) Data from SC to AFC machines and vice versa; and

(iii) Any other data exchange required for AFC operation.

(6) Passenger Traffic

The SC shall provide passenger traffic data from the gates to the CC. This data shall be updated every 60 seconds to enable the CC to calculate number of passengers at station at that time (this data may be used in emergency).

(7) Alarms

(a) Alarm signals shall be transmitted for display on the SC. All important alarms shall be acknowledged. They will include the following examples:

(i) Encoding errors in Gates and TOM;

(ii) Power failure to any AFC machine;

(iii) Unauthorised entry/intrusion, tampering with cash handling modules; and

(iv) Communications failure to any AFC machine.

(b) Other mechanical and electronic problems or anomalies output from the device's own diagnostic and condition monitoring system;

(c) Ticket collection bin full up to 75% and 100% in Gates;

(d) Application program or parameter files download error to any AFC machine; and

(e) Any gate or TOM (or other AFC equipment on the AFC LAN) showing an 'in service' status to passengers but has not processed a transaction for a defined period of time during peak hour (this time shall be programmable at the SC and may vary from location to location) shall transmit a warning message to the SC that there may be an undetected

(8) Report Generation

(a) The SC shall generate and enable printing of the station daily activity reports. The entire end of Day routine shall never take longer than 30 minutes in total to prepare and print each day report.

(b) SC data shall be stored in a rational data base structure to permit ad- hoc reporting. The SC shall enable all reports to be printed sequentially or selected reports or individual reports on request

(c) The reports shall include but not be limited to:

(i) Daily Station Summary Report, summary totals of passengers in and out, tickets vended, cash received or refunded, booking office transactions;

(ii) Entry/Exit Gate passenger flow, totals in totals out.

Ticket CSCs sold or refunded from booking offices, type of CSC sold, cash value sold/added. Each transaction with date and time stamped.

(iii) Traffic report by hour, passengers in and passengers out per 1/4 hour period throughout the operating day, with sub-totals for each hour and grand total for the day.

(iv) Event log, chronological report of daily activities. Each event shall have date and time recorded.

(v) Periodic Contactless Smart Card (PCSC) activity report consolidated report of data retrieved from the CC.

(vi) Log event and operator command reports

(vii) Operators shall be able to select report and print the same or view only.

(viii) Consolidate reports shall be stored for 5 days and it shall be able to print out these reports on demand.

(ix) Daily and periodic reports to be generated have been tabulated in.

The Private Party shall finalize this during engineering review with the Engineer's Representative.

(x) Any other report required by Engineer's Representative.

3.2.8 AFC Local Area Network (LAN)

(1) The SC shall communicate with the station AFC machines via the AFC LAN.

(2) The Private Party shall be responsible to configure the AFC hardware and software to ensure the LAN communication from SC to CC and vice versa.

(3) The LAN at OCC will communicate with the station AFC LAN through a 2 Mbps link.

(4) OTCP/IP network communication protocol should be used for all data communication in the system. IP addresses shall be engineered and implemented by the Private Party in consultation with the Engineer's Representative,

(5) In order to assure station communication at an optimum rate, the speed of station LAN shall be at least 1O Mbps. Other operating speeds may be proposed if equipment performance of the system can demonstrated.

(6) Full LAN redundancy shall be provided. The LAN shall be compatible with the IEEE 802.3 CSMA/CD standard

(7) All network computers and equipment shall be connected through intelligent HUBs. Any single failure in the network shall be automatically isolated and shall not cause any system disruptions.

3.2.9 Components of LAN

The minimum requirement of various network components areas follows:

(1) HUBs

(a) RJ45 port complying with 1O Mbps Ethernet I IEEE 802.3 standard and/or 100 Mbps FAST Ethernet. The speed of the port shall be configurable;

(b) A minimum of 16 ports easily expandable to 48;

(c) SNMP compliant and able to remotely monitor and control the status of each port;

(d) Size shall be adequate to be fitted in a 19 rack;

(e) Auto partitioning function;

(f) Data collision and jabber handling functions;

(g) Security functions including port and group intrusion control; and

(h) Ability to cascade HUB's.

(2) Repeater I Bridge

(a) SNMP compliant and able to be remotely monitored and controlled;

(b) Size compatible to 19 rack; and

(c) Able to link networks that is· separated more than the recommended distances.

(3) Routers

(a) 2x2 Mbps port complying to G703, 2 Mbps interface; and

(b) 2x LAN interface complying with Ethernet/ IEEE802.3.

(4) For any other network components not mentioned above. The Private Party shall give the technical details of the products and standards to which the product adheres to and supply and install the same.

3.2.10 AFC Data cable distribution and control

(1) General

The Private Party shall be responsible for the specifications, sizing, procurement, installation, wiring, terminating and testing of all cables and wires required for the AFC network. This shall include all necessary connecting cables to the WAN infrastructure to the DTS. Cable shall meet national or international standards applicable to data processing and data transmission systems and appropriate to the duty.

(2) Requirements

(a) The following requirements shall be the minimum, but not limited to, ensuring that the engineering follow sound engineering practice and are suitable for their intended purposes and environments.

(b) All material used shall be subjected to the Engineer's Representative inspection and examination on site or the factory.

(c) In station areas generally, the Private Party shall determine the requirements for brackets, ducts, conduits, troughs, trays and other fittings required to protect the cables for the systems supplied under this Contract. Where cable routes are, or can be made common, the Private Party shall determine a mutually acceptable arrangement of common routes, for the acceptance of the Engineer's Representative.

(d) The cables shall be installed at a safe separation from potential interfering sources, including power cables, LCX, etc. The Private Party should refer to guidelines recommended by IEC 1000-5-2 wherever possible.

(e) The cables used in the AFC network must be adequately protected against external interference. Additional protective measures, including but not limited to the use of metallic (steel) conduits, armors, ferrite chokes, EMI filters must be used to reduce such external interference wherever required.

(f) For protection against the electrostatic capacitance coupling, direct electrical connection between ducts of power cables and controls/monitoring cables must be avoided.

(g) The Private Party shall prepare installation drawings and specifications for the Engineer’s Representative approval prior to commencing any work on site. These shall include a schedule of locations, activities and key dates, together with lists and details of staff to be employed.

(h) Cable routes shall be engineered to avoid trapping rubbish, which could become a fire hazard. Bends shall be of maximum radius and not less than is appropriate to the size and construction of the cable. Sharp edges shall be avoided.

(i) The Private Party shall demonstrate satisfactory use of the type of cable proposed for use in a comparable railway and tropical environment, be able to meet the specifications, and shall guarantee at least 15 years service life for the product to be provided.

(3) Cable Specification

(a) Hazardous conditions arising from the over-heating or ignition of cables shall be avoided. All cables shall therefore, be manufactured from fire retardant, low smoke, halogen free materials. In addition, the cables shall meet the following minimum requirements:

(i) All cables totally exposed in above ground guideway or above ground open areas shall be armoured: and

(ii) Fire retardant low smoke, halogen free material shall meet the requirements of NFPA 130 Guidelines, or similar International Specification:

(b) Anti termite, pest resistant, and chemicals used shall conform to the requirements of the local authority.

(4) The cable shall be marked with the following information through the length of cable.

(a) The cable shall be sufficiently shielded to minimize its susceptibility to external noise. It shall also be suitable for routing through different areas via false ceilings, raised floors, cable ducts, trunkings, conduits etc.

(b) Installation shall be carried out strictly in accordance with this Specifications, and with requirements of the Laws, Regulations and Codes of Practice of the Engineering Institute of Thailand. The Private Party's installation specifications shall ensure that installation work conforms to the best accepted Industry Standards for data processing.

(c) The Private Party shall supply full details of his proposal and the specification to the Engineer's Representative for acceptance before proceeding with detailed system engineering.

(5) Fibre Optic Cable

(a) For the control systems required by this Contract, the Private Party is encouraged to propose the use of fiber optic cable as an alternative to conventional multicore cable if they can demonstrate that the use of such cable will be more efficient or economical or both. Full details shall be provided.

(b) The cable shall comply with requirements of 3.28 and other standard for its engineering and construction.

(c) The Private Party shall supply full details of his proposal and specification to the Engineer's Representative for acceptance before proceeding with detailed system engineering.

3.2.11 Power cable distribution and control

(1) AFC Area Distribution Panels

The AFC Area Distribution panel shall distribute power from the isolator to individual gates and, TOMs. The panel shall contain a correctly rated isolator for each machine. Each isolator shall be clearly identified and labeled in English and Thai languages. The panel shall conform to the relevant wiring regulations.

(2) Ducting

(a) AFC ducting will be provided by station Private Partys to enable the distribution of power, data. and control cables to equipment on the station concourse and platforms

(b) AFC ducting will be installed in the floor screed for the use of the AFC power, data and control cabling.

(c) There will be an earth cable throughout the length of the ducting and in addition there will be earth bonding of the ducting itself. It shall be the responsibility of the Private Party to verify the integrity of the earth bonding.

(3) Circuit Breakers

Each AFC equipment shall be protected against over current by providing a properly rated over current circuit breaker. These circuit breakers shall be located inside the machine and shall be protected against accidental operation. The

Private Party shall also provide an appropriate Earth Leakage Circuit Breaker (ELCB) at the AFC Area Distribution Panel.

3.2.12 Interfaces

The Private Party shall supply and install the necessary hardware and software to integrate with the Communication System.

3.3 AFC System Components

3.3.1 Gate

(1) Gate Function

(a) Gate arrays shall be the normal-means of controlling entry to and exit from the paid areas. Control shall be by means of actuating a physical barrier on recognition of a valid ticket or card by the gate. The barrier may be a bi-parting leaves or turnstile type. The gate shall be capable of operating either normally open or normally closed.

(b) There shall be provision as part of the gate array in each station for wheelchair passengers, which will also handle luggage.

(c) Where required, the Private Party shall provide the fencing in continuation as per the gate arrays to separate paid and unpaid areas in the concourse. The fencing should be strong and aesthetically merged with station engineering.

(d) Gate arrays on all lines shall be providing for high passenger throughput.

(e) All gates in an array shall allow passenger access on presentation of a valid ticket.

(2) General

(a) Earthing

(i) There shall be a main earth to each array of equipment linking each machine to the station earth bus bar; and

(ii) There will be main earth and clean earth terminals provided at each AFC Area Power distribution panel which, if required, shall be connected to the individual AFC equipment.

(b) Fire Safety Requirements

Gates shall comply with the American National Standards, National Fire Protection Association (NFPA) 130 Guidelines with regard to emergency exit mode on loss of power; the standard gates shall not prohibit movement of passengers in the direction of the emergency exit.

(3) Features

(a) Power Failure - In the event of a total power failure to the gates, the gates shall open to allow unrestricted passenger access. All latch gates shall automatically unlatch where electric locks are installed.

(b) Concourse Emergency Mode -All AFC gates shall open whenever the Concourse Operating Mode ii; in emergency.

(4) Gate Ticket Processing

(a) There shall be following gate operating modes when the concourse Operating Mode is open:

(i) Normal Mode;

(ii) Time Mode Override -There shall be no time check and ignore the checking on anti pass back bit; and

(iii) Incident Mode - When a railway operations incident causes a journey to be interrupted, excess fare shall be deducted from CSC ticket.

(b) Complete data on encoding for the High Speed Project shall be discussed with the Engineer's Representative during the Engineering Phase. The software of gate shall be able to retry the read/write function on ticket.

(5) Types of Gates

There shall be several types of controlled access gates including:

(a) Passenger Entry Gate

The Passenger Entry Gate shall control the entry of passengers into the paid area by validating the fare media.

(b) Passenger Exit Gate

The Passenger Exit Gate shall control the exit from the paid area by validating the fare media, and where necessary, processing the fare media, capturing the fare media.

(c) Passenger Reversible Gate

The Reversible Gate shall combine the features of the Entry and Exit gates and will be switched from the Station Control Room terminal from one mode to the other depending on the operational requirements of passenger flow.

(d) End Stanchion

The End Stanchion shall be used to complete an array of either Entry or Exit gates. It shall have the same length, height and finish as the gates.

The End Stanchion may house a gate array controller for the array.

(e) End Barrier

The End Barrier shall be used to complete an array of Entry or Exit Gates. The End Barrier may be narrower than the normal gate stanchion, but of the same height and length.

(f) Gate for Disabled/ Emergency

Space shall be provided for the Disabled Gate, normally adjacent to ticket Office will allow those passengers in wheel chairs to validate their ticket and gain access to, or exit frdm the paid area. This will be kept opened during emergency situations.

(6) Common Engineering for Passenger Gates Passenger Gate General Requirement

(a) The engineering and construction of the passenger Entry Gate, Exit Gate and Reversible Gates shall have common Components and subsystems. It shall be possible to convert an Entry Gate to an Exit Gate by changing its software and display module information.

(b) The passenger Entry, Exit And Reversible Gates shall read, check and verify data on the fare media, re-encode with new data and allow passage by releasing a barrier only if the fare media is valid. If the fare media is not valid the barrier shall remain closed. A display shall instruct the passenger accordingly. (Normally open bi-parting/ retractable door types gates shall close).

(c) The reversible gate shall have the same overall dimensions as the Entry and Exit gates and combine the functions and features of both.

(7) Dimensions and Spacing

(a) Maximum outside dimensions of the gate cabinet shall be generally based on following criteria :

(i) Length 2000mm

(ii) Width 300mm (350mm for gates for disabled) .

(iii) Height 1040mm

(b) Way out spacing for passenger gates will be based on the following dimensional criteria:

(i) Gate centre spacing Max. 880mm (Max. 1,450 for gates for disabled)

(ii) Aisle width Max. 580mm (Max. 1,1OOmm for gates for disabled)

Min. 465mm (Min. 900mm for gates for disabled)

(c) The positioning of the readers and collection slot of single journey ticket has to be engineered in such a way to ensure passengers to proceed without stopping through the gate.

(d) Above parameters shall be finalized during the engineering stage and prototype approval.

(8) Gate Enclosure

(a) The gate enclosure shall be fabricated of stainless steel. The gate shall be finished to conform to the architectural requirements of the station.

(b) The degree of protection provided by the enclosure against dust, splashing, intrusion of foreign objects shall be to the standard IP54, as defined by British Standards.

(9) Barrier Mechanism

(a) The gates shall be a biparting door type/ retractable type with material of enough strength for use in mass transit system.

(b) There shall be a shock absorber to reduce the shock and sound associated with the arresting of the arm and mechanism in the closed position. This device shall not impair the passenger designed flow rate.

(c) If the barrier is forced open, no damage shall happen to gate components and gate should automatically restore to normal. An alarm should be generated during forced opening.

(10) Electronic Modules

(a) The electronic modules shall be a self-contained unit capable of being easily removed and replaced in the event of failure.

(b) Program and register memory shall be protected for at least 2 years.

(c) The electronic modules shall include 14 activated non-resettable electronic registers, which shall retain their reading when power ·is removed. They shall not be easily removed without the requirement for an audit trail.

(d) The electronic modules shall incorporate an electronic and physical ID number unique to each module. This number shall be transferred to the SC.

(e) The gate processor shall control and process data from the readers

(11) Gate Non Resettable Registers

(a) The contents of the non-resettable registers shall be transmitted to the SC. The registers shall include, but not be limited to the following information:

(i) Number of adult, child, senior citizen and student;

(ii) Value charged to adult, child, senior citizen and student;

(iii) Number of adult and Private Party single journey tickets processed;

(iv) Individual register on the number of transactions failed;

(v) Number of times out of service;

(vi) Number of times in maintenance mode; and

(vii) Number of times gate-forced open.

(b) There shall be at least 10 spare registers available for future use.

(12) Power Supply Unit

Power shall be provided from the AFC Area Power distribution panel at 230V, 50Hz.

(13) Fare Media Processing

(a) The Entry, Exit and Reversible gates shall include provision for a device to read, encode and verify tokens I tickets. Only those to be used for Exit shall be equipped with tokens ticket capture facilities. Captured tickets shall be collected in a bin and selected for re use in TUM's.

(b) The single journey token or tickets that are not accepted by the exit gate have to be returned to the passengers for approaching excess fare office.

(14) Passenger Throughput Capacity

(a) The throughput capacity of the gates shall be at least 45 Passengers Per Minutes (PPM). · ·

(b) Engineering shall take into account that daily passenger usage may typically be 10,000 passengers per day per gate and may be up to 20,000 passengers per day per gate in the busiest locations.

(15) Safety to Passengers

(a) There shall not be any sharp edge in the gate, which can hurt passengers while passing through Gates.

(b) Opening and closing of Gates shall be depending on application of force that can be parametarised by the SRT.

(16) Gate Passenger Information Display

(a) The Passenger Information Display (PIO) shall be located on top of the gate flush with the top panel. The display shall be a dynamic programmable device capable of displaying information in English and Thai. It shall be capable of displaying pictograms.

(b) The display shall also be capable of displaying 4 rows of 30 alphanumeric characters, 12 mm high and include some special characters such as direction arrow and no entry symbol.

(c) Reversible gates shall have a passenger information display for each end.

(d) Displays shall be clearly visible in the ambient light level of 300 Lux at gate arrays and at installations in shaded sunlight. The display shall be mounted in a convenient position so that it is approximately perpendicular to the normal angle of view of passengers approaching the gate. The display angle shall enable passengers of various heights to read it, excluding persons under the height of 950mm.

(e) The top displays shall be informative and instructional showing Thai/English text including the following typical message:

(i) STOP

(ii) PRESENT TICKET

(iii) GO/PROCEED;

(iv) GO TICKET OFFICE;

(v) ADD VALUE TO TICKET SOON;

(vi) DISCOUNT FARE;

(vii) OUT OF SERVICE;

(viii) FARE DUE DISPLAY Bht.xxx (NO LEADING O'S);

and

(ix) TICKET/PASS EXPIRES IN "N" DAYS.

(f) Display during gate use shall be static or flashing on and off (STOP).

Displays in the idle mode may be dynamic (moving).

(g) In the event a ticket or card does not work first time the display shall inform the passenger as to what he should do next, such instructions shall include "Try Again", "Ticket Invalid", "Booking Office".

(17) End Of Gate Display

(a) There shall be selectively illuminated "ENTRY" and "NO ENTRY" sign on both ends of each gate Thal/English language. The "ENTRY" display shall be illuminated whenever the gate is intended for use in the direction shown.

(b) The "ENTRY" display shall be illuminated on the paid side of Entry only gates when they are in the free-wheel emergency mode.

(18) Installation

(a) The stanchion frame shall be secured to the floor by at least four stainless steel bolts of minimum diameter 15mm.

(b) Cables shall be terminated within the gate no less than 300 mm above the finished floor surface. Cable entry from the under floor ducting shall be sealed from the cable duct.

(c) The circumference of the base shall be sealed with the floor finish after installation so as to prevent the ingress of water.

3.3.2 Entry Gate

(1) Entry Gate General

(a) The Entry gate shall be a single ended gate incorporating displays, interface for a CSC reader and processor, barrier mechanism and support electronics module.

(b) The gate shall have only one target to present all types of tickets.

(2) Entry Gate Displays

(a) The Entry Gate shall have three display areas, the passenger information display on the top surface at the entry end and the two ends of gate displays.

(b) There shall be a visible indicator on the end of the Entry Gate in the paid area that shall indicate when a Private Party ticket or special pass is being used. This shall remain visible for 5 seconds or until the next ticket/pass is processed.

(c) The "EXlr' display on the end gate display of an Entry gate shall be illuminated when they are in the free-wheel emergency exit mode (provided there is power available).

(3) Barrier Mechanism

The barrier shall normally be mounted in such a way to make the gate user friendly.

(4) Electronics Module

The electronics module in entry gates shall be used for logic and control operation. The use of Electro-magnetic components shall be reduced to minimum.

3.3.3 Exit Gate

(1) The Exit Gate shall be identical to the Entry Gate except with the addition of a ticket collection bin, corresponding diverter and associated equipment.

(2) The gate shall be programmed as an Exit Gate that shall determine the mode of operation and graphic responses of the top display and end displays.

(3) It shall be possible to convert an Entry Gate into an Exit Gate and an Exit Gate into an Entry Gate, before installation, by software and the addition of a ticket collection bin and corresponding diverter.

(4) The single journey tokens tickets (CST) processing shall be completed by one presentation only by the passenger.

3.3.4 Reversible Gate

(1) Reversible Gate General

The Reversible Gate combines the features of both Entry and Exit Gates in one gate enclosure. The Reversible Gate shall be a double ended gate incorporating two passenger display modules, two CSC targets, barrier mechanism and support electronics. The software shall determine the operational and graphic response.

(2) Mode Of Operation

Reversible Gates shall be able to be remotely set to any of the following operating modes.

(a) Entry;

(b) Exit; and

(c) Both Entry and Exit, the mode determined by the passenger presenting a ticket on a "first-come-first-served" basis.

(3) Displays

(a) There shall be four display areas, two top displays, one entry end display and one exit end display.

(b) There shall be one display for the entry mode and one display for the exit mode of operation; they shall be the similar as for the Entry only and Exit only gates. The display and CSC reader associated with.each direction shall be grouped such that they bias the passenger towards the aisle through which the passenger should pass.

(c) The end displays shall signify the mode of operation of the gate, entry, no exit or exit, no entry or no entry in either direction.

(4) Barrier Mechanism

The engineering of the gate arrays should be such that the passenger uses reader placed on the right hand side while passing through the gate.

(5) Electronics Module

There shall be one electronics module serving both the entry and exit sub-systems.

3.3.5 End Stanchion

(1) End Stanchion General

(a) The End stanchion shall not have a barrier mechanism installed. It shall be used to complete the entry mode of the last aisle in an array of Reversible

Gates. The End Stanchion shall include the features of an entry gate, without a barrier.

(b) The End Stanchion may house a controller for communication between a group or array of gates and the SC.

(2) Displays

There shall be three-display area entry and exit end displays and one top display.

(3) Electronics Module

There shall be one electronics module interfacing with the adjacent gate; this may not be required if the electronics module of the adjacent gate also controls the End Stanchion.

3.3.6 End Barrier

The end Barrier shall be used, where necessary, to complete an array of entry or exit gates. This shall be no more than half the width of the normal gate. -But have the same height and length. The materials and finish shall be the same as the entry, exit and reversible gates.

3.3.7 Gates for Disables/ Emergency

(1) General

(a) Gates for disabled will be a self-closing, hinged swing gate, forming part of the barrier between the paid and unpaid areas.

(b) The Gate for disabled shall be operated by presenting a ticket or by a staff in the Ticket Office.

(c) The Gate for disabled will remain opened when the Concourse Operating Mode is Emergency.

(d) Gate for disabled will be adjacent to the Ticket Office.

3.3.8 Ticket Office Automation Terminal

(1) TOA Terminal General

(a) The Ticket Office Automation (TOA) terminal shall be connected to the AFC LAN and shall include a computer terminal/PC or workstation, Visual Display Unit (VDU) and Keyboard.

(b) The TOA terminal shall interface with the TOM.

(c) It may also be possible to use the station computer as TOA terminal.

The Private Party may, therefore, finalise this with Engineer's Representative during engineering review.

(2) Functional Description

(a) The TOA terminal shall enable the transfer of certain data over the AFC LAN to the SC and CC facility.

(b) The TOA terminal interfaces with the TOM and enables the display of certain data on the VDU in a legible form, in English and on the Passenger Information Display (PIO) in English and Thai which will be part of the OCP package. This data shall include information on CSC transactions for excess fare payment and ticket replacement information.

(3) Local Control Of Gates

Provision shall be made in the software provided with the Ticket Office Automation terminal to control certain functions of the gates in arrays.

(4) Power Supply

Power shall be provided from the AFC Area Power distribution panel.

3.3.9 Ticket Office Machine (TOM)

(1) Function

(a) The TOM shall be installed in the SCA at the ticket counter at all stations. This machine will be operated by the staff and will issue all types of tickets.

(b) The TOM will include the following:

(i) TOM Software;

(ii) CSC Target;

(iii) Passenger Information Display; and

(iv) Receipt Printer.

(c) The TOM function shall include the following:

(i) Sale of all kinds of tickets;

(ii) Analyse tickets; and

(iii) Add value to CSCs.

It is preferred to have one exclusive counter in all stations for stored value cards. However, the exclusive counter may not be required if the total number of TOMs is less than three in a station. This shall be finalized in consultation with the Engineer's Representative during engineering stage.

(2) Data Communication

(a) The TOM shall interface with the TOA terminal.

(b) The TOM shall communicate with the Central Computer for authorization of certain transactions.

3.3.10 Token/Ticket Vending Machine (TVM)

(1) Operation

Vending Machines are to be provided to enable passengers to purchase contactless smart tokens that may be used as the fare media or magnetic stripe tickets for a single journey on the SAAL. The machines will accept payment in the form of bank notes or coins, and will interact with the passengers via a Man Machine Interface (MMI) touch screen display and receipt printer. If the machine is configured to display a graphical representation of the system map, the passenger may touch the screen at the point where the station of destination is indicated, whereupon the display will indicate the amount of money the passenger needs to insert into the machine to purchase a token of the appropriate value.

Alternatively, the machine may be configured to display the fare value for journeys between each station or between designated zones encompassing more than one station.

Provided the value of the money deposited equals or exceeds the value selected, the machine will issue a token that can be used to enter the paid area of station.

(2) TVM Functionality

The TVM's will be made from stainless steel and will be recessed into the walls of the Token Vending Machine rooms. Access to the rear of the machines will be from inside the TVM rooms allowing the staff to remove notes and cash, replenish the change, remove and insert token containers and service the machines in safety; out of sight of the public. The TVM's will accept cash and notes and give change and a reject button will be provided to enable a passenger to abort a transaction before a token issue cycle has commenced. The bank note reader will accept notes inserted in any orientation (any way up or round) and change will be provided via a 4x120 coin recirculating mechanism, which minimises the number of times the station staff have to replenish the machines with change. In case of transaction cancellation, the coins introduced are returned to the user (escrow function). Separate tamper-proof coin boxes and note vaults will be provided and the token magazines will be interchangeable with those used in the exit gates enabling closed loop rotation of the tokens on each station for maximum security. Details of valid and aborted transactions, and relevant audit data are recorded and reported to the Station Computer via the LAN. As are status, activity monitoring and alarm conditions.

(3) Performances

Main performances of the machine are given in the below table:

(a)	Time between power up and TVM fully operational at +10° C	Approx. 10 minutes
(b)	Acknowledgement of a Station Processing System command in normal LAN conditions:	Approx. 2 seconds
(c)	Time to indicate a TVM status change to the Station Processing System in normal LAN conditions:	Approx. 2 seconds
(d)	Time to download EOD files (application files excluded:	Approx. 5 minutes
(e)	Time to process a ticket sale:	
(i)	With one coin payment, no change from the coin insertion-	Approx. 8 seconds;
(ii)	With one banknote, no change from banknote insertion-	Approx. 10 seconds;
(iii)	With one banknote, 2 coins change from banknote insertion-	Approx. 12 seconds;
(f)	Number of transactions per hour (maximum)	Approx. 50 seconds

3.3.11 Ticket Reader

(1) General

(a) There shall be a ticket readers installed at Don Mueang, Bang Sue, Makasan, SA Airport, Pattaya and U-Tapao to be used by passengers who wish to know the remaining value of the ticket.

(b) The ticket reader shall read encoded data from tickets.

(c) Data from the tickets shall be decoded and displayed in English and Thai.

(2) Features

(a) The ticket reader shall be a self-contained incorporating a CSC ticket reader.

(b) There shall be an intelligent display capable of displaying in English and Thai.

(c) The display, two rows of 24 characters, shall be easily visible in the ambient light conditions on the stations.

3.3.12 Bulk Initialisation Machine

(1) General

On receipt of CSC tickets from the manufacturer, the SRT shall encode his own security codes to the tickets. A suitable machine along with software that can handle large volume of smart cards for initialization has to be supplied by the Private Party. The machine shall have facility for counting and stacking the CSC tickets/ tokens. The out-put of the machine should be ready in all respects to dispatch to the stations.

(2) Ticket Initialisation

(a) Initialization of contact less smart card shall be done in bulk during initial use. The Private Party shall submit the plan to the Engineer’s Representative whether to do the bulk initialization at manufacturer's premises or at the site.

(b) CSCs will be issued at the ticket Office and encoded by the Office CSC Processor attached to the Ticket Office Machine. Gates shall process the data received from the gate CSC processor and provide the CSC processor with data to be re encoded on the CSC. Data from the processor shall be sent to the SC.

(c) Single journey tickets shall be collected in the exit gates and shall be recycled.

(3) Initialisation Requirement

Tickets shall be formatted, processed and encoded to the same standard as specified in ticket specification.

(4) Coding

Coding format shall be decided in consultation with the Engineer’s Representative.

3.3.13 Ticket Office

(1) General

The ticket office counter in the SCR may be considered as a Point of Sale of tickets and for handling passenger's inquiries.

(2) Functions of Ticket Office

(a) Analyzing and encoding Contactless Smart Cards (CSCs).

(b) Reading, analyzing and encoding Single Journey (SJ) tickets.

(c) Handling replacement of tickets

(d) Handling passenger inquiries

(e) It shall be main point of sale at station for all type of tickets.

(f) It shall handle all passenger queries in respect of reading analysing and encoding of tickets.

(3) Function of Ticket Office

It shall be of the following functions:

(a) Reading, analysing and encoding all ticket types;

(b) Handling replacement, collection of excess fare, refund of tickets; and

(c) Handling passenger inquiries.

(4) It shall include a Ticket Office Machine including Office CSC Processor (OCP) and software, CSC Target and receipt printer.

3.3.14 Cash Circulation and Collection

(1) Cash Collection concerns the system, procedures and equipment employed for the movement of cash and fare media stock in a safe and secure manner between the Ticket Office and Audit/Revenue Room.

(2) The Cash Room will be used primarily as a cash transfer storage room pending cash collection.

3.3.15 Ticket System

(1) System Functionality

The High Speed Rail Ticketing System shall provide functionality similar in format to that provided by a typical low-cost airline booking system. It shall allow passengers to select their travel class, date and time of travel, select their seats, pay for their tickets and print their boarding documents.

The above activities shall be performed:

1. At the station ticket window
2. At the station via an automatic machine
3. At a suitably equipped travel agent
4. On-line via a WWW site (PC or Android / iOS mobile application)
5. By an airline in conjunction with a connecting flight booking
6. Other undefined methods.

A loyalty (Frequent Flyer) program shall be implemented possibly integrated with the Rabbit or other common ticketing card systems to enable HSR tickets to be eligible for loyalty points.

Seating shall be 100% allocated at time of booking, a free-seating area of one car may be configured for use by last-minute passengers. In the event that no seats are available standing tickets may be issued, subject to regulations permitting these on High Speed Rail trains.

Through-ticketing on more than one High Speed Rail service via an interchange station is likely to be required by SRT. Therefore a single central ticket database and consistent media format is needed across all High Speed Rail lines.

(2) Ticket Media Choice

Tickets must be human readable so that passengers can easily find their seats meaning that the media must be disposable. Simple thermal print paper or light card ticket stock is therefore recommended. The use of thermally printed paper ticket media is in line with other High Speed Rail systems around the world.

The Ticketing System shall be an on-line system with all ticket and passenger data held on a central database.

Tickets shall be issued on standard thermal printable stock (either airline boarding-pass or credit card size) using encrypted 2-D (QR) bar codes to store relevant data. The passenger, date and time of travel, train car and seat allocation shall also be printed in human-readable form.

Seats shall be allocated on a trip-by-trip basis therefore a separate ticket shall be issued for each journey.

Self-print tickets are an option along with MMS and NFC electronic systems (although many existing High Speed Rail systems do not issue self-print cards for security reasons)

Because reserved seating is implemented only single ride and return journey tickets shall be issued. Stored value functionality shall be provided by Rabbit or other common ticket and payment cards being used a payment vehicle at a Passenger Operated Machine or ticket window.

(3) System Architecture

The High Speed Rail Ticketing System shall consist of the following major components and associated sub-systems:

1. Central Computer System

   a) Timetable and Train Configuration Management (data imported from Traffic Management system)

   b) Booking and Reservation System

   c) Payment Management System

   d) Fare Management System

e) Transaction Database System

f) Reporting System

2. Maintenance Management System

3. Station Computer System

a) Station Management and Control

b) Local financial management / cash accounting

4. Station Level Equipment

a) Ticket Office Equipment

b) Passenger Operated Machines

c) Platform Access Control Equipment (manual or automatic gates

(4) Central Computer System

- Timetable and Train Configuration Management

  Holds and distributes data on train departures, routing and train configuration for each journey (integrated with traffic management system).

- Booking and Reservation System

  The booking and reservation process is similar whether the passenger is using the internet, ticket window or passenger operated machine.

  Web bookings and payments shall be via a separate secure server and payment gateway, the process is however, identical.

  The Booking and Reservation System performs the following functions:

  1) Select origin / destination

  2) Select travel date

  3) Insert any promotion code / voucher details

  4) Show train availability (from Timetable and Train Configuration Management)

  5) Select train

  6) Select seat(s)

  7) Insert passenger details (level of detail to be defined).

  8) Specify any special requirements, meal choice, disabled facilities etc.

- Payment Management System

Payment may be made by credit/debit card online or at the station, cash or prepaid card at the station, via bank ATM, via internet banking or at a local convenience store.

- Select payment method
- Pay
- Collect/print ticket. Collection is available at stations from passenger operated machine or ticket window, postal delivery is possible (if timing allows).

- Fare Management System
  - Defines the fares for each journey.
  - Discounts based upon date/time or Frequent Flyer status are possible.
- Reporting System

  Creates management reports for traffic planning and financial reporting.

(5) Maintenance Management System

Monitors the system and collates fault reports from stations, dispatches technicians, maintains spares database and produces maintenance reports

(6) Station Computer System

Monitors and controls the station equipment, distributes configuration data to equipment and provides store and forward functionality for transaction data.

(7) Station Level Equipment

- Ticket Office Machine
  - Issues tickets to passengers via a ticket window.
  - Passenger can select date / time of travel and choose his seat(s).
  - Payment by coins / notes, credit / debit card, Stored Value card, voucher or other means.
  - Prints tickets for passengers who have booked via remote means.
  - The TOM can also make database enquiries and replace lost tickets (provided the passenger has suitable ID and proof of purchase).
- Ticket Vending Machines (TVM)
  - Issues tickets to passengers via an automated system.
  - Passenger can select date / time of travel and choose his seat(s).
  - Payment by coins / notes, credit / debit card, Stored Value card.

- Prints tickets for passengers who have booked via remote means.

(8) Platform Access Control Equipment (Ticket Checking Terminal)

The train frequency and passenger loading of High Speed Rail often does not warrant the use of fully automatic mass-transit style ticketing gates. In this case manned barriers with ticket checking terminals shall be implemented as part of the station security screening process.

In the event that passenger numbers are viable the use of mass-transit style gates is possible without re-design of higher system levels. Mixing of manual and automatic platform access systems on the system or on stations is possible without issue.

Mixing of manual and automatic platform access systems on the system or on stations is possible without issue.

(9) Check-in Process (Manual)

- Passengers proceed to platform access point, access point has a manual control gate and ticket scanner / display for staff use.
- To access the platform passengers present ticket along with ID
- Staff scan the ticket, checks validity and compare ID with stored da
- Passenger proceeds to security and baggage scanning
- Passenger accesses platform and train.

(10) Check-in Process (Automatic)

- Passengers proceed to platform access point, access point has an automatic control gate and ticket scanner.
- To access the platform passengers present ticket to the reader
- Reader scans the ticket and checks validity, if ticket is valid platform access is permitted.
- Passenger accesses platform and train.

(11) Check-out Process

Passengers leave the station via automatic one-way barriers, no ticket reading is performed.

Inspectors may be stationed at these gates to perform random passenger checks.

(12) During Travel

Ticket inspectors may examine all tickets after the first and subsequent stops to ensure passengers are not over-riding. Since tickets are human readable portable inspection machines are not necessary, although these may be provided in order to issue penalties or on-board tickets.

(13) Other Types Of Ticket

(a) The system shall also provide, or be capable of processing, the following types of ticket:

(i) Single journey Ticket;

(ii) Tourist Ticket;

(iii) Staff/Employee Pass

(iv) Test Ticket; and

(v) Stored value CSC.

(b) The validity of each ticket shall be parameterized so that it is possible to invalidate any ticket type. All tickets shall be initialized with the ticket type code and a unique serial number.

(i) Single Journey Ticket (SJT = CST)

A SJT (CST) shall be valid for travel only on the day of issue and good for one journey. Should a journey time require transition past 24:00 hours, the following day, the validity of the SJT shall be automatically extended. On exit, the remaining value shall be encoded to zero value and the ticket is captured. (anti passback and station of entry shall be encoded into the ticket during entry)

(ii) Tourist Ticket (TST)

This ticket shall be encoded with a pre-determined value and valid for use for a period of time as parameterized by CC.

(iii) Staff I Employee Pass (EP)

This pass shall be valid for an unlimited number of journeys on any operational day. The pass shall be good for use in any manner of entry or exit and the entry/exit code shall not be checked for correct sequence. The EP shall also not be subject to the Time-in-System check as required. The System shall, however, keep all records of such usage for scrutiny, if required. This pass shall also be used as an identity card.

(iv) Test Ticket (TT)

This ticket shall be used to test the functionality of all AFC equipment for maintenance purposes only. Test tickets shall be usable only when the equipment is in maintenance mode.

(v) Stored Value (SV)

There shall be provision of not less than sixteen (16) SV fares types. Each SV type shall be allocated a set of fares and shall be capable of change by means of downloaded parameters.

The value of a journey shall be subtracted from the value stored in the CSC ticket during processing at the exit gate. The passenger information display in each gate shall indicate the remaining value of the CSC tickets at the start and the completion of each journey.

CSC shall have an expiry date determined by an operating parameter. Passenger shall retain the CSC at the end of the expiry period. Sufficient security shall be provided to prevent an increase in the remaining value of the ticket except at machines having revaluation function.

Since the initialization machine will encode ticket with security ID, this information shall pass to the central system. It is because the central system will need to know whether any unauthorized or duplicated ticket with same ID is being used in the system. Therefore, the initialization machine shall have a communication link or through diskette to pass this intonation back to the CC. In addition, the initialization machines are also need to communicate among each other or controlled by a master computer to avoid encode duplicated ID.

(14) Ticket Specification

(a) CSC

The ticket should have built-in anti collision algorithm. Should automatically disable if attacked by voltage, current, and UV exposure. Should ensure transaction integrity.

(i)	Operation Frequency	13.56 MHz;
(ii)	Transmission speed:	>100kbps;
(iii)	External Dimensions:	Credit card size;
(iv)	models:	A. ISO 14443 Type A or B already proven; B. Type C or cards having similar capabilities (e.g. Security, multi-operatorapplication, data transfer rate, memory, speed, etc.) for Metro applications and having proven technologies;
(v)	Security:	Single/Triple DES;

(vi) File access mode: Random access file, cyclic access file, purse access file.

(vii) Memory: EEPROM 1,536 BYTES (16 BYTES X 96 BLOCKS).

(b) Reader Specification

(i) Operating magnetic field strength H: 0.4A/m,H,7.5 Alm;

(ii) Operating Frequency: 13.56MHz;

(iii) Power supply: 12VDC;

(iv) Communication input/output: RS 485 or RS 232; and

(v) Compatibility: Type A, B, C or other suitable types_ as approved

(c) Encoded Data

Data on the tickets shall include but not limited to:

(i) Railway code;

(ii) Type of ticket;

(iii) Serial number;

(iv) Validity;

(v) Issuing station;

(vi) Current Value;

(vii) Recycling number;

(viii) Data and time of issue; and

(ix) Station of last use.

(d) Contactless Token

(i) Should automatically disable if subjected to voltage, current, and UV exposure.

(ii) Should ensure transaction integrity.

Compatibility: Type A, B, C or other suitable types as approved by the Engineer's Representative

Operating Frequency: 13.56MHz;

External Dimensions: to be finalised with Engineer's

Representative during the engineering phase;

3.3.16 Trouble Shooting

The Private Party shall supply all necessary tools and test equipment including six sets of technical descriptions to allow full functional tests of the AFC equipment for trouble shooting and performance tests.

3.4 Security

Security shall cover physical protection of equipment, protection of revenue, protection of SRT operating personnel and security of cash through audit trails and security of data.

(1) Revenue Protection

(a) The AFC machines shall resist tampering by either passengers or unauthorized staff of the SRT;

(b) Valid identification shall be required before opening any machine containing cash;

(c) All machines shall have locked enclosures to satisfy the overall security requirement; and

(d) All fare media shall be protected from being tampered with during the period that they are being processed within a machine. It shall be impossible to substitute a ticket or card and validate it once a transaction has been initiated.

(2) Revenue Security

(a) The AFC machines and system shall provide a complete audit trail of all transactions, transfers of cash and other payments.

(b) Non-resettable transaction and audit registers shall be provided in gates and TOMs, to record essential information sent to the SC. These registers shall be easily visible and shall be readable when the machine is switched off or on. Each gate and TOM shall have at least 10 spare registers over and above those required.

(c) Cash handling equipment and systems will be an integral part of the audit trail. The engineering of the system shall be accurately and reliably recorded and stored to ensure production of reliable reports.

(3) Data Security

(a) In the event the SC fails, each item of equipment will be able to operate autonomously without loss of data. When the SC becomes operational after a failure, it shall automatically be updated with outstanding data from the AFC equipment.

(b) Security of communications between the AFC equipment, SC and CC system shall ensure no loss of data in transmission

(4) Keys

The Private Party shall provide one set of keys for every ten pieces of equipment similarly keyed (it shall depend both the number of equipment and number of station e.g. two minimum set per station etc.). Similar equipment shall be keyed similarly. The keying arrangement shall be with the approval of the SRT.

3.5 Alternative-Magnetic Recyclable Single Journey Tickets

3.5.1 General

This section covers the Specification of additional equipment required for the AFC system based on contactless and magnetic recyclable tickets. Some of the equipment mentioned in base tender may be common to both systems.

The AFC system shall be based on smart cards to be used as stored value tickets for multiple journey and magnetic recyclable tickets for single journey. The system shall consist of the following components:

(1) Encoder/Sorter (EIS)

(2) Analyzer I Dispenser, AID, (combined for CSC and magnetic tickets)

(3) Gates equipped with CSC card reader and ticket transport mechanism for magnetic ticket (combined for CSC and magnetic tickets)

(4) Ticket Reader, TR, (combined for CSC and tickets)

(5) Credit card size PET type magnetic recyclable ticket

3.5.2 Encoder Sorter

(1) General

The Encoder Sorter (EIS) shall sort mixed tickets into several main categories such as:

(a) Adult (full);

(b) Concessionary fares ticket;

(c) Special ticket; and

(d) Unusable ticket.

(2) Functional Description

(a) Tickets shall be tipped into a hopper and fed from the hopper to the sorting mechanism. The sorting mechanism shall read the ticket code, assess the suitability of the magnetic material for further use, and divert the ticket into the appropriate magazine.

(b) There shall be four categories: full fare, concessionary fare, special ticket category, and unusable tickets (tickets to be withdrawn from the system). They shall be stacked into magazines for dispatching to stations.

(c) The Encoder Sorter shall read the magnetic coding on all tickets, be capable of re-encoding data for dispensing from A/Os. This data shall be verified as a check on the quality of the tickets magnetic material. Below a certain quality threshold the ticket shall be withdrawn from further use.

(3) Throughput Capacity and its Installation

The EIS shall be capable of sorting at a rate of 2.5 tickets per second at continuous issuing. It shall be installed at the OCC. Two Encoder I Sorter shall be required.

(4) EIS Construction

The methods of construction and material proposed shall be strong, durable and approved by the Engineer's Representative.

(5) Specifications

(a) Operation unit

(i) Hardware:	IBM PC or equivalent;
(ii) External I/F:	10 Base Track;
(iii) Printer unit:	Laser printer for A4 size· cut paper; and
(iv) Display:	15 inch CRT;

(b) Ticket processing unit

(i) Ticket magazine Capacity:	1,100 tickets/magazine Total 2 magazines
(ii) Encode portion:	
Write Track:	Private Party to engineering.
Encoding method:	FM (75BPI) Read after write function is provided
(iii) Ticket magazine (for sorted ticket stacking) :	
Capacity:	1,100 tickets/magazine. Total 8 magazines (Sorted to max. 8 kinds of tickets at one time.)
(iv) Ticket processing speed:	Approx. 2 ticket/second (At continuously issuing)
(v) Abnormal ticket:	Tickets miss-encoded or inferior encoding characteristics are collected into a collection box.

(c) Cabinet

(i) Structure	Free standing
(ii) Measure against	An audible alarm is provided, if someone tries to gain unauthorized

access.

(d) Others

(i) Memories — Shall be backed up by batteries so as to keep the data at power failure.

(ii) Noise — 75 dBA or less.

3.5.3 Analyzer Dispenser (A/D - TOM)

(1) The A/D shall

(a) Read all specified magnetic and CSC tickets.

(b) Read and encode tickets for excess fare or replacement procedures.

(2) The A/D shall interface with the TOA terminal computer, which shall be connected to the AFC LAN. The A/D shall be able to communicate with the SC for reconciliation of excess fares and ticket sales.

(3) The A/D shall be used for manual issue of CSC tickets and single journey magnetic recyclable tickets.

(4) The A/D shall read data encoded on a ticket, check that data against a set of parameters, determine the validity of the ticket, enable the display of selected data on the PIO and encode a ticket such that it may be used to proceed through the system.

(5) Data for encoding a new ticket or a replacement shall be selected from the TOA terminal through the keyboard.

(6) The A/D may utilize motorized reader/writer.

(7) The method of construction and material proposed shall be strong and durable.

(8) It is preferred to have the A/D merged together with the OCP as one equipment.

3.5.4 Gates

(1) General

Gates shall have features of contactless smart cards (CSC). In addition, it shall have magnetic transport mechanism to handle magnetic tickets and CST.

(2) Magnetic Ticket Transport

(a) The magnetic ticket transport shall be mounted in the gate frame in such a way that it is easily accessible for daily maintenance procedures, including cleaning and clearing ticket jams. It shall be easily removed without the need for special tools (preferably without the need for any tools) for second line maintenance.

(b) The ticket transport shall process magnetic tickets to the latest specification of the SRT.

(c) The ticket transport shall incorporate an entry throat blocker to prevent entry of an incorrectly orientated ticket and to reduce the ingress of dust or foreign object when the blocker is closed.

(d) The ticket transport shall read, write and verify the coding according to the standard data encoding. When a verify fails, the ticket transport shall re-write and verify the ticket once more.

(e) There shall be a diverter to divert captured tickets into a collection bin magazines.

(f) The ticket transport shall complete processing of the ticket from ticket entry slot to ticket exit slot in 300 ms or less, timed from release of ticket into transport to release of barrier.

(g) There shall be a minimum of moving parts in the engineering of the transport.

(h) The magnetic head shall be able to read or write at least 3 million transactions before replacement.

(i) The ticket entry slot shall be distinctive and easily noticed by approaching passengers, since not all gates will have a transport it shall serve assist in directing passengers to the correct gate

(j) The gate software shall be capable to have at least two consecutive validation of ticket card entry / exit movement.

(k) Single Journey Tickets will be collected at exit gates. No sorting will be done at the gate.

3.5.5 Ticket Decoder and Ticket Reader (CSC/MA)

(1) General

(a) There shall be facilities to analyse and inspect, but not issue CSC, CST or magnetic tickets in the paid areas of Don Mueang, Bangsue, Makasan, SA Airport, Pattaya and U-Tapao.

(b) Data from magnetic tickets shall be decoded and displayed in English and Thai. The data displayed shall enable ticket inspection to determine the validity of a ticket.

(c) Ticket readers shall be provided in station premises to be used by passengers to find remaining value on tickets.

(2) CSC/MA Features

(a) The CSC/MA shall be a self-contained device incorporating a CSC, CST or magnetic card reader (swipe reader).

(b) There shall be an intelligent display capable of displaying in English and Thai and a keypad for selecting the decoded data to be displayed.

(c) The display, two rows of 24 characters, shall be easily visible in the ambient tight conditions on the stations and on the trains.

(d) The CSC/MA shall store data on tickets and CSCs internally; this data shall be downloaded to a PC.

(e) The stored data shall be downloaded to the SC via a RS232 interface. The SC shall format an activity report for the PMA.

3.5.6 Single Journey Tickets Magnetic Type

(1) General

(a) The format of ticket & coding shall be decided in consultation with Engineer's Representative.

(b) Tickets will be recyclable PET types.

(c) A representative sample of tickets in daily circulation shall be proposed for the Engineer's Representative approval during the engineering phase.

The Private Party shall print advertisement on tickets as decided by the SRT.

(2) Ticket Distribution and Coding

Recyclable tickets will be distributed to the stations where they will be stacked into magazines for issue from ND.

(a) Environment

Environment shall be as specified in SRT's Requirements.

(b) Ticket Orientation Hole

The ticket will have an orientation hole positioned according to the ticket specification. This hole shall be recognized by the machines that process the ticket.

(c) Ticket Specifications (Magnetic Recyclable)

(i) Dimensions: Credit Card Size;

(ii) Material: PET;

(iii) Magnetic track: Private Party to engineering;

(iv) Encoding density: 75BPI;

(v) Corecivity: 2,750 Oe; and

(vi) Life: More than 500 passes.

(d) Encoded magnetic Data

Magnetic data on the tickets shall include but not limited to:

(i) Type of ticket;

(ii) Serial number;

(iii) Validity;

(iv) Issuing station;

(v) Current value;

(vi) Recycling number;

(vii) Data and time of issue; and

(viii) Station of last use.

(3) Magnetic data location

The location of magnetic data is divided into two areas:

(a) The above (d)(i)-(iii) are encoded as fixed data and (d)(iv)-(viii) as variable data.

(b) Fixed data will be encoded only by the encoded/sorter (ES) and is not· subject to change by other AFC terminals. The variable data is subject to change by the AFC terminals with each use.

(4) Encoding sequence

(a) Initialization of tickets

Both fixed track data and variable data are encoded for initialization by EIS. The encoded data are verified so that miss-encoded tickets are rejected and correctly encoded tickets are stored into a magazine which can contain up to maximum 1,100 new tickets. The initialized tickets shall have no value encoded.

(b) Re-encoding of the recycled tickets.

Recycled tickets are read by ES and shall reject these tickets when recycled time exceeds a predetermined number of recycling times, (say 500). The serviceable tickets shall be stored into magazines. The tickets have no value encoded and so invalid as a ticket.

(c) Tickets issued by AID

The ticket value will be encoded on the variable data to make the ticket valid.

(d) Entry/Exit through AG

Encoded data are read for the validity check at entry or exit. Variable track data such as "station of last use", "remaining value" and "recycling number" on the valid tickets will be updated. Single journey token/tickets with no remaining value will be captured by exit AG. CSC are valid regardless to their recycling numbers until the last journey when the value become zero.

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SECTION 7 – DEPOT WORKSHOP SYSTEMS

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SECTION 7

DEPOT WORKSHOP SYSTEMS

1 INTERPRETATION

1.1 Definitions

In this Contract, unless the context otherwise requires:

Abbreviation	Description
CNC	means Computer Numerical Control
DWE	means Depot Workshop Equipment
OCS	means Overhead Catenary System
PPTA	means PPP of 3 Airports Seamless Connection by High Speed Rail (Don Mueang – Suvarnabhumi – U-Tapao Airports)
PPTA CITY LINE	means CITY LINE System of 3 Airports Seamless Connection by High Speed Rail
PPTA HSR	means High Speed Railway System of 3 Airports Seamless Connection by High Speed Rail
RST	means Rolling Stock

2 GENERAL REQUIREMENTS

2.1 General

2.1.1 This document mainly provides general requirement for Depot Workshop of PPTA HSR at Chachoengsao, which shall be newly constructed. For PPTA CITY LINE, the existing ARL Depot Workshop at Klong Tan shall be further used.

2.1.2 This requirement is applied to design, selection, manufacturing, fabrication, factory acceptance test, supply, delivery, site acceptance test, and training for depot & workshop equipment. The Private Party is responsible to maintain all activities on these requirements.

a) The Private Party shall provide following information for the Engineer's Representative's approval;

b) Full details with specification and technical data of equipment and associated components;

c) Outline of maintenance philosophy;

d) Detail depot arrangement with dimensions indicating each shop dimensions;

e) Detail workshop arrangement with dimensions indicating work area space dimensions.

2.1.3 The Private Party is responsible to apply all following requirements to depot workshop equipment and components what are concerned with. The Private Party shall provide full details of technical comparison for reviewed and approved by the Engineer's Representative where it is not applicable or cannot be applied. Any deletion or alternative of equipment specified in this requirement without official approval will not be accepted.

2.2 Completeness of Maintenance Work

2.2.1 Equipment specified in this requirement are identified as minimum. The Private Party shall be responsible to provide all necessary equipment for complete maintenance work what will be furnished in depot and in the PPTA HSR-CITY LINE System.

2.3 Maintenance Philosophy

2.3.1 Full maintenance procedure shall be provided by the Private Party for review and approval by the Engineer's Representative.

2.3.2 Maintenance philosophy shall include full process and details of maintenance work with man-power schedule, work time table, organization and related information for review and approval by the Engineer's Representative.

2.3.3 Maintenance philosophy shall identify applicable standards and/or regulations and provide technical demonstration how it shall be applied.

2.3.4 All equipment offered by Private Party shall be consistent with the requirements of applicable standards and/or regulations and maintenance philosophy.

2.4 Safety Consideration

2.4.1 Design of all equipment and associated components shall be taken full safe operation into consideration.

2.4.2 All safety measurements shall be identified and full procedure of safety work shall be provided for review and approval by the Engineer's Representative.

2.4.3 Any equipment and associated components shall not be delivered without the Engineer's Representative's approval of those provisions.

2.5 Utility Services

2.5.1 Utility supply services for maintenance equipment shall be identified and provided full details for review and approval by the Engineer's Representative.

2.5.2 Electrical power supply shall be consistent with power distribution system and the capacities required for equipment shall be incorporated into the design of power distribution system.

2.5.3 Rating of electric power supply shall be same as what is utilized in district/area located workshop. Special rating of power supply source where applicable shall be subject for the Engineer's Representative's approval.

2.6 Interface Completeness

2.6.1 Report on interface activity shall be provided for review and approval by the Engineer's Representative, and filed for future review.

2.6.2 Interface activity shall be incorporated into detail design of maintenance equipment and associated component.

2.6.3 Design review and approval will be given under full design information and full interface completeness.

2.7 Design Approval

2.7.1 All design shall be subject for review and approval by the Engineer's Representative. Full details of design shall be provided by Private Party for review and approval by the Engineer's Representative.

2.7.2 Insufficient design information will be rejected and shall be submitted with additional details again. The Engineer's Representative will have no responsibility for any delay against such repeated design submission.

Witness Inspection

2.8.1 Two inspections shall be applied for all equipment required.

2.8.2 First inspection shall be completed as "factory acceptance inspection". This inspection shall be made after manufacturing/assembling at factory.

2.8.3 Equipment and/or associated component shall be delivered to the site only after acceptance of inspection, with sufficient packaging.

2.8.4 Second inspection shall be completed as "site acceptance inspection". This inspection shall be made after site installation work.

2.8.5 Equipment and/or associated component shall be handed over to the SRT after the expiration of the Contract.

2.8.6 The Engineer's Representative's approval of inspection procedure identified method, criteria, item, location, etc., shall be obtained before inspection. Any inspection without approval will not be accepted.

2.8.7 All inspection reports shall have photograph what date and time shall be clearly indicated and shall be submitted and filed for future review.

2.9 Test Piece

2.9.1 Test piece shall be provided for inspections. Test piece shall be suitable for performance and functional check of equipment.

2.9.2 Details of test piece shall be identified in the inspection procedure what shall be subject for the Engineer's Representative's approval.

2.10 Quantity

2.10.1 Quantity indicated in this requirement is just identical. The Private Party shall be responsible to identify necessary quantity for complete maintenance work.

2.10.2 However, the Engineer's Representative will not be responsible for any lack of identification and/or quantity specified by Private Party.

3 REQUIREMENT FOR EQUIPMENT

3.1 Provision of Equipment's Information

3.1.1 The Private Party shall provide full details of the maintenance equipment necessary for maintenance work.

3.1.2 The Private Party shall be responsible to provide full details to suit effective and suitable maintenance work. The Engineer's Representative will not be responsible for any lack of information in this requirement. The Private Party shall complete necessary equipment with associated components for full maintenance service.

REQUIREMENT FOR MAINTENANCE

4.1 Provision of Equipment for Maintenance Levels

4.1.1 The Private Party shall supply full equipment to meet the requirements for maintenance of the PPTA HSR-CITY LINE System, which includes but not limited to:

a) Level 1 Maintenance: Cleaning, Inspections, and Replacement of Consumables

b) Level 2 Maintenance: Routine Preventative Maintenance

c) Level 3 Maintenance: Complex Preventative and Corrective Maintenance

d) Level 4 Maintenance: Overhauls

e) Level 5 Maintenance: System Enhancements and Renewals

5 DESIGN OF DEPOT WORKSHOP EQUIPMENT

5.1 Design Basic

5.1.1 This Design has been prepared to be able to accommodate the final fleet size. At the time of writing this report the ultimate fleet size is expected to be 27 trains of 8 cars.

5.1.2 The Design of the PPTA HSR Depot and Workshop Equipment is based on basic information following:

- Number of RST : 216 cars
- Configuration : 8 cars (extendable to 10 cars)
- Dimensions : Upon Design / Compatible with exist. ARL
- Max. Axle Load : 16t
- Track Gauge : 1,435 mm
- Power Supply : 25Kv ac 50Hz via Overhead Catenary

5.2 Number of Workshop, Inspection and Cleaning Tracks Required

5.2.1 Based on Design of Depot and Main Workshop and general demand for maintenance tasks, the number of maintenance tracks has been defined as follows:

- Cleaning Track : 2 Tracks
- Wheel Re-profiling Track : 1 Track
- Inspection Track : 2 Tracks
- Final Inspection Track : 1 Track
- Unscheduled Repair Track : 1 Track
- Train Lifting / Bogie Removal Track : 1 Track
- Bogie Moving Track : 1 Track
- Overhaul Track : 2 Tracks

5.3 Operation testing track

5.3.1 A minimum length of 1.5 Km test track is provided for testing train function and operation after being repaired such as overhaul, semi-overhaul, and replacement of essential components to ensure the train functional before being returned to the mainline. It also can be used for interface and integrated between on-board and line-side system such as Signaling, Telecommunication system, and etc.

This track should be equipped with:

a) OCS disconnection switch to enable ease of power supply isolation

b) Flank protection to prevent the train run into stabling track unexpectedly

c) Simulated stations to check signalling and associated train operations.

Testing activities which require full speed train running will need to be conducted on the mainline.

The test track could be extended to be longer than 1.5 Km, this depend on the design and location of transition track between main line and depot.

5.4 Stabling Tracks

5.4.1 Sufficient Stabling tracks shall be provided. They shall be designed to give access from either side of the depot direct from the main line access tracks or from any part of the facility via shunting movements. The distance between track center is 5.4 meters allow for both wide and narrow body type.

5.4.2 In case the stabling track will be constructed as phasing when fleet size grows, it is recommended that the turnouts should be installed at the initial phase. This is to minimize the interruption to the operation railway during construction of additional stabling track.

5.5 Cleaning Track

5.5.1 Two (2) cleaning tracks which can stable two (2) trains are provided next to the stabling track for train exterior and interior cleaning activities. The raised platform at car floor level is provided between these tracks to facilitate cleaning staff in their work. Access to trains must be properly designed so that cleaning staff can reach work site safely whilst carrying their equipment.

5.5.2 Two cleaning categories are carried out at this track. The first one is a daily train interior cleaning and disposing of passenger rubbish after revenue service and another is periodical extensive cleaning of interior and also exterior of the car-body.

5.5.3 The following facilities will be provided:

a) Overhead catenary system with local disconnecting switches,

b) The OCS power shall also be able to remotely isolated from OCC/Depot Controller

c) Manual cleaning tools including vacuum cleaner, etc.

d) Water Refilling Facilities

e) Waste Disposal Facilities

f) Electric power Outlet

g) Drainage device,

5.6 Train Washing Track (Draw-out / Approach)

5.6.1 An automatic train washing plant shall be installed complete with water treatment plant and operations room (or area) on the exit/entry track of the depot. The proper drainage facilities shall be designed. Trains can be cleaned either upon arrival and entry to the Depot facility or prior to returning into operational service. The train wash plant can be positioned on either side of the Depot facility utilizing approach tracks to provide the most effective and direct access to stabling and cleaning tracks or workshop. The exact location could be determined and agreed between operations group throughout design stage until construction stage. The Washing Plant requires straight track section for at least one car's length. This is to ensure that the car goes into the wash straight. The water recycle shall be taken into consideration of Train Wash Plant design.

5.6.2 For normal washing, the train washing plant will permit effective cleaning of vehicles automatically by one single wash procedure.

5.6.3 The train washing plant equipment should consist of the following main components:

h) Brush stations

i) Pre-wet station

j) Front, side, rear roof brushes cleaning brush station with solution mixing equipment

k) Rinsing station

l) Plant initiation switches, traffic lights and other electronic controls

m) Set chemical and water supply

n) Control panel

o) Storage tanks

p) Neutralizing plant station and water recycling

5.7 Automatic Drive through Wheel Diagnostic System (Optional)

5.7.1 As an option, depend upon agreement between the SRT and the Private Party during Tendering phase, an Automatic Drive Through Wheel Diagnostic System shall be considered. This system is used for Wheel inspection for crack and damage without disassembly of the wheel set.

5.7.2 It is noted that the Engineer's Representative does not recommend this equipment considering fleet size and other facilities that has been provided, functions are duplicated. This equipment is suit to big fleet size that inspection time is critical.

5.8 Wheel Re-profiling Track

5.8.1 On the basis that surface of wheels will require re-profiling, which strongly depends on the operating conditions of the vehicles, the surface of the wheels and the wheel flange are abraded. A dedicated facility is provided. This facility is independently situated at one side of the main workshop and can be accessed either end as a drive through from the main line approach or via shunting maneuver from stabling tracks. The shop designed for the re-profiling of worn wheel tread with bogie and wheel set still attached to trains on a drive through basis. The re-profiling facility will comprise of an under floor wheel lathe complete with swarf (metal chips) removal system and train traversing system all installed within the floor so as not to impede movement of trains.

5.8.2 The under floor wheel lathe is suitable for:

a) Profile machining and machining of the inner faces of the wheels

b) Turning of the treads up to the flange top and the flange rear face

c) Unilateral re-profiling of one wheel set.

5.8.3 The machine is operated via a central control panel allow operator to have continuous access to all machine functions. During machining, the operator will be protected against flying chips.

5.8.4 The base machine is a standard unit, which is Computer Numerical Control or CNC controlled and designed to lift, measure and machine a wheel set together with its customer-specific supplementary modules.

5.8.5 The wheel on a bogie or wheels on a single vehicle must be re-profiled within limits compared with each other. This will be specified by rolling stock specification.

5.9 Main Workshop

The Main workshop is approximate size of 290 meters long and 190 meters wide. It is designed to accommodate inspections, overhaul and repairs of 8 cars train set. However, the length of Main workshop is long enough to allow for 10 cars train consists. The workshop comprises;

5.9.1 Inspection Tracks

The inspection work can be categorised into Daily and Monthly inspection. Daily inspection, major inspection is a visual inspection of bogies, under floor equipment, interior equipment and on-roof equipment, and train function check on the monitoring device and on-board diagnostic equipment in the cab. Monthly inspection, more detail inspection is carried out in addition to the daily inspection such as wear measurement, replacement of consumable parts, emergency direct braking performance check, failure log recording, etc. The train enters in the shop by self-propulsion. The OCS with hinge (allow OCS line to be folded over when needed) shall be provided at these tracks.

Two (2) tracks dedicated to monthly and daily inspection of 8 car trains. The inspection tracks will be designed with swimming pool type inspection pit where the floor is sunk and the tracks are mounted on posts and having elevated platform included in the design for roof top inspections. This type of pit allows easy access to the side and below of the train. It also improves the light level under the car. The design shall be taken into consideration the ergonomic work space. The access to roof top inspection platform shall be interlocked with OCS system to prevent electric shock hazard. Any person working on the roof will have a personal access key for the lock to ensure the current remains off until the work is complete and it is safe for it to be restored. The access stairs to the roof level walkway will also have a locked gate which can only be unlocked if current is off.

5.9.2 Final Inspection Track

A single track dedicated to train inspection following completion of overhaul or semi-overhaul and train testing after being repaired. Dual height inspection pit and elevated platform will be included in design of this facility. This track is equipped with Wheel Load Measuring System. It measures axle load of each wheel of one car (8 wheels/car) at the same time to confirm that wheel load distribution and deviation required by Rolling Stock maintenance manual are to be within acceptable range.

5.9.3 Unscheduled Repair Track

To restore unexpected failure of the train, unscheduled repair facilities enabling repair work without interfere to the scheduled maintenance work is provided. A single bay track sufficient for splitting and lifting 8 cars train to enable repair/replacement of under-slung equipment via mobile lifting jacks and body stands. The track will be of pitted road design to enable release of bogies prior to lifting. Sufficient side access is required to allow positioning of side/roof access platforms.

Vehicle can be lifted either individually or whole train set. Thank to synchronised jacks, where jacks are linked by control cables and controlled by one person from a control desk. The big advantage of this system is that the train does not have to be uncoupled into individual cars to do the work on one vehicle. This will eventually reduce dwell time.

5.9.4 Train Lifting/Bogie Removal Track

A single bay track equipped with under floor lifting system sufficient to lift 8 cars train for removal and replacement of bogies (semi-overhaul). The under floor lifting system could be extended to allow for 10 cars train consist if required. Train set can be lifted on a track where there is no pit, especially if the under-bogie equipment needs to be exchanged. A fork lift truck and/or under-bogie equipment unloader can be used to facilitate the equipment swap over. Adjacent to the lifting track will be a bogie moving track linked to the lifting track via sets of bogie turntables to allow transition of bogies to and from the Bogie/Wheel set Shop and positioning cars for overhaul works.

5.9.5 Overhaul Tracks

A double bay equipped with dual tracks sufficient to house four - five individual train cars per track, providing sufficient space at sides and ends to undertake complete overhaul of cars without impeding other works. Approximate area 150 meters long by 26 meters wide. The overhauling bay shall be equipped with either or both mobile lifting jacks and synchronised overhead cranes spanning the full width of the bay (both tracks) for lifting train cars from bogies and placing on body stands. The rail from both overhaul tracks is extended connect to Bogie/Wheel set shop allow traverse of bogies to and from the Bogie/Wheel set shop.

There is sufficient space allow for car-body to be put on the stand beside each track to extend the capacity when workload is increase. In all cases, both lifting jack and in-floor lifting system, it is essential to ensure that the floor will take the weight of the train raised on jacks.

5.9.6 Bogie/Wheel set Shop

A dedicated workshop area of approximate size 120 meters by 68 meters designed to be capable of complete breakdown and repair of all bogie mounted equipment.

This workshop is mainly used for major overhaul and for additional repairs such as defects or accidents. The bogies are detached from train at bogie removal track and overhaul track then transfer to this shop via turntable and transition track. There shall be also is sufficient space for bogies to be stored.

The workshop area will be designed on a flow-line basis and comprise but not limited to:

a) Bogie wash booth

b) Bogie Disassembly

c) Wheel set ultrasonic flaw detector (wheel set rotating type)
Magnetic particle flaw detector

e) Above floor wheel re-profiling machine

f) Wheel fitting press machine

g) Axle lathe

h) Wheel boring machine

i) Bogie frame paint booth

j) Bogie pre-load test equipment

k) Drive unit test machine

l) Bogie frame stand

m) Wheel set/Bogie Turntable

n) Wheel measurement and recording device

o) Bearing Remover/fitting machine

p) Overhead crane

5.9.7 Mechanical and Electric Shop

This is a dedicated workshop area for conducting repairs and maintenance of mechanical and electrical train bourn equipment/components. The overall area will be laid out to provide logistical movement of equipment for the build of trains having areas for the following but not limited to;

a) Electrical/Electronic shops

b) Motor shop

c) Brake shop

d) Air Valve shop

e) Pantograph shop

f) Damper shop

g) Coupler shop

h) Air conditioner/Cooler shop

i) Compressor shop

j) Machine shop

k) Parts shop

l) Cleaning shop
Valve shop

n) Axle-box shop

o) Battery vehicle charging area

p) Material stores.

5.10 Wheel set Storage

5.10.1 Wheel set Storage is a covered area with track facilities for storing refurbished and worn wheel sets. The wheel set storage will be connected to wheel set shop by embedded rail track allow wheel set to be rolled between two areas. The wheel set could also been delivered to/from this area by fork lift truck.

5.11 Permanent Way and OCS Work Shop

5.11.1 The shop is for housing permanent way and maintenance vehicles and equipment to maintain the Trackwork and OCS of the overall system. Adjacent to the shop shall be a loading and storage area for track and sleepers to rail mounted flatbed trailers, OCS equipment, OCS cable, and etc.

5.11.2 It is recommended that the Permanent way and OCS workshop should be combined as many facilities can be shared.

5.12 Carbody Paint Shop

5.12.1 Due to the environmental conditions, or advertising purpose the vehicles may require re-painted. Therefore, dedicated carbody paint shop may be required. The paint shop is equipped with a complete painting and exhaust system. One track, but separated through a partition, is necessary. Currently, only land provision is done. It is defined as future provision and the cost is not included in the cost estimation due to this shop will not be required until 5-10 year time from start of operation or even not required at all if non-painted rolling stock type is used.

5.13 Power Sub-station

5.13.1 The Sub-station is intended for electric power receiving transformer, sub-station for Traction Power, Systems Power distribution and Back-up Power Generator.

5.14 Power Distribution Station

5.14.1 The distribution station is dedicated for control and switching of depot electric power systems.

5.15 Waste Disposal Shop

5.15.1 The waste disposal shop is for processing garbage and waste products generated by the Depot and cleaning facilities for handling by local authority's.

Boiler Room

5.16.1 To provide sufficient boiler capacity to supply steam for component washing machine within the main workshop.

5.17 Compressed Air Room

5.17.1 The shop will house compressed air system to supply clean dry compressed air (usually 10 bar) to the main workshop general use and air brake testing.

5.18 Hazardous Store

5.18.1 Storage facility for explosive or chemical irritant materials used within the maintenance facility and fuel for diesel shunting vehicles.

5.19 Truck Garage

5.19.1 The garage is for maintaining and parking of cargo vehicles and Road Rail vehicles utilised in the operation and maintenance of the railway system.

5.20 Material Store

5.20.1 To implement train maintenance and infrastructure maintenance according to the program, and to restore unscheduled failure quickly, it is essential to store spare parts and consumable parts appropriately and to manage just enough material control with consideration of lead-time.

5.20.2 MMS provides functions of the material management, purchasing management and inventory control. Acceptance of delivered goods is desirable to carry out at the material store in the depot.

5.20.3 The store is the main receiving store for stocking spare parts of HSR electric cars. Spares, materials and consumables, for use in the main workshop shall be distributed to the local material store and controlled within each workshop.

5.21 Fuel Station

5.21.1 For diesel driven rail vehicle, a Fuel Supply Equipment with a fuel tank is provided near the entrance of their workshop. The fuel tank can be either underground or above ground type and located at the convenient position for supplying fuel to the supply equipment and receiving fuel from the tank lorry.

5.22 Depot Workshop Office

5.22.1 A (400 m^2) Workshop Office for those staffs who work in Main Workshop (rolling stock maintenance) is located in the Main Workshop on the mezzanine floor item for worker's convenience and initial cost saving.

MAINTENANCE EQUIPMENT SUPPLY

6.1 Scope

6.1.1 Equipment and tools for system-wide maintenance shall be supplied for all rolling stock and infrastructure maintenance processes. This shall include equipment and tools for train inspection, preventive maintenance, repairs, overhauls, and refurbishment, as well as inspection, preventive maintenance, repair, overhaul and refurbishment of all systems, equipment, and installations on viaducts and in stations buildings and civil structures.

6.1.2 The scope of work shall comprise the engineering, co-ordination, preparation of layout's testing at factory, supply of materials and transportation to site, documentation, installation, commissioning, and training in the use of the maintenance equipment.

6.1.3 Maintenance equipment shall be provided to satisfy the needs for system-wide maintenance for the initial period of service operation until end of the Contract.

6.2 Proven design

6.2.1 All maintenance equipment shall be of proven design, adequate for the PPTA HSR System and suitable for the local environment conditions.

6.3 Documentation

6.3.1 Manuals shall be provided in sufficient detail for the SRT to operate properly and safely, maintain and repair the equipment, including adequate descriptions and guidance on the salient design features. Equipment specifications, parts lists, and number of manuals of major equipment shall be provided.

6.4 Spare and consumables

6.4.1 Spare parts and / or consumables shall be provided by the Private Party in amount as required to ensure that Service Performance Level will meet targets.

6.5 Inspections, testing, commissioning and acceptance

6.5.1 A plan shall be provided indicating inspection, testing, commissioning, and acceptance activities for major equipment, as well as the sequence of events and location of activities. This plan shall outline major features and emphasis of inspection programs, extent of testing and commissioning, factory acceptance tests, and acceptance at site to assure delivery of fully functional equipment on time.

6.6 Training

6.6.1 A training program outline shall be provided describing the methodology for the training of the SRT's and the Private Party's personnel on maintenance equipment.

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SECTION 8 - PLATFORM SCREEN DOOR

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SECTION 8

PLATFORM SCREEN DOOR

1 INTRODUCTION

1.1 General

1.1.1 This Specification describes the performance characteristics of the Platform Screen Doors to be designed, manufactured, delivered, installed, tested and commissioned by the Private Party for the High Speed Project: Don Mueang – Suvarnabhumi – U-Tapao Airports

1.1.2 This Specification shall be read in conjunction with the applicable sections of the Design Criteria and Standards, the Contract, the SRT's Requirements, other performance Specifications for parts of the works which interface with the scope of work defined in this Specification and the applicable sections of the Private Party's Technical Proposal.

1.1.3 In the event of a conflict between the requirements of this Functional Specification and any other Technical Specification (SRT's Requirements, Materials and Workmanship Specification) the most stringent requirements shall prevail.

1.1.4 It must be considered that whilst proven platform screen door systems are available for a wide range of duties those suitable for High Speed Railway applications must be to the highest standards of construction and reliability. They must incorporate special features, which are required for railway operation and its environment.

1.1.5 All equipment and works shall comply with the appropriate International / European standards and have been previously employed by a High Speed Railway and / or railway administration. Equipment in this context shall be taken to include hardware and software.

1.1.6 The Private Party shall state which specifications are complied with and shall explain in detail any conflicts of specifications or any specification requirements that are not complied with.

1.1.7 All drawings, schedules and plans shall be produced to a format agreed with the Engineer's Representative. All symbols, nomenclature and abbreviations shall be fully described on the drawings and shall conform to those currently used by the SRT.

1.1.8 All drawings, wiring diagrams and schedules, plans, etc., shall be supported by clearly presented tables of controls, flow charts and written descriptions explaining the operation of the systems proposed.

2 QUALIFICATIONS OF MANUFACTURER

2.1 Material and Private Partys Commitment

All materials and equipment to be provided for the platform screen door system shall be of proven design and shall be provided by a manufacturer who has accomplished similar platform screen door system projects for a period of at least 10 years unless otherwise approved by the Engineer's Requirements.

The Private Party shall be committed to support the entire Platform Screen Door system for a minimum of 15 years and shall ensure that all manufacturers who supply equipment under this Contract give an equivalent commitment or take such measures as are necessary to safeguard the Private Party's overall commitment.

3 SCOPE OF WORK

3.1 General

3.1.1 The Private Party shall provide a platform screen door (PSD) system for all stations, comprising of modern attractive platform screen doors and associated control equipment. The PSD system shall be constructed to conform to the Specification and other internationally recognised standards and shall be designed for safe efficient operation.

3.1.2 The PSD system shall prevent unauthorised passenger access from the station platforms to the Main Line and shall complement the design of the platform air conditioning system, by sealing off the outside air until a Train is correctly positioned adjacent to the platform.

3.1.3 The PSD system shall comprise a structural frame extending for the full length of the station platform and up to a height of 2.75 m from floor level, where it shall connect to the down stand for the stations. The so-called "half-height" PSDs to be installed at open air stations, shall have a minimum height of 1.50 m from floor level.

Pairs of sliding screen doors (door sets) shall be installed in the structural frame and located opposite each set of train passenger doors. Between each pair of sliding screen doors and also between the end sliding doors and the end of platform screen returns, shall be installed a series of transparent fixed screens. At each end of the platform, in the screen return, an emergency walkway door shall be provided giving access to the emergency walkway. The PSD system shall include all the associated control and operation mechanisms for the safe operation of the platform screen doors.

3.1.4 The Private Party shall be responsible for the design, manufacture and installation, testing and commissioning of the PSD system including all the associated control and interfacing equipment.

3.1.5 The Private Party shall be responsible to deliver the following:

- The formulation and supply of technical documents (drawings, catalogues, operating and maintenance manuals etc.), according to the clauses of the SRT's Requirements, regarding all aspects of the PSD system and the associated interfaces to other systems of the High Speed Project.
- Preliminary operation manuals coordinated with the signalling and Rolling Stock requirements in particular addressing emergency situations, sufficient for staff training and commissioning of the platform screen doors at least 4 months prior to the Trial Run period according to the SRT's Requirements.
- Supply of drawings, design calculations, catalogues and specifications to the Engineer's request for design review according to the SRT's Requirements.
- Consultation with the Engineer's requests and its associated consultants regarding the design and implementation of the PSD system. Examples shall be given of the successful operation of identical PSD systems in a similar operational environment.
- Supply of all materials (equipment, consumables, appliances, tools and special tools) and implementation of training, as far as necessary, for installation and testing according to the SRT's Requirements. This shall also include work or material which may not be specifically mentioned in this specification or shown on the drawings.
- The Private Party shall develop a comprehensive training programme for staff training regarding operation, service and maintenance of the PSD System. The training programme shall be approved by the SRT according to his requirements. After approval the Private Party shall go ahead with the staff training according to his training programme.

3.1.6 The Service Life for the PSD system shall be 30 years with the need for refurbishment running not less than 20 years into this period.

3.2 RAMS

The Private Party shall prepare and submit for the Engineer's Requirements's review and approval a hazard analysis and design safety study report that addresses all possible hazards and proposed mitigation measues arising from the installation of the PSD system in accordance with Standard EN50126 and / or equivalent as approved by the Engineer's Representative.

The Private Party shall prepare for the Engineer's Requirements's review and approval a RAM report giving details of predicted component and system level MTBF and the proposed methods of demonstrating that these MTBF have been achieved on completion.

4 DESIGN REQUIREMENTS

4.1 General

4.1.1 At each station platform face, the Private Party shall provide a sufficient number of door sets, each comprising a pair of sliding screen doors, equally spaced to correspond to the doors of the Vehicle consist. The Private Party shall provide sufficient drive mechanisms and controls to support the initial 1 Vehicle consist that shall be used at the commencement of revenue operation. The PSD system shall allow for the future installation of drive mechanisms and controls by the SRT on the remaining door sets, without the requirement for modifications to the installed PSD equipment.

4.1.2 With the exception of the terminal stations the PSD system shall be initially designed to accommodate the Vehicle consist, stopping symmetrically about the mid-point of the station platform. At terminal stations, the PSD system shall be designed to accommodate the Vehicle consist stopping on the first half of the platform. The PSD system shall be designed to ultimately accommodate the Vehicle consist stopping at all platform headwalls. The PSD system shall allow operation of Trains in either direction at any platform.

4.1.3 A set of local controls and indications for the operation of the PSD system, by the train drivers, shall be housed at suitable locations on the platform and with protection for operation by authorised staff only.

4.1.4 Each door set shall consist of bi-parting power operated sliding screen doors. The sliding screen doors shall be synchronously controlled throughout the length of the platform. The sliding screen doors shall provide a clear opening width of not less than 2.0 metres and a clear opening height of not less than 2.0 metres within enclosed platforms. A stopping accuracy of +/- 250 mm as stipulated in the Signalling Specification shall be considered.

4.1.5 Each door mechanism shall incorporate a mechanical latch, which shall automatically engage when the door is fully closed, preventing the doors from being opened by the passengers on the platform. The mechanical latch shall release automatically when the door opening mechanism is operated.

4.1.6 The PSD system shall be designed to accommodate a power supply consisting of a 415V 50 Hz 3-phase AC supply, terminated by means of switched fused isolators. The Private Party shall be responsible for the power distribution from the switched fused isolators to the PSD system. The PSD System shall be incorporated in the protection measures against electric shock and the short circuit protection measures. The PSD system shall be designed to prevent any corrosion resulting from any stray current, if any.

4.1.7 With the exception of the structural frame, replacement or rectification of faults of all components, sub-assemblies, or major assemblies shall be accessible entirely from the platform side without influence on train operations on the tracks and shall be capable of maintenance or replacement within a maximum time period of 3 hours.

4.1.8 All electrical equipment interconnections shall be made with mechanically retained plugs and sockets, and all terminations shall be clearly marked. When similar plugs are situated adjacent to each other they shall be constructed to prevent a plug being inserted into the incorrect socket.

4.2 Safety Requirements

4.2.1 Passenger safety is the prime consideration in the design and construction of the PSD system. In particular, door control and monitoring shall be Safety Critical in accordance with the safety requirements of the Specification.

4.2.2 No part of any sliding screen door or its control system or any other component used in the PSD system shall be capable of causing injury to passengers or personnel as a result of door operation. Particular attention shall be paid to detecting trapped obstacles in the sliding screen doors. No single defect or failure of any part of the PSD system shall produce a situation capable of causing injury to personnel. No spurious electrical signals shall cause any sliding screen door to be activated accidentally.

4.2.3 The PSD system shall incorporate a platform monitoring system for proving that all the sliding doors are closed and latched. The mechanism to check the status of the sliding screen doors shall be designed to be Safety Critical. Once all the platform screen doors have proved to be closed and latched, a corresponding signal shall be transmitted to the Train, via the signalling system, to enable train movement as detailed in the Technical Specification for Rolling Stock. An additional closed and latched signal shall also be used to illuminate a corresponding platform indicator. The position of the platform indicator shall be located to ensure that it can be clearly observed by the train drivers from their seated position. The closed and latched status of all sliding screen doors shall be continuously monitored by the PSD system.

4.2.4 In the event of a failure causing the loss of the 'closed' or 'latched' signal, even though it has been ascertained that the sliding screen doors are physically closed, a mechanism shall be provided to enable authorised staff to temporarily override the door status. A manual facility shall be provided on the platform, accessible only by the authorised staff and adjacent to the rest of the door controls, as referred to in Clause 5.1.3, to transmit a pseudo 'closed' and 'latched' signal to the Train, via the signalling system. The pseudo signal shall be identical to the genuine 'closed' or 'latched' signal, to enable the Train to depart from the station. Use of the pseudo facility shall be recorded.

4.2.5 Once the Train has completely left the station zone, following an activation of the pseudo signal, the PSD system shall immediately cancel/reset the pseudo signal, to ensure that the monitoring circuit reverts to the normal condition, including the fault condition if any. Each time the pseudo signal is activated a corresponding signal shall trigger an alarm at the SOR. Sliding screen door monitoring alarms shall be implemented through the SCADA system, with alarm presentation as detailed in the Technical Specification for SCADA.

4.2.6 The emergency walkway door shall be a hinged door that opens in both directions and shall be locked when closed. The lock assembly shall be fitted with an approved emergency handle or push bar on the platform side, to enable quick passenger access to the emergency walkway. Once the emergency handle or push bar has been activated it shall remain in the activated position until reset by means of a key. It shall be possible for authorised persons on the platform side to manually unlock, by means of the key, and open the emergency walkway door, without activating the emergency handle or push bar. It shall be possible to manually unlock, without the need of any key, and open the emergency walkway door from the trackside, to enable the driver, maintenance personnel or passengers being evacuated from the tunnel or underground station to gain access to the platform.

4.2.7 The PSD system shall maintain all metallic parts exposed to passengers or station personnel at an equal electrical potential to the body of the Train. Measures shall be implemented to prevent the possibility of electric shock due a potential difference between the train body and the PSD System. The PSD shall be incorporated in the protective measures against an excessive touch voltage and the short circuit protection measures.

4.3 Passenger Interface

4.3.1 The sliding screen doors shall not exert a closing force greater than 140 Newton and/or a closing kinetic energy greater than 9.5 Joules. The limiting value of sliding screen door movement kinetic energy for the last 150mm of door travel shall be less than 2 Joules per door. The time for unlatching and opening shall be no longer than 3 seconds. The time for closing and latching shall be no longer than 3.5 seconds and shall be achieved within a maximum speed of 0.5 metres/ second. Each door opening or closing speed shall not vary by more than +/-10% when compared with the speed of adjacent doors on the same platform. The opening/closing speeds of each sliding screen door shall be capable of individual adjustment. During all operating modes and under all power supply conditions, sliding screen door movements shall be smooth, controlled and devoid of jerks or any violent motion.

4.3.2 The sliding screen doors shall include an obstruction detection system, which shall be capable of detecting any obstruction causing a gap of more than 20 mm between a pair of sliding screen doors. In the event of an obstruction causing a gap of less than 20 mm becoming trapped, and the sliding screen doors closing, the compression of the sliding screen door seals shall be such as to allow the obstruction to be removed. If a door set whilst closing detects an obstruction, then the door set shall pause to enable removal of the obstruction. Following a short delay the door set shall attempt to close again. In the event that the door set fails to close following 3 consecutive attempts, further door set movement shall cease on the offending door. In the event that a door has stopped movement following this condition, further door set closure shall require another activation of the door close command. The sliding screen doors shall not slam after removal of an obstruction or on loss of power supply. The number of attempts that door sets make to close in the event of an obstruction shall be adjustable.

4.3.3 Positioned on the trackside of each door set, a manual means shall be provided for the passengers to easily release the latch and open a door set so as to gain access to the platform in an emergency. The manual release of the latch shall be achieved without the use of any tools or key or the need to break any seal. It shall be possible for authorised persons on the platform side to manually release the latch and open any door set using an approved key. No component failure shall inhibit manual opening of any sliding screen door when the release mechanism is operated.

4.3.4 The gap between the sliding screen doors and the Train shall be sized to prevent any person passing between the sliding screen doors and the Train.

4.4 Power Failure

4.4.1 In the event of failure of the normal power supply to the PSD system, the monitoring and control functions only of the PSD system shall continue to operate from an uninterruptible power supply for a period of not less than 3 hours. If the sliding screen doors are open, they shall remain open, and similarly when fully closed, they shall remain closed.

4.4.2 In the event of failure of the normal power supply and/or the UPS supply to the PSD system, the mechanism to manually unlatch the sliding screen doors, either by an authorised person on the platform side or from the trackside, shall not be affected.

5 CONTROL AND MONITORING

5.1 Opening and Closing Operation

5.1.1 When a Train is correctly positioned at a platform, the PSD system shall receive door commands signals, which originate from the Train via the signalling system, to either open or close the sliding screen doors. The open and close command signals will correspond with the operation of the train passenger doors, ensuring that the train passenger doors are synchronised with the sliding screen doors.

5.1.2 The opening operation of the sliding screen doors shall be synchronised with the train passenger doors following a short delay, provided by the Train, ensuring that the train passenger doors open first. Similarly the closing operation shall also be synchronised with the train passenger doors to ensure that the train passenger doors close first, again following a short delay provided by the Train. The time difference of both opening and closing of the sliding screen doors, compared with the operation of the train passenger doors, shall be identical on every station.

5.1.3 In the event of a trackside signal transmission failure, preventing the Train from transmitting door control commands, local means shall be provided on the platform, accessible only to the authorised staff, to manually activate either an open or close command of the sliding screen doors. In the event that a local door command is activated, a corresponding message shall be transmitted to the Station Control Room (SCR).

5.2 Door Monitoring

5.2.1 Doorset Numbering

Each door set shall be assigned an individual door number. In the event of a door set failure, a corresponding message shall be triggered in the SCR identifying a failure with the door number and the relative platform location. The number sequence allocated for each door set shall be identical on each platform and at each station.

5.2.2 Door set Open Indicator Light

Each door set shall include an associated 'door open' indicator light, which shall be amber in colour, that shall be illuminated when the door set is open and extinguished when the door set is proved closed and latched. The indicator shall be placed in a position above the associated door set and shall be clearly visible to the train driver or station personnel when standing at the emergency walkway doorway.

5.2.3 Sliding Screen Door Monitoring Devices

Sliding screen door monitoring devices shall be positioned to ensure that they are not affected by lateral or longitudinal displacement of the sliding screen doors, or by normal wear of any part of the sliding screen doors in service. The sliding screen door monitoring device shall detect and prove that the sliding screen doors are fully closed. Such device shall be capable of detecting any obstruction causing a gap of 10 mm or greater and so preventing the sliding screen door closed and latched status from being achieved.

5.2.4 Out of Service Indicator Light

Each door set shall also incorporate an additional red status indicator light to identify either an 'out of service' condition or malfunction on that door set e.g. failure to open or close when instructed. The 'out of service' indicator light shall be located so as not to be confused with the 'door open' indicator. In the event that a door set is 'out of service', a remote indication of the 'out of service' condition shall be transmitted to the SOR.

5.2.5 Emergency Walkway Door

Each emergency walkway door shall be fitted with a monitoring sensor that shall trigger an alarm at the SCR, in the event that any emergency walkway door is open without a Train being present at the adjacent platform or the emergency handle or push bar has been activated.

5.3 Door set Isolation

5.3.1 Each door set shall be provided with a manual isolation device, which shall be used to mechanically lock the door set 'out of service', isolate the power supply and bypass the system monitoring for closed and latched status, as referred to in Clause 4.2.3. The manual isolation device also prevent the respective door set from being opened by normal means, including the trackside release mechanism as referred to in Clause 4.3.3.

5.3.2 The manual isolation device shall be capable of locking a door set in either the closed or open position, with no effect on the operation of any other door set. Access to the manual isolation device shall be achieved by means of a lockable cover requiring the use of an approved key. The key shall not be capable of being removed when in the 'unlock' position.

6 STRUCTURAL INTEGRITY AND DURABILITY

6.1 General

6.1.1 The structural works shall include all the elements required to support, house or frame the PSD installation.

6.1.2 The structural frame supporting the transparent screens, sliding screen doors and header units shall be designed to resist torsion, lateral and vertical loading to prevent excessive deflection in any direction. The structural frame shall be connected to the platform and to the down stand above it.

6.1.3 Sliding screen doors shall be adjustable in the event of any long term vertical loading on support elements causing vertical downward deflections of up to 2 mm maximum. The door weight shall be kept to a practical minimum and shall not exceed 100 kg including the running gear and ancillaries.

6.1.4 The installation of the PSD system shall accommodate the constructional and movement tolerances of the supporting and surrounding structures.

6.1.5 The design of the PSD system shall resist all expected combination of loading conditions, throughout the Service Life of the installation. As a minimum the PSD system shall provide a satisfactory door operation when subjected to the following design loads:

Crowd loading pressure of 500 Newton metre² at a height of 1.125 m without any deformation or reduction in operating performance, and a pressure of 1500 Newton/ metre² without rupture or permanent damage; train generated pressure loading of a differential air pressure of 500 Newton/ metre² of at least 300,000 operations per year, associated with the entry or departure of a Train at a station, at 60 km/hr; and environmental control system pressure of a pressure differential of up to 250 Newton/ metre².

6.1.6 The design of the PSD system shall also ensure that no detrimental damage is caused from the effects of cyclic and repetitive loading associated with crowd load, impact, wind and/or train movements over the Service Life of the PSD installation.

7 ARCHITECTURAL TREATMENT

7.1 General

7.1.1 The PSD system shall be constructed of robust, maintenance-free and easily cleaned materials.

7.1.2 The materials used in the PSD system shall:

i) not introduce a significant fire load into the station;

ii) not be a cause of flame spread; and

iii) be constructed of materials, which minimise smoke and heat emission and shall not generate toxic gases during fires.

7.1.3 The fire resistance shall be achieved by the use of material of limited combustibility as defined in BS 5588 part 1 and shall be acceptable to the local fire services department.

7.1.4 The sliding screen doors and structural frame shall be equipped with glazed top and bottom panels stiffened horizontally with a middle rail, not more than 100 mm wide, located approximately 1050 mm above the finished floor level. Means shall be provided to limit the loss of conditioned air past the edges of all doors when they are fully closed:

7.1.5 Glazing shall be of toughened, non-shattering clear glass. The glazing shall be secured by a removable beading to facilitate replacement from the platform side.

7.1.6 Sliding screen doors of full height shall be supported on overhead track mechanisms. The overhead track mechanism and drive control facilities shall be contained within a header unit protected by means of fixed fascia panels. Lockable, hinged fascia panels shall be installed on the platform side for maintenance access.

The drive and lock mechanism of half-height platform screen doors shall be installed within the Driving Panels located beside each door way, enabling maintenance access entirely from the platform side without influence on train operations on the tracks

7.1.7 The door thresholds shall be flush with the platform floor finished surfaces. The thresholds shall be wear resistant, non-skid and readily cleaned.

7.1.8 The emergency walkway doors shall be constructed of toughened glass.

VOLUME 3 : OUTLINE SPECIFICATIONS

VOLUME 3/1 : THE RAIL-RELATED WORKS OF THE PROJECT

PART 3 – OUTLINE SPECIFICATIONS FOR RAILWAY SYSTEMS

SECTION 9 - TRACKWORK

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SECTION 9

TRACKWORK

1. General

1.1 Introduction

With reference to the Government policy to develop the infrastructure to raise the quality of life of the people and increase the competitive capability of Thailand, this will be achieved by developing train networks throughout the country and developing the connections with regional and international production bases and also developing the services and facilities to meet the required standard in order to increase the convenience, rapidity, safety and reduction of transportation costs.

One of the projects to achieve this objective is the construction of the Bang Sue – Suvarnabhumi – Pattaya – U-Tapao High Speed Rail.

This Trackwork design specifications represent the technical requirements for the design and construction of the mainline and depot tracks and turnouts

1.2 Units, Abbreviations and Definitions

This document includes units, abbreviations and specifically defined terms that are used throughout the entire document. These are indicated below.

1.2.1 Units

Only metric units according to the International systems of units (SI) are used.

km/h	Kilometres per Hour
m, cm, mm, km	Meter, Centimetre, Millimetre, Kilometre
N, kN, kg, g	Newton, Kilonewton, Kilogram, Gram

1.2.2 Definitions

The following definitions apply for this document:

“**Chainage**” means the distance, measured in meters, from a single reference location (origin). Chainage in depots and service tracks generally have different origins corresponding to the beginning of each track.

“**Depot and Service Tracks**” means all tracks outside of the limits of the main line tracks and associated station tracks. Depot and service tracks include stabling yards, maintenance bases or depots, workshop tracks, building tracks, wash tracks, and approach tracks to all of the preceding facilities.

"**Indicative**" means that the criteria or data given are either dependent upon interfacing designs or are based on minimum criteria used on the Reference System. The Private Party shall determine actual criteria or data during the Trackwork design.

"**Main Line Track**" means the main line tracks of the project and includes main line crossovers, turnout connecting the mainline with the tracks to depot and service tracks, station tracks, and station parking or refuge tracks.

"**Nominal**" means initial criteria values used without consideration of tolerances or design variations.

"**Project**" means the currently planned High-Speed Rail Bang Sue – Suvarnabhumi – Pattaya – U-Tapao and the future extension of the line to Trat

"**Reference System**" means a comparable operating system or railway that shall be used to establish a benchmark for the required level of safety, passenger comfort, environmental factors and professional standard/quality for the Trackwork in the Project

"**Sub-grade**" means the foundation or structure surface on which the Trackwork is constructed. In general, this is the direct physical interface between the civil works and Trackwork.

"**Track**" means the physical limits of the structure defined by the limits of the rail, rail fasteners, sleepers, and either ballast or infill concrete above the guideway support structure.

1.3 Purpose

This document represents a summary description of the scope of works, functional requirements for the engineering/procurement/construction of the required Trackwork and identifies the operating conditions to which the Trackwork will be exposed to.

This document is not intended to serve as a complete detailed specification or to identify all areas of Trackwork design, procurement, installation, and interfaces. This document indicates only matters on which the SRT has certain requirements, and in general, this SRT's requirements are stated in a functional manner. In addition to this document the Private Party shall prepare a complete proposal for the works. The Private Party has to provide a complete Trackwork, which is capable to allow high-speed train operation at the specified conditions and at the locations, indicated herein and to allow the operation on all other tracks.

1.4 Norms and Standards

For design and construction international standards in their latest version shall be used. For convenience this specification refers in general to Euronorms, however, where existing, other international standards can be used. These standards have to be issued by reputable organizations such as International Standards Organisation (ISO), Union International de Chemins de Fers (UIC), American Railway Engineers & Maintenance of Way (AREMA) and others.

2. TRACKWORK GENERAL DESCRIPTION AND SCOPE

2.1 General Description of Trackwork

2.1.1 General Requirements

2.1.1.1 Rails

- All rails have to be continuously welded.
- The profile of the rails for main lines will be 60E1, alternatively cross section 60E2, and for depot 54E1, according to EN13674-1 Railway applications - Track - Rail - Part 1: Vignole railway rails 46 kg/m and above
- The rails are inclined towards the centre line of the track as follows:
  - In Main line tracks 1:40
  - In Depots tracks 1:40.
  - Workshop tracks 1:40 or 1:∞, at the interface between inclined and not inclined rails provisions in the supporting structure or components for twisting the rails are to be designed.
- In all Turnouts with the inclination is 1:40 applied by the supporting baseplates or provisions in the rail head to be incorporated to achieve an inclination equivalent to 1:40
- Transition rail between 60E1/60E2 and 54E1.

2.1.1.2 Fastening system

A direct fixation fastening system shall be used in reference to the specified properties in Sub-Clause 5.3 and 6.3

2.1.1.3 Mainline Slabs

It is envisaged to use pre-fabricated concrete slabs or alternatively pre-stressed monoblock sleepers for the construction of the non-ballasted mainline tracks.

Slabs shall be reinforced concrete slabs supported on a layer of self-compacting concrete.

Sleepers shall be embedded in infill concrete.

2.1.1.4 Mainline Sleeper

Mainline sleepers used in addition to the mainline slabs shall be pre-stressed monoblock sleepers.

2.1.1.5 Mainline Turnout Sleeper

In non-ballasted main line turnouts pre-stressed monoblock sleepers are to be used.

2.1.1.6 Sleepers in Depot Tracks

For all ballasted tracks in the depot pre-stressed concrete monoblock sleeper or alternatively synthetic sleepers have to be installed.

2.1.1.7 Sleepers in Depot Turnouts

In the depot turnouts pre-stressed concrete sleepers or sleepers from synthetic material are acceptable.

2.1.1.8 Ballast

Generally, tracks in depots will be ballasted, unless otherwise shown. For the detailed specification of the ballast material refer to the Sub-Clause 6.5

2.1.1.9 Gauge

The gauge is measured as shortest distance between the head of the rails, measured between 0 and 14 mm below top of rail.

The nominal gauge in all sections of the track is 1435 mm.

In turnouts for high-speed section the gauge can vary according to the designed limits of this special Trackwork equipment.

Rail expansion joints are to be designed such that during operation of the rail expansion joint no gauge variations occur.

2.1.1.10 Derailment Containment

Provisions to prevent derailed vehicles from leaving the non-ballasted tracks and to protect adjacent structures from derailed vehicles are to be designed and installed.

Derailment containment shall be provided along the entire length of non-ballasted tracks constructed on elevated structures, earthworks and in the tunnel.

It is preferred to have the derailment containment incorporated into the concrete structure of the non-ballasted tracks by providing concrete upstands at the outside of the tracks or between the rails with an elevation of the upstand in level with top of rail.

2.1.1.11 Turnout

In all mainline tracks operated with a speed through the straight track of the turnout ≥ 160km/h turnouts with swing nose crossings shall be installed.

Turnouts with rigid frogs are permitted on the main line in all other turnouts operated with speed <160km/h in straight direction.

The switch rails of all turnouts are to be manufactured from asymmetrical switch rail profiles according to EN13764-3 Railway applications – Track – Rail –.Part 2: Switch and crossing rails used in conjunction with Vignole railway rails 46 kg/m and above

Turnouts in ballasted depot tracks shall be supported on pre-stressed monoblock sleepers or sleepers from synthetic material

Turnouts on slab have to be installed on pre-stressed monoblock concrete sleepers embedded in infill concrete.

The turnouts have to be designed such that they are compatible with new and worn wheel profile.

2.1.1.12 Rail Expansion Joints

Rail expansion joints have to be installed at locations, where the additional longitudinal stress in the rails caused by the structure due to by temperature, braking, acceleration, vertical deflection and creeping and shrinkage of the structure’s concrete exceed the allowable values.

The Private Party shall review the elevated civil structure and shall perform rail-stress analysis at critical locations to define the necessity of the installation of rail expansion joints.

2.1.2 Main Line Track

Main line Trackwork shall be constructed as non-ballasted track. All components used and the type of non-ballasted track structure shall meet the requirements appropriate for high speed operations. The track shall be constructed to meet the installation tolerances defined in Sub-Clause 5.15

2.1.3 Tracks between Main Line and Depot, Stabling Yard and Workshops

The Tracks connecting the Main Line and the Depot may be constructed of a non-ballasted slab track type.

2.1.4 Depot Tracks

Depot tracks are to be constructed as ballasted tracks with pre-stressed monoblock concrete sleeper or sleeper from synthetic material. The tracks are to be continuously welded. Turnouts are to be constructed using rigid crossings.

2.2 Requirements

The Private Party shall be responsible to provide the design, materials inclusive handling provisions (loading, unloading), transportation from source to the site, installation, testing, procedures, and other works necessary for the completion of a Trackwork system. All material used and track structure proposed has to be capable of reliable train operations at the required speed levels, and reliable depot and service track operations at the required speed. No matter what the actual operation speed on the respective track and turnouts is, all material and track / turnout components, rail expansion joints and other trackwork components to be used in the main lines has to be service proven for high speed conditions of ≥250km/h.

2.1.1 Main Line Slab Track, Viaduct and Tunnel

Main line slab Trackwork on a viaduct or tunnel structure includes the detailed design co-ordination with the Civil Works, material supply, material delivery and storage, testing, installation, etc. of the following major components:

- Rails
- Concrete slab or concrete sleepers
- Direct fixation fastenings system for rails
- Insulated rail joints in diverging track of the turnouts and in the main lines, if applicable
- Embedment concrete layer, including base or levelling concrete
- Surface Drainage from the top of track slab
- Turnouts
- Rail expansion joints, if applicable
- Earthing and return current provisions and terminals in the slab structure

Before beginning the Trackwork construction, the Private Party has to inspect the track bed or surface of the civil work and seek consent from the Engineer's Representative prior to start the construction.

2.1.2. Main Line Slab Track, At-Grade

Main line slab Trackwork on at-grade structure includes the detailed design with necessary structural calculation, material supply, material delivery and storage, installation, testing, etc. of the following major components:

- Rails
- Concrete Slab or Concrete Sleepers
- Direct fixation fastening system for rails
- Slab concrete
- Hydraulic bonded layer on top of earthworks
- Ballast shoulder material

- Filling the section between the tracks with gravel (0/46) and covering with 8 cm asphalt layer (0/12), draining in direction to the tracks
- Earthing and return current provisions and terminals in the slab structure
- Transitions.

2.1.3 Tracks between Main Line and Depot

Between the Main Line and the Depot non-ballasted Tracks are to be constructed on top of the elevated viaduct structure.

The Trackwork between the main line and the Depot includes the detailed design with necessary structural calculation, material supply, material delivery and storage, installation, testing, etc. of the following major components:

- Rails
- Concrete Sleepers
- Direct fixation fastening System
- Rail expansion joints (if applicable)
- Insulated rail joints
- Embedment concrete layer, including base or levelling concrete

2.1.14 Depot and Service Tracks

Ballasted Trackwork shall be provided in all tracks in the depots, maintenance facilities and workshops and all other service tracks not included in the main line or in the approaching tracks to the above mentioned facilities. This work shall include the detailed design, material supply, material delivery and storage, installation, testing, etc. of the following major components:

- Rails
- Sleepers (concrete or from synthetic material)
- Direct fixation fastening system for rails
- Ballast
- Turnouts
- Insulated Rail Joints
- Pedestrian crossings
- Roadway vehicle crossings
- Buffer stops / wheel stops.

2.1.5 In-Building Trackwork

The Private Party shall install all special tracks in the depot and workshop buildings, which will be utilised by the rolling stock.

Such tracks will be:

- Embedded tracks
- Rails installed on individual columns
- Rails installed at pit tracks
- Tracks at depot facilities (such as train lifting plant), if applicable.

This work shall include the detailed design, material supply, material delivery and storage, installation, testing, etc. of the following major components:

- Rails
- Direct fixation fastening system for ballasted tracks
- Rail fastening systems in special tracks
- Insulated rail joints (if applicable)
- Pedestrian crossings
- Roadway vehicle crossings
- Buffer stops/wheel stops.

2.1.6 Grinding

Before beginning of the operation all rails and mainline turnouts shall be ground in accordance with Sub-Clause 5.2.3 clause 15

For the sections where no grinding is permitted in turnouts refer to Sub-Clause 5.2.3 item 16.

For the grinding of the approaching tracks to the Depot refer to Sub-Clause 6.2.3

3. General Trackwork Requirements

3.1 Reference System for Slab Tracks

The Private Party shall propose a non-ballasted track system which was successfully used in major international railway organisations. The reference system shall be approved by the Engineer's Representative and shall be one of the standard non-ballasted track systems in the respective railway organisation.

The Reference System shall be operated for more than 5 years with an operation speed ≥250km/h over an installed track length of minimum 25km.

It is not desired to copy the reference system but it has to be modified / improved to suit the climatic conditions in Thailand and the specific operational conditions of the Project.

3.2 General Performance Criteria

The proposed Trackwork for the Project shall conform to the following general performance criteria. The Private Party shall incorporate these criteria in both the proposal and all design submissions. Any submission by the Private Party will be evaluated with special emphasis given to the following:

Passenger Comfort: The completed Trackwork shall have sufficiently close geometric tolerances including long wave track failures and track characteristics (e.g., vertical dynamic stiffness, etc.) to permit the SRT's rolling stock to maintain specified comfort levels at all operating speeds.

Noise and Vibration: The Trackwork shall be designed and constructed in co-ordination with the characteristics of the rolling stock and the civil works, in order that the completed operating system has low noise and vibration levels.

Reliability and Safety: All components and the overall Trackwork system shall operate to a very high degree of dependability under all normal climatic and operating conditions. The components have to be service-proven on high speed lined with speed ≥250 km/h for at least 5 years. Critical Trackwork components shall have an absolutely minimal probability of failure in revenue service.

Maintainability: The Trackwork shall be capable of retaining the high quality necessary to sustain the preceding performance criteria without intensive levels of maintenance effort. Design life of all components shall be considered in the evaluation of these performance criteria.

Life Cycle Cost: The Trackwork shall have a favourable life cycle cost compared to that of the Reference System for both individual components and the overall track system. The life cycle cost comparison between alternatives under conditions of the Project shall include initial cost, maintenance requirements, service life, replacement costs, comparative ease of replacement with an acceptable maintenance program, and accepted methods of cost amortisation. Performance and reliability, compared to the Reference System, shall not be compromised in favour of a lower life cycle cost.

The Private Party shall demonstrate that, even for components, systems, designs, and procedures comparable to that of the Reference System, the Trackwork performance shall function at least as well under the climatic and operating conditions in Thailand as in the country of origin. The Private Party shall thus provide submissions on reliability, maintainability, life cycle cost, etc. as described in this Clause even if the Trackwork component is identical to that of the Reference System.

3.3 Codes and Standards

Reference standards used in this document relate to those issued by the Comité Européen de Normalisation (CEN)

Where the specifications contain no requirement for compliance with a national or international standard, the Works shall comply with the following standard, code, or practice, or recommendations from one of the following:

- The International Organisation for Standardisation (ISO)
- The International Electro-technical Commission (IEC)
- International Union of Railways (UIC)
- Office of Research and Experiments (ORE)

The Private Party shall maintain consistency in the adoption of, and conformance to, any of the standards chosen. In the case where the Private Party is required to change from one standard to another, and where there is a conflict between provisions of two or more applicable standards, the more restrictive standard shall apply unless otherwise approved by the Engineer’s Representative.

The national or international standards referred to in this Clause represent the minimum standards, which shall be met. The Private Party shall be permitted to adopt other standards, including those of the country of source, provided that such standards are equivalent or superior to those stated in this document. If the proposed standard is issued in a language different from English, the Private Party shall submit one copy in English language of the standards proposed.

Where alternative standards to those mentioned in this document are proposed, the Private Party shall also indicate the differences, and shall also submit a reason for the equivalence to or superiority over the original Reference System standard. Where the Engineer’s Representative does not consider the alternative to be superior to the standard indicated in the SRT’s Functional and Technical Requirements, the Engineer’s Representative reserves the right to base acceptance on compliance with the specified standards.

Wherever references are made to a specific standard, the reference shall be taken to mean the current standard and all subsequent amendments, changes, or additions that are in effect at the date of the tender. Modified versions of standards or a later version of a standard shall be an acceptable alternative.

The International System (SI) units shall be used throughout the Contract.

3.4 Reliability/Availability/Maintenance

The Trackwork systems shall be developed to a sufficient reliability, based on annual system traffic volume, that Trackwork failures affecting the timetable schedule of the system occur less than once per year.

The Private Party shall also ensure that all Trackwork sub-components, e.g. rail fastenings and rail pads, can be replaced in the future without replacement of an entire major Trackwork assembly and that isolated track defects can be partially adjusted vertically and / or horizontally.

The Private Party shall address the requirements of component reliability, maintenance, and availability in the Trackwork proposal.

3.5 Interchangeability

In the interests of reducing maintenance inventory and providing maximum standardisation of material, the Private Party shall minimise the number of different component types used in the Trackwork. To the greatest extent practicable, rail fasteners and other components on main line ballasted track, main line slab track, and depot and service tracks shall have identical or interchangeable components.

3.6 Design Life

The design life of all track components shall be over 30 years wherever possible. Where the expected design life of a particular component is less than 30 years, the Private Party shall state the anticipated useful component life in the Private Party's proposal and design submissions.

4. Alignment

The Private Party is responsible for installing the tracks to the alignment provided by the SRT. The Private Party shall install the track alignment to a high degree of accuracy in deviations both from design alignment and relative alignment variation.

In accordance with the civil construction tolerance and required cross sections, the earthwork and elevated structure are expected to be constructed within tolerance and should not introduce realignment problems for Trackwork. In case of out-of-tolerance, the earthwork and elevated structure will be repaired to the required alignment tolerances. If necessary, re-alignment of sections where the civil structure is out of tolerance has to be performed.

The Private Party shall install the track within the tolerances in Sub-Clauses 5.15 and 6.12 based on the approved as-built alignment.

5. Requirements For The Main Line Track System

5.1 General

The main line Trackwork shall consist of continuous welded rail (CWR), welded turnouts with swing nose crossings or rigid crossings and asymmetrical switch rail profile with low switch entry angle; elastic rail fastenings and non-ballasted tracks from concrete slabs or concrete sleepers embedded in infill concrete. The Trackwork installation procedures have to be suitable for the construction of tracks of ≥250km/h operation speed

Station and station passing tracks shall be constructed to the same standards as main line track and are thus covered under all requirements of this Clause.

5.1.1 Construction method

An important criterion for the selection of the main line slab track system is the construction method.

The Private Party shall describe the following details of his proposed slab track system:

- Transport of the track components to the site and assembling of the track on site
- Setting out and securing of the track alignment before casting the concrete
- Permanent securing of the track alignment during the construction and during the following activities before releasing the supports.

The Private Party should confirm that the proposed construction procedure is suitable for the expected daily construction output. The method should already been successfully used in the construction of another major high speed line.

The Private Party should submit details of the method for the construction of the slab track to the Engineer’s Representative.

5.2 Rails

5.2.1 General Technical Requirements

The rails shall be manufactured in accordance with European Norm EN 13674-1- “Railway application - Track - Rail Part 1; Flat bottom symmetrical railway rails 46 kg/m and above” in the actual edition.

Rail section for all tracks shall be of rail profile 60 E1 or 60E2.

If the Private Party intends to provide rails different from the above-mentioned EN, he shall submit with his proposal a copy of the actual version of the proposed specification, which is basis for his rail supply.

All mainline tracks shall be constructed using rails of grade R260.

Head hardened rails of grade R350HT shall be used in tracks with:

- Radius between <1500 and >700m and >15000 Load tons / day

- Radius between ≤700m and >300m and >30000 Load tons / day
- Radius ≤300m and >20000 Load tons / day.

Mainline turnouts are to be manufactured from rails of grade R350HT.

On line and off line head-hardening processes are acceptable. The head hardened rails shall be installed in the circular curve and in the complete length of the adjacent transition curves.

The profile class the rails shall be "x".

Straightness class "A" shall be applied for the rails.

The minimum length the rails have to be delivered to the welding plant, shall be 25 meter. Rails shall be delivered undrilled.

The minimum length of the welded rails shall be

- in the mainline tracks 12m
- in depot tracks 7m.

5.2.2 Identification

1) Branding

Rails shall be marked according to section 7.4.1 of EN13674-1.

In addition, head hardened rails are to be marked with letters “HH” following each of the branding marks.

The branding mark has to incorporate the SRT logo.

After flash butt welding the brand marks have to be located at one side of the welded rail.

2) Hot stamping

Hot stamping shall be applied in accordance section 7.4.2 of EN13674-1.

The hot stamp has to be painted with white colour.

3) Cold stamping of rails

Any stamping of the cold rail by the rail manufacturer is not permitted.

4) Other identification

For easy identification, head hardened rails have to marked by painting the end surface and the circumference of the rail over a length of 10cm in yellow colour.

5) Qualifying tests

Qualifying tests shall be executed in accordance with section 8 of EN13674-1.

6) Acceptance tests

Acceptance tests have to be carried out in accordance with section 9 of EN13674-1.

7) Dimension Tolerances

Dimensional tolerances shall follow the requirements in section 9.2 of EN13674-1.

a) Profile according to profile class "X"

The tolerances of the profile shall follow section 9.2.1, table 7 of EN13674-1 with the rails being used for the Project to be of profile class “x”.

b) Straightness, surface flatness and twist

For all rails being used for the Project the tolerances for straightness, surface flatness and twist shall meet the requirements of class “A” as given in section 9.2.2., table 8 of EN13674-1.

c) Cutting and drilling

Rails for the Project shall be delivered undrilled.

The right-angled ends of the rail and rail length shall be within the tolerances given in table 9 of EN13674-1.

Rail ends shall be de-burred.

d) Gauges

The gauges to be used for the geometrical check of the rails shall follow Annex E of EN13674-1.

e) Surface quality

Surface quality shall meet the requirements of section 9.4.2 of EN13674-1.

5.2.3 Rail Welding and Grinding

1) Preparation for flash butt welding

The Private Party shall propose a flash butt welding procedure in accordance with

- EN14587-1 Railway applications – Track – Flash butt welding of rails – Part 1: New R220, R260, R260Mn and R350HT grade rails in a fixed plant; or
- EN14587-2 Railway applications – Track – Flash butt welding of rails – Part 2: New R220, R260, R260Mn and R350HT grade rails by mobile welding machines at sites other than a fixed plant.

Before flash butt welding the rails are to be stored such that the branding marks face in the same direction. The running edge shall be clearly marked by means of a white painted line at the end of the rail over a length of 20 cm.

The Private Party shall remove all mill scale from the head and the base of the rail down to the bare metal over a length of at least 150 mm from the end of the rail or as recommended by the manufacturer of the welding machine.

The Private Party has to remove all burrs and shall prepare the surfaces where the electrodes contact the rail as recommended by the manufacturer of the welding machine.

2) Flash butt welding

Before welding of rails, trial welds of flash butt welds have to be executed in order to determine the welding parameter for the welding unit for each rail profile and steel grade. In the presence of the Engineer's Representative the Private Party shall produce six samples of welds for testing, two samples each consisting of:

- Two standard rails together
- One head hardened rail and one standard rail together
- Two head-hardened rails together.

Each specimen weld shall be tested by ultrasonic test procedure and one of each type shall be subject of a slow bending test and the other shall be longitudinal cross-sectioned and prepared such (macroeched), that any imperfections in the surface can be investigated.

The slow bending test specimen shall be tested in accordance with Annex A of EN14578-1 to a deflection as stated in table A.1 of EN14578-1.

During the bending test the weld shall show no cracking or other distresses. The load shall then be increased until failure of the weld with the final achieved deflection noted and the end surface of the fractured rail evaluated according to Annex B of EN14578-1.

The macroeched section shall show no evidence of cracks, lack of fusion or incomplete weld penetration. The total area of weld defects should not exceed 10 mm^2; the single failure should not exceed 2 mm in diameter.

All welds shall be done on the basis of these welding parameters.

3) Treatment of Flash Butt Welds

After the welding process, the welds shall be clipped in warm condition by hand or in a clipping machine. During clipping works, tension forces on the weld shall be avoided. No permanent marking of the rail is allowed by the welding process. The rail web and the rail foot shall be treated such that the functions of the fastening system are not impaired.

Heat-treated rails shall be quenched to a temperature of less than 500°C by means of an appropriate cooling regime (such as compressed air).

Regular rails shall be protected against immediate quenching (for instance heavy rain).

4) Straightening

The welded rails are permitted to be straightened horizontally and vertically on a straightening machine after welding. In the temperature range of the rails between 200°C and 350°C, straightening is not allowed.

5) Grinding after Flash Butt Welding

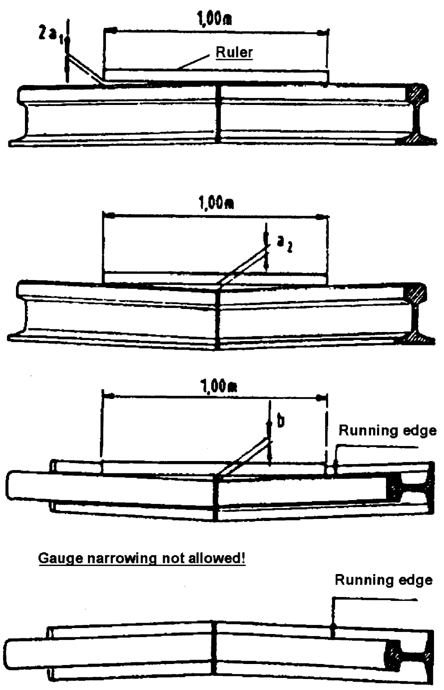
The final precise grinding shall be done after quenching.

The geometrical tolerances after final grinding are

- for the level ≤ +0.3 / -0.2mm
- at the running edge ≤ +0.3 / -0.0mm

Measured by application of a 1m ruler as shown in the following sketch:

Welding tolerance



	Limit value	Basic value
a_1	+0,3mm 1)	0
a_2	-0,2mm 1)	0
b	+0,3mm 1)	0

1) Remedial Works
Deviation from the Limit value, Repair by grinding with a slope Of 1:1000 is allowed for UIC 60 Rails

6) Thermit welding

Trial welds of Thermit welds according to Sub-Clause 5.2.3(2) are to be prepared and tested.

The tests are to be performed in accordance with EN17430-1.

7) Grinding of Thermit welding

Thermit welds shall be ground with tolerances in accordance with Sub-Clause 5.2.3(5).

8) Rail Installation and Branding Marker Location

At any single location of the track the branding markers of one rail in the track shall always face to the centre line of the track.

The branding marker of the other rail shall face away from the centre line of the track.

9) Treatment of welded rails

Cutting of rails is only allowed by sawing or abrasive grinding.

During cutting of Head hardened rails it has to be ensured that the hardness of the rail will not be increased by more than 20 HB within 10 mm of the cut rail end. This has to be established by an appropriate cooling regime, tested under laboratory testing conditions. The Private Party shall strictly observe the cooling regime.

The cuts shall be right angled with permitted deviations in any direction of max. 0.6mm according to number 2 in table 9 of EN13674-1.

10) Ultrasonic test of welds

Ultrasonic inspectors are to be certified according to EN473 Non-destructive testing - Qualification and certification of NDT personnel - General principles.

Every Flash-Butt weld shall be ultrasonically tested. Vertical and angled ultrasonic detector has to be applied. The testing and pass criteria have to be in accordance with an existing procedure used by major high-speed railways. The procedure shall be submitted to the Engineer's Representative for statement of no-objection.

The ultrasonic test shall be carried out at the location where the weld was executed.

11) Documentation of Flash-Butt welds

During production, a recorder has to be attached to the welding machine in order to plot platen movements and current impulse against time. The Private Party shall carefully examine the plot after each weld. If the plot indicates characteristics, which vary significantly from the expected characteristics, the weld shall be considered as defective and has to be replaced immediately.

The control records of the Flash-Butt welding machine have to be collected for every weld. Additionally, the measurements of the straightness of the welds (geometrical measurement) with 1m rulers have to be documented for every weld.

The soft copy of the records shall be handed over to the SRT and Engineer's Representative.

12) Welding of rails on site

On site the welding methods are limited to

- Flash-Butt welding with machines (service proven for welding on High-Speed Lines with speed $\geq$ 250km/h) either in a welding yard with a stationary machine or with a mobile flash butt welding machine
- Thermic welding for the execution of the final welds in the Continuously Welded Track.

Flash butt welding can be done by the Private Party or can be sub-contracted to another welding sub-contractor. In both cases the acting company has to be certified according to section 8 of EN14587-1 or section 7 of EN14874-2.

The Thermit welding process shall be certified according to EN14730-1 Railway applications – Track – Aluminothermic welding of rails – Part 1: Approval of welding processes (includes Amendment A1:2010).

The welding company and its Thermit welders are to be certified according to EN14730-2 Track – Aluminothermic welding of rails – Part 2: Qualification of aluminothermic welders, approval of Private Party and acceptance of welds;

The following documents related to the welding company are to be submitted:

- Equipment to be used
- Certificate of the welding company
- Certification of welding crews
- Procedure for detecting defective welds
- Procedure for replacement of defective welds (wide gap welds will not be permitted, closure rails should not be shorter than 10 m in the main line and 7 m in the depot/workshop)
- Proposed minimum and maximum gap between the rails before thermic welding
- Method of placing, fixing and maintaining the rails in position during welding
- Method used for preheating
- Tapping procedure, including the minimum time required to cool the weld under the mould
- Proposed method to be used for welding including description of special tools for removing excess metal and finishing the weld to the required rail contour.
- Cooling regime for head hardened rails

The Private Party shall take into account the three possible combinations of welding of normal and head hardened rails.

13) Marking of site welds

All welds on site have to be marked with a label at the outer side of the rail web. The mark must indicate the welding company, the month and the year of the execution of the weld.

Between execution of the weld and application of the final label temporary marking shall be performed, such as with painted number and letters.

The label shall be located 10 to 20 cm from the weld.

14) Structure requirements

Flash butt welds are to be treated according to table 2 in section 5.10 of EN14874-1 / table 2 in section 4.9 of EN14874-2. Welds with remaining material not exceeding the stated tolerances at the circumference of the rail foot can be located within the area of the rail fastening system.

Thermit welding joints are to be located minimum 15cn from the edge of the fastening system, preferably in the center between adjacent fasteners.

No Thermit welds shall fall within a distance lower than 3m from structural expansion joints.

15) Grinding and ultrasonic testing of Rails

All rails in main line tracks, station tracks and passing tracks in the stations shall be ground before beginning of test or trial running.

The purpose of this grinding works is to remove the mill skin and the other surface irregularities caused by or occurred during construction.

These grinding works shall be done in a accordance EN13231-3 Railway Applications – Track – Acceptance of Works – Part 3: Acceptance of rail grinding, milling and planning work in tracks or an existing procedure used on a major high speed line. If the alternative procedure is proposed, the Private Party has to prove that it fulfils the requirements of EN13231-3 as a minimum.

Following the grinding, the rail surface shall be smooth and shiny and the roughness shall not exceed 10 μm in a 10 cm chord. Reference shall be made to EN15610 Railway Application – Noise emission – Rail roughness measurement related to rolling noise generation.

Only grinding machines with minimum 2 rotating grinding stones per grinding unit are acceptable. The Private Party may also propose milling of the rail head surface with following grinding of the milled rail head surface.

The completed track shall be checked by an ultrasonic test procedure. The Private Party shall submit the proposed equipment, the test method and the acceptance tolerances to the Engineer's Representative for statement of no-objection.

Sections in turnouts and rail expansion joints which cannot be ground by machine shall be ground using hand-operated grinding machines.

At sections in turnouts and rail expansion joints which cannot be ultrasonic inspected by machine, the inspection shall be carried out by hand. The equipment, procedure and the acceptance tolerances are subject of the statement.

16) Grinding of Turnouts

The Private Party shall grind all not machined rails within the turnout by track mounted, self-propelled grinding / milling machine.

Sections where hand operated machines are to be used since self-propelled machines cannot be used are to be defined by the Private Party and to be submitted for approval.

5.2.4 Insulated Rail Joints

5.2.4.1 General

Insulated rail joints may be required in the main line and in the diverging tracks of the turnouts.

Where insulated rail joints are required in co-ordination with the proposed signalling system, the Private Party shall propose a design suitable for main line track conditions and in accordance with the following requirements:

- All insulated joints shall be factory-made and welded into the track unless space constraints make insitu joints unavoidable (for example at the end of turnouts in crossovers).
- The pre-fabricated joint shall be manufactured from a rail, corresponding to the profile and type of the rails in the track, with a length not less than 10 m for main lines and 5 m for depot and workshop, which has been cut in its centre for the insulated rail joint.
- The cut has to be done in the upper half of the rail under an angle of 30° with the lower section of the rail cut under 90°. For separation of the 2 cuts a hole shall be drilled into the neutral axis of the web. Special insulators separating the two rail ends are to be used.
- Insulated rail joints shall be of a glued design with six bolted high tensile fastenings and approximately 1.0m length fishplates.
- The railhead shall not be heat treated before cutting.
- The minimum distance between an in-situ prepared insulated rail joint and any adjacent weld shall be 4.50m unless space constraints require a shorter distance.
- Insulated rail joints with cut of 90° over the complete height of the rail may be proposed for turnouts.

The exact location of the insulated rail joints will be determined according to the requirements of the signalling system.

5.2.4.2 Material

The fishplates shall be quenched and tempered carbon steel in accordance with the UIC Code 864-4/0.

The bolts shall be high strength and shall comply with the requirements of UIC 864-2/0 for the strength category 8.8. Washers shall comply with the requirements according UIC 864-3/0 for steel spring washer.

The insulating material shall be of high pressure, laminated design. It shall be impervious to oil and grease.

The Private Party shall show that the durability of the adhesive to be used for the fabrication of the Insulated Rail Joint exceeds 20 years.

5.2.4.3 Installation

Insulated Rail Joints shall be in the centre of the adjacent rail seats within a tolerance of ±50 mm. Where joints are installed in both rails they shall be square within a tolerance of ± 50 mm. The designed spacing of the sleepers are permitted to be adjusted by ± 30 mm over ten consecutive sleeper on each side of the joint.

5.2.4.4 Pre-Production Testing

- Test Specimen

  Two specimen should be prepared by cold-cutting a 1125 mm long rail end 450 mm from one end and re-joining the pieces as a bonded insulated joint.

- Electrical resistance

  The Private Party shall measure the electrical resistance across the specimen joint before and after the mechanical tests described below. A joint in isolation under dry conditions shall have the resistance measured from rail to rail and from the rail end to both fishplates at 50 Volts AC.

  Each test will be applied for duration of three minutes for a frequency of 20 Hertz to 10 Kilohertz in increments of 20 Hertz to 100 Hertz, 200 Hertz to 1000 Hertz and 2000 Hertz up to 10 Kilohertz. The actual current flow shall be measured to the nearest 0.1 Milliampere and recorded for each frequency.

  The maximum current for 500 Volts DC shall be 100 Milliamperes. The minimum impedance for any frequency with 50 Volts AC shall be 7500 Ohms.

  The measured for comparative purposes is a benchmark resistance for the production testing described in Sub-Clause 5.2.4.6

- Stroke Rolling Load Test

  The Private Party shall mount the insulated rail joint on a 675mm stroke rolling machine between supports at 900 mm centers with the joint centralized between the supports.

  The Private Party shall apply 20.000 kg load on the rail for 2 Million load cycles at approximately one cycle per second. At the first 500.000 cycles and than every 50.000 cycles the Private Party shall record the deflection at the rail center line to the nearest 0.025 mm.

  After 2 Million load cycles the joint shall exhibits no evidence of failure by bending of the bonded joint. The measured deflections shall nowhere exceed 1.65 mm.

5.2.4.5 Longitudinal Tensile and Compression Tests

One end of the joint has to be fixed and to the other end a force shall be applied for compression and tensile testing. If necessary, holes have to be drilled into the web for the application of the forces.

For the tensile and compression test, a load of 750 kN has to be applied. The force has to be increased by 50 kN in each step and has to be kept, until the longitudinal deflection of the rail has ceased before the load will be increased to the next increment. At each increment the Private Party shall monitor the load and the respective deflection of the rail and the fishplates to the nearest 0.025-mm.

There shall be no signs of slipping of the rail before reaching the 750 kN load. Differential movements in all directions should be limited to a maximum of 3 mm. The difference between the initial position of the fishplate and the position of the fishplate after the final load of 750 kN has been released should not be more than 0.8 mm.

5.2.4.6 Production Testing

The Private Party shall test the resistance of every bonded insulated rail joint prior to installation by applying 50V DC across the joint. The resistance shall not be less than 10 Megaohm.

5.2.5 Cable Connections to Rails and Turnouts

5.2.5.1 General

The Private Party shall co-ordinate the cable connection locations with the respective sub-systems.

All cable connections shall be carried out only in the rail web at the neutral axis of the rail.

5.2.5.2 Connection Type

In all tracks and turnouts in main line and depot, any connections to the rail shall be made by bolting.

5.2.5.3 Responsibility

The provisions for the bolted connections are to be made by the Private Party. The Private Party shall drill a hole of the appropriate size into the rail and de-burr immediately after drilling. An electrolytic tin plated copper bush has to be installed in the hole and secured.

All holes shall be protected of a layer of approved grease.

The cable connection will be carried out by the respective sub-system.

The Private Party shall submit his proposals for drilling the holes into the rail and the proposed fixation system for approval.

5.3 Fastening System

The rail fastening system shall provide support, guidance, resilience and insulation between rail and sleeper on both ballasted and slab tracks.

The main components of the rail fastening system, depending on design, shall be as follows

For Slab Track

- Base plate or load distribution plate
- Resilient pad
- Insulating elements
- Rail pad
- Elastic spring steel clip
- Sleeper screws
- Plastic dowel in sleeper or slab

The exact design and configuration of the rail fastening is subject to the technical requirements of this Clause.

5.3.1 General Requirements

The general requirements for the rail fastening system are to provide adequate resilience and high accuracy of gauge and rail inclination.

Fastening systems shall be supplied by original manufacturers with a supply record of rail fastenings installed on high-speed lines with a speed of ≥250km/h for more than 5 years, and a minimum installed length of 25km.

The fastening systems shall meet the requirements in accordance to European Norm EN 13481-2, Fastening systems, part 2, Performance requirements for fastening systems for concrete sleepers.

The fastening system has to be tested according the EN 13146-1 to 8 Railway applications Track –Test methods for fastening systems – Part 1 to 8. The results shall be submitted to the Engineer's Representative for statement of no-objection.

If the Private Party intends to test the fastening system according another than the above-mentioned Euronorm he should submit a copy of the standard to the Engineer's Representative. Additionally he has to show that the proposed testing standard meets or betters the EN 13146, part 1 to 8.

Test shall be performed in an institute independent from the supplier, the results from the approved test institute have to be submitted with the proposal.

The test institute has to be submitted to the Engineer's Representative for approval.

The detailed design of the rail fastening system for the different purposes (ballasted track, slab track and depot track etc.), shall contain a complete fastening system drawing (with tolerances) and detailed drawings of all components. These drawings have to be submitted to the Engineer's Representative.

5.3.2 Slab Track

The fastening system for slab track shall provide appropriate elasticity (approximately 1~1.5mm vertical rail deflection under a static axle load of 13 tonnes).

Only slab track solutions, which have been service proven under high-speed conditions with speeds of ≥250km/h and more will be accepted.

The slab track rail fastening system shall have provisions to raise and lower the rail with a total vertical adjustment of at least +72mm and a horizontal adjustment of each rail of at least +5/-5 mm.

The design of the adjustability shall minimise the number of different types of additional components to be introduced or removed, and the time to carry out the adjustment.

The installation of the system shall not cause any major effect on the adjacent slab track system and shall not change the dynamic behaviour of the complete trackform in the area of installation and in the adjacent slab track sections. The major components of this system shall be compatible with the adjustable standard fastening system as described above.

The fastening system for non-ballasted tracks shall be completely pre-assembled in the sleeper / concrete slab factory

The detailed design of the rail fastening system with detailed drawing showing the adjustability and all components shall be submitted.

The toe load per each rail seat shall be ≥ 18KN and the minimum longitudinal creep resistance per rail shall be ≥9kN per rail seat. However on elevated structures the maximum toe load is limited to 14KN per rail seat and the longitudinal creep resistance per rail shall be 7 kN per rail seat.

All other performance requirements for fastening systems for slab track, laid down in EN 13481-5 have to be fulfilled.

5.3.3 Spacing between the fastener

The spacing between the centre lines of the fastener shall be as follows:

Ballasted Track Depot		nominal 700 mm
Slab Track	Elevated main line tracks	nominal 650 mm
	Elevated station track	nominal 650 mm
	Main line tracks at grade and in tunnels	nominal 650 mm

Under special circumstances the spacing between the fastener can vary from the above mentioned values. The difference of the spacing between adjacent fasteners shall not exceed 50mm.

5.4 Sleepers

5.4.1 Slabs for non-ballasted tracks

Slabs for non-ballasted tracks shall be manufactured from reinforced concrete. For the arrangement of the reinforcement in the upper layer clause 5.10 has to be considered.

The slabs shall be suitable for all installation locations. Suitable standard lengths of the slab shall be selected with special slabs to be provided where special conditions apply, such as at the end of elevated structure of different length.

Slabs shall have openings for the application of self-compacting concrete and for transportation, handling, lifting etc. The derailment containment upstand shall be provided during manufacturing of the slab.

The embedded items for the fastening system shall be incorporated into the slab during manufacturing.

The design of the slabs shall be submitted to the Engineer's Representative for approval.

5.4.2 Sleepers for slab track

Sleepers for slab track shall be pre-stressed monoblock sleepers, suitable for the slab track system proposed by the Private Party and accepted by the Engineer's Representative. The sleepers shall be embedded in a layer of infill concrete during track construction.

Dimensions of the sleepers shall be designed in accordance with the proposed slab track system and design.

Sleepers for slab track may require provisions for the integration of reinforcement between slab and sleepers. The provisions shall be in accordance to the slab track design, submitted by the Private Party.

The Private Party shall submit evidence that the proposed sleeper design is service proven under high speed rail conditions with speeds of 250km/h or more for at least 5 years with a minimum installed length of 25 km.

The proposed sleeper design should meet the requirements of the EN 13230-1 Railway applications – Track – Concrete sleepers and bearers – Part 1 and part 2.

If the Private Party proposes design and manufacturing of the concrete sleepers to a different standard, the Private Party shall provide a copy of this standard to show that the proposed standard meets or betters the requirements of the specified Euronorm.

5.5 Hydraulic Bonded Layer

5.5.1 Purpose and Installation Procedure

To prevent any overstressing of the load-bearing layer due to dynamic forces, in at-grade structures, a hydraulic bonded layer will be installed. This hydraulic bonded layer will be placed on top of the upper, non-bonded layer and forms the basis for the later slab track construction.

The hydraulic bonded layer has to have a full connection with this upper, non-bonded layer.

The preferred method is to install the hydraulic bonded layer in one layer. Where this is not possible, the Private Party shall use a maximum of two layers. Consideration should be taken of the minimum thickness of the layers.

The total thickness of the hydraulic bonded layer shall be calculated by the Private Party taking under consideration all components of the slab track such, that the deformation modulus at the upper, non-bonded loading bearing layer does not exceed $E_{V2} \geq 120$ N/mm^2.

Under no circumstances the minimum thickness of the hydraulic bonded layer shall be below 30 cm under each location of the track concrete structure above.

After casting the hydraulic bonded layer, this shall be cured by keeping wet for a minimum of four days.

The hydraulic bonded layer has to be cut every 5 m, whereby the depth of the cut has to be more than 35 % of the layer thickness. If the installation has been done in two layers, only the lower layer has to be cut.

Between the installation of the hydraulic bonded layer and the casting of the trough for the slab track, the hydraulic bonded layer has to be protected from heavy rain.

Before casting the slab track the surface of the Hydraulic Bonded Layer has to be cleaned and soaked with water several times.

The protection of the exposed areas beside the already cast slabs has to be done permanently by covering the hydraulic bonded layer with ballast or a crushed and graded material of similar composition approved by the Engineer's Representative.

5.5.2 Materials

5.5.2.1 Mineral aggregates

The size of the aggregates for the hydraulic bonded layer is designated by the paired minimum / maximum square sieve size (mm). "d" defines the lower limit designation sieve and "D" defines the upper limit designation sieve.

The grading (d/D) for the aggregates for a hydraulic bonded layer is 0/31.5 or 0/42.

The percentage of the different grades of passing material through the sieves shall be as follows:

$<$ 0.063 mm	$\leq$15%
$>$ 2 mm	16 – 45 %
32 / 42 mm	$\geq$10%

For the grading also reference should be made to the Figure 6.2.

5.5.2.2 Cement

The cement shall fulfill the requirements according EN197-1 Cement. Composition, specifications and conformity criteria for common cements or an equivalent regulation.

Additional requirements are as follows:

- For Portland cement CEM 1 the maximum lime content should not exceed 1.0 weight-% Na_2O-equivalent.
- For Portland cement CEM 1 32.5 R the cement shall be milled to $\leq$ 3500 cm^2/g. The water content shall be $\leq$ 28 weight - % and the compressive strength after 2 days shall be $\geq$ 29.0 N/mm^2.
- For all types of cements, used for the installation of hydraulic bonded layer, the process of hardening shall not begin before 2 hours after mixing (at a temperature of 20 °C).

The minimum content of the cement shall be 3 – 6 mass-% (60 – 120 kg/m^3)

5.5.2.3 Water

The optimum water content in the just mixed material shall be 4.5 – 6.5 mass-% (90 – 130 l/ m^3)

The water content during the installation of the material shall be 3.5 – 5.5 mass-% (70 – 110 l/ m^3)

5.5.2.4 Specific Requirements

The material for the hydraulic bonded layer shall fulfill the following requirements:

- Size of the aggregate variations of more than 8 % by weight at the grade size 2, 8

  and 16 mm are not permitted.
- Rate of compaction of the not yet hardened hydraulic bonded layer

  $\frac{\text{Density of the dry material}}{\text{Proctor density}} > 98\ \%$
- Compressive strength after 28 days $\geq$ 10 N/mm2
- Accuracy of the installed layer

  Absolute deviation from the requested position $\leq$ - 1.5 cm

  $\leq$ + 0.5 cm

Minimum thickness of the installed layer $\geq$ 9 cm

(during installation in more than one layer)

Average thickness $\leq$ 10 % but not less than 30 cm

At any single location not less than 3 cm below the designed thickness

The following major inspection parameters have to be fulfilled:

- Straightness, checked with a 4-m measuring basis $\leq$ 1.5 cm
- Just mixed material Proctor-density and related water content
- Hardened material Cylinder compressive strength: after 28 days

  Cement content $>$ 3 %
- Installed material compressive strength

  Ratio of compaction

At the location of transition between the at-grade structure and any civil structure or tunnels, special provisions shall be accommodated to compensate the different track modulus of the earthwork and the civil / tunnel structure.

5.6 Special Trackwork, Turnouts

5.6.1 General

Turnout geometry shall be as shown on the alignment drawings.

For all mainline turnouts the un-machined rail sections shall be manufactured of rails R350HT.

5.6.2 Bearers

All turnouts shall be mounted on pre-stressed concrete sleepers embedded in infill concrete of the non-ballasted turnout structure. Sleeper design shall incorporate the requirements of long turnout sleepers for point operating equipment.

5.6.3 Fastening system

The rail fastening system of the turnouts shall provide a track elasticity equivalent to the adjacent track. Between the turnout and the adjacent track a transition of the elasticity from turnout to track shall be designed and incorporated.

5.6.4 Sliding baseplates

The sliding baseplates of all turnouts installed on the main line shall be of a lubrication-free design. Rollers lifting / lowering the switch rail during movement shall be provided.

Only rollers integrated in the sliding baseplates are acceptable.

The rollers shall be adjustable in order to ensure the correct vertical distance between the baseplate and the tongue rail.

5.6.5 Crossing

In all turnouts in mainline tracks with an operation speed through the straight track of the turnout of ≥160km/h swing nose crossings will be installed. All other turnouts can be provided with common frogs.

Provisions shall be provided to prevent a vertical movement of the elastic supported running rail independent from the swing nose during the loading by running vehicles.

Common crossings shall be manufactured from solid cast manganese steel crossing with welded rail steel extensions.

Crossings shall be welded to adjacent turnout rails.

5.6.6 Switch Rails

Switch rails shall be manufactured from a head hardened, asymmetrical rail section with tangential (low entry angle) geometry at the switch toe and a forged transition to a section of 60E1 / 60E2 rail.

The Private Party shall demonstrate that the remaining cross section of the switch rail after machining is still within the head hardened area. Otherwise head hardening of switchblades shall be executed after machining.

The switch rail design shall be designed for both new and fully worn wheel profiles.

The switch rail drive system, locking devices, and position detection devices shall be coordinated with the sub-system signalling.

5.6.7 Co-ordination with Sub-system Signalling

The following items shall be coordinated with the sub-system signalling and shall be considered accordingly:

- Holes in the running rails
- Machining of the tip of the switch rail to connect signalling components
- Threaded inserts in the sleeper
- Sleeper spacers
- Required insulation of turnout components

5.7 Rail Expansion Joints

Rail expansion joints (REJ) are required where the rail stresses at specific locations, such as at long civil structures, exceed permissible limits.

The Private Party has to carry out respective rail-structure-interaction calculations to calculate the rail stress caused by interaction between civil structure and trackwork.

The rail fastening system of the REJ shall provide a track elasticity similar to that of the adjacent track.

The proposed REJ shall be service proven in tracks operated with speeds ≥250km/h.

The design of the REJ shall be such that during the operation of the REJ no gauge widening / narrowing occurs.

5.8 Slab Track

For the main line track sections indicated in the drawings, the Private Party shall install a ballastless track system suitable for the required operating speed and the traffic conditions.

The Private Party shall provide a complete description of the proposed track system in his proposal.

The following types of slab track systems are acceptable:

- Systems consisting of individual, pre-fabricated reinforced concrete panels (slabs), supported on a layer of infill concrete between the supporting civil structure and the bottom of the slab
- Systems consisting of pre-fabricated, pre-stressed concrete sleepers embedded in an infill concrete.

The selected system shall be a standard design of non-ballasted tracks, approved by the respective railway organisation and shall be used for tracks operated with an operation speed of ≥250km/h for at least five years on tracks with an installation length exceeding 25km.

The Private Party may propose an alternative service proven system which is already in service for at least 5 years or was subject to minimum 100 million gross tons in tracks of minimum 25km length at operation speeds ≥250km/h.

The non-ballasted track system shall be possible to be used under all conditions, i.e. it shall be suitable long and short viaducts, tracks on embankments and in tunnels.

On elevated structures the proposed system shall ensure the safe transfer of longitudinal and lateral forces into the structure due to live load and temperature gradient between the trackform and the structure. The Track system shall be designed such that the above mentioned requirements are fulfilled during the complete lifetime of the system.

On at-grade structures, the slab track generally requires a multi-layer structure. The relative elastic stiffness increases from bottom to top of the layers in order to avoid overloading of the track sub-grade and provide for large dynamic forces on the track. The Private Party shall use a hydraulically bonded layer between the track structure and sub-grade in the design of at-grade slab track. An alternative design of non-ballasted tracks without supporting hydraulic bonded layer may be proposed and is subject to the approval by the Engineer's Representative.

The Private Party shall consider for his design that the components of the non-ballasted track shall be possible to be exchanged with minimum influence to the adjacent track sections. The complete system shall be adjustable in vertical direction.

5.9 Transitions

The Private Party shall describe in his proposal how the track transitions are accomplished, which shall meet the following requirements.

5.9.1 General

There are two general types of track transitions that must be considered, both which affect the track design:

Substructure Transition: This describes transitions from structures (bridges and tunnels) with slab tracks to earthworks with slab tracks.

Superstructure (Track Structure) Transition: This describes the transition in the track structure from slab to ballasted.

All transitions require special measures to compensate elasticity differences in the track modulus and potential settlement differences.

5.9.2 Substructure Transitions

The following types of substructure transitions occur in the Project:

- Viaduct-Earthworks
- Tunnel-Earthworks

5.9.2.1 Viaduct-Earthworks Transition

It shall be necessary to produce special structure transitions under the continuous slab track to compensate for differences in settlement and differences between the earthwork and bridge structures. The exact design of the transition is the responsibility of the Private Party, and depends on the following:

- The proposed slab track design
- The design of the bridge or tunnel termination structure
- Geotechnical backfill conditions and settlements expected at the structure limit

It might be necessary to provide special provisions in the track.

5.9.2.2 Tunnel-Earthworks Transition

For slab track between tunnel and earthworks structures, elastic/plastic intermediate layers shall be installed over a length of 3.0 meters to avoid overstressing the track slab concrete.

5.9.3 Track Structure Transitions

5.9.3.1 Transition between the ballasted and slab track

Both ballasted and non-ballasted track are installed on a concrete structure, viaduct and depot slab structure, thus no special provisions in the supporting structure to be considered.

The thickness of the ballast at the transition and in subsequent ballasted track shall be adequate to meet the requirements imposed by the service conditions.

According the construction height of the slab track system, the height accommodation should be achieved in the slab track system or in the ballasted layer. The Private Party shall evaluate the civil structure and shall design the transition at the interface accordingly.

To compensate the different stiffness between slab track and ballasted track, two additional rails can be installed at the location of transition (length of the rail 20 m, 15 m fastened to the sleeper in the ballasted section and 5 m fastened to the sleeper in the slab section).

Where a significant difference in stiffness is encountered in the fastening support points, a staggered elasticity layer shall be necessary at the transition between the slab track and the ballasted track.

To accommodate stiffness differences the ballast in the vicinity of the slab tracks may be bonded at different cross sections and the sleeper distance in the ballasted track section may vary.

5.10 Earthing and Return Current Provisions for Slab Track

Due to the special character of the chosen Slab track system, special requirements for the earthing and bonding, the return current system and the Potential balance have to be considered.

The reinforcement of the concrete trough for the Track has to be electrically connected in its longitudinal direction. The reinforcement has to be connected to the earthing system at the locations as determined respective sub-systems. Earthing terminals at the track structure shall be provided by the Private Party.

The reinforcement has to be incorporated into the earthing system in order to switch off the OCS system in case of fracture of the OCS wire and to prevent that potentials will be distributed along the Tracks.

In the slab track system with embedded concrete sleepers the upper layer of the concrete slab structure a minimum of six reinforcement bars with a diameter of minimum 16 mm have to be connected. The 200 mm overlapped single reinforcement bars have to be welded together by arc welding. The connected reinforcement bars shall be located in the vicinity of the running rails of the track. Terminals at the edge of the continuous slab track structure are to be installed where defined by the respective sub-systems.

At the location of the OCS poles the three endless reinforcement bars have to be connected to each other by a flat steel profile with a cross section of minimum 120 mm^2 The steel profile has to be welded to the rebars. For the later connection between the steel profile and the earthing system at the end of the steel a terminal has to be connected. The surface of the terminal has to be in the same level as the concrete surface.

In the slab track system with pre-fabricated concrete slabs the upper layer of the concrete slab structure a minimum of six reinforcement bars with a diameter of minimum 16 mm have to be provided, 3 bars each in the vicinity of the running rail.. At the end each slab the longitudinal reinforcement shall be connected by flat steel profile of minimum 120mm^2 cross section with terminals at the ends of the bars. Terminals are to be provided to connects the individual reinforcement mesh of the slabs with each other and to provide a continuous earthing and return current system.

At the gap between adjacent slabs the Private Party has to connect the earthing terminals of the slabs by copper wire with a minimum cross section of 80 mm^2.

Earthing and bonding requirements in the vicinity of signaling equipment have to be coordinated with the sub-system Signalling.

5.11 Derailment Containment

On all mainline tracks and turnouts and at the non-ballasted tracks connecting the mainline with the ballasted tracks in the depot derailment containment shall be provided. The derailment containment shall consist of a concrete upstand of about 200mm width located towards the field side of the track. Top of upstand shall be in level with top of rails.

The Private Party may propose to install the derailment containment between the rails in tracks. At the interface between tracks with upstand between the rails and the upstand at the field side of the turnouts the upstands have to overlap.

5.12 Mainline Buffer Stops

Friction Type Buffer stops shall be installed at the ends of all main line tracks and sidings..

The type and design of the buffer stop shall capable to stop a fully loaded train at a speed of 10 km/h within a distance of 15 m between the bumping surface of the buffer stop and the end of the rail.

In general no welds shall be located within the sliding distance of the buffer stops. If flash butt welds are within the sliding distance the weld at the circumference of the rail head shall be ground to conform cross section 60E1.

No Thermit welds shall be within the sliding distance.

Buffer stops shall be durable finished by the application of three layers of paint in comprising a base coat, primer and a finishing coat. The body of the buffer stop shall be painted in bright yellow colour. The coating shall be designed with a design life of 10 years before a re-painting is necessary.

5.13 Level Crossings

Level roadway crossings will not be used in main line tracks.

5.14 Signs and Markers

5.14.1 General

Signs and markers shall be manufactured from aluminium plates with a thickness of 2 mm. The background colour shall be washable reflective yellow, with the characters in matt black.

The signs and markers shall be connected to the relevant surfaces as described below using suitable provisions.

The signs and marker have to be provided and installed by the Private Party. The descriptions on each marker are subject to the statement of no-objection of the Engineer's Representative.

5.14.2 Chainage markers

Distance Chainage marker shall be provided at intervals of 50m.

On earthworks and elevated structures the chainage markers have to be installed to the nearest OCS pole. The actual chainage has to be noted at the marker as described in the drawing.

In the tunnel the marker shall be fixed to the tunnel wall at the exact location of the chainage.

The chainage markers shall be installed staggered.

They shall refer to the actual as-built re-measured chainage, without chainage jumps, using a location of origin, as defined by the Engineer's Representative.

The location of the chainage marker is subject to the statement of no-objection by the Engineer's Representative.

Additional alignment chainage markers shall be installed at every change in horizontal alignment conditions (TS, SC, CS, ST points) and shall contain additional curve and cant information. Similar markers have to be provided at the beginning and the end of every vertical curve and at every switch toe..

5.14.3 Survey Control Points

Survey control points shall be established at the location of every OCS pole or, in tunnels, at the mounting location of the OCS system along the whole length of each track. Marker plates affixed to the OCS pole or the tunnel wall shall identify the Survey Control Points.

The survey points consist of stainless steel cylinder with a diameter of 12 mm and a length of 30 mm.

In the tunnel a hole shall be drilled into the tunnel wall and the threaded cylinder connected to an insert. For the connection of the survey control points to round OCS poles stainless steel bands shall be used. In case OCS poles made from steel profiles, a hole with the diameter of 9 mm shall be drilled through the steel. The cylinder will be fixed to the pole by means of a bolt.

5.14.4 Fouling Point Marker

Fouling Point Marker shall be affixed to the relevant sleeper of the turnout at all locations, where tracks converge.

5.15 Acceptance Tolerances

The following measures apply for the acceptance tolerances of Main line tracks, Turnouts and Rail Expansion Joints:

Main Line Tracks

Item	Required Tolerances	Description
Gauge (nominal 1435 mm)	+ 2 mm - 2 mm	Deviation from the nominal Value, the rate of change of gauge shall not exceed 1:1500
Cant/Cross Level	± 2 mm in straight tracks and circular curves ± 2 mm in transition curves	Deviation from the designed value
Vertical alignment (level)	Max. difference between adjacent versines: + 2 mm - 2 mm	Related to a versine with a 20-m-chord, measured at points with 5 m spacing. versine $v=S^2/8R$
Horizontal alignment	Max. difference between adjacent versines: + 2 mm - 2 mm	Versine measured with a 20-m-chord in curves and transition curves according the calculated value. Distance between the measurements 5 m.
Designed level	Max. deviation from designed level: + 5 mm - 5 mm	Measured at the reference points at the catenary masts, for speed > 160 km/h the max. Rate of change of the level must not exceed 1:2500. Between two adjacent reference points the different should be less than 10 mm. At platforms the track shall not be located below the designed level.
Designed alignment	Max. deviation to designed position at reference points + 5 mm - 5 mm	Measured between centreline of track and reference point. The rate of change of the designed alignment should not exceed 1:2500.
Twist	1:1500	Deviation over 2.5 m ≤1.7 mm
Welding	Running surface on the railhead, max deviation: ≤+ 0.3 mm ≤- 0.2 mm	Measured with a 1-m straight edge

Item	Required Tolerances	Description
	Running edge, max. deviation: ≤+0.3 mm to the field side 0.0 mm to centreline of track	

Turnout

Item	Proposed Tolerance	Description
Gauge	No deviation	From allowed tolerance at measuring location according turnout inspection record
Relative position of stock rail to tongue rail	+ 2 mm - 2 mm	In order to ensure the function of the locking device
Check-rail gauge (if applicable)	No deviation	From allowed tolerance at measuring location according turnout inspection record
Flangeway (if applicable)	No deviation	From allowed tolerance at measuring location according turnout inspection record
Cant/Cross level	+ 2 mm - 2 mm	Deviation from the designed value
Designed level	Max. deviation from designed level: + 5 mm - 5 mm	Measured at the reference points at the catenary masts, for speed > 160 km/h the max. difference of the deviation for adjacent points must not exceed 10 mm.
Designed alignment	Max. deviation to designed position at reference points + 5 mm - 5 mm	Measured between centreline of track and reference point
Sleeper spacing and location	Deviation to the designed spacing: Max. ± 3 mm	Deviation from spacing according Turnout Supplier's Shop Drawing
Welding	Running surface on the railhead, max deviation: ≤+ 0.3 mm ≤- 0.2 mm Running edge, max. deviation: ≤ 0.3 mm to the field side 0.0 mm to centreline of track	Measured with a 1-m straight edge

Item	Proposed Tolerance	Description
Distance between switch rail and sliding baseplate	Max. 2 mm	
Distance between switch rail and stock rails/heels	Max. 1 mm	

Rail Expansion Joint

Item	Additional Tolerance	Description
Gauge	No deviation	according rail expansion joint inspection report and measuring location
Adjustment of the rail expansion joint	Less than 10 mm immediately after installation of the Rail Expansion joint	Will be compared with the Bridge Elongation Measuring Device.
Spacing between tongue rail and stock rail	Max. 1.5 mm	Measured at the stock rail, attached to the tongue rail
Mobility between tongue rail and stock rail	Max. 1.5 mm	Visual check of spacing between tongue rail and supporting plate

5.16 Acceptance of the Trackwork

After completion of the Trackwork construction a final acceptance test of the geometry shall be carried out with a self-propelled measuring vehicle, which shall be able to check/calculate the following Trackwork parameters as a minimum:

- Speed of the vehicle
- Chainage
- Gauge
- Cant/Cross level
- Horizontal alignment
- Vertical alignment
- Twist
- Special Trackwork components

The parameters shall be recorded on paper and must also be available as computer file for later reference.

The Private Party shall demonstrate to the Engineer's Representative that the recorded parameters are within the specified tolerances.

6. Requirements For Depot Tracks

6.1 General

The Trackwork used for depot and service tracks shall consist of continuously welded rail (CWR); turnouts with fixed nose crossings and asymmetrical switch points, elastic rail fastenings, ballasted sleeper trackforms. The Trackwork must be reliable with minimal maintenance and shall fulfil the requirements of the proposed depot and maintenance operations.

Depot and service tracks include all tracks not included in the main line and station track operations. These include stabling yards, maintenance bases/depots, depot buildings, and the approach tracks to these facilities.

The non-ballasted section of the tracks connection on the main line tracks to the depot facilities and the turnout is considered part of the main line.

6.2 Rails

6.2.1 General Technical Requirements

Requirements as per clause 5.2.1 apply with modifications as follows:

- Rail section for all depot tracks shall be 54E1 according to EN13674-1.
- Head hardened Rails are not required in the depot and service tracks.

6.2.2 Material Requirements

The rails shall be supplied in accordance with Sub-Clause 5.2.1.

6.2.3 Rail Welding and Grinding

All rail welds shall be performed by flash butt welding either in a welding plant or with an on-site mobile welding unit to form CWR sections.

Tests welds are to be prepared in accordance with Sub-Clause 5.2.3 item 2.

Testing of the trial welds shall be according to Sub-Clause 5.2.3 item 6.

The minimum distance between two rail welds is 7 meters.

Final welding of the long rail sections may be carried out with a thermic welding process or flash butt welds after final rail thermal de-stressing.

Skim grinding shall be performed at the approaching tracks between the main line and the depot before commencement of operations, to remove mill scale, rust, and rail weld imperfections. Grinding shall be done in accordance with Sub-Clause 5.2.3 item 15.

6.2.4 Insulated and Bolted Rail Joints

The signalling system in the depots and service tracks will require the use of insulated rail joints, particularly at turnout areas. The Private Party shall co-ordinate with the signalling design to understand the exact signalling requirements regarding provisions in the rail for signalling purposes.

The Private Party will determine the final position of the rail joints and the joints have to be installed accordingly.

The details of the Insulated Rail Joints shall follow the requirements in sub-Sub-Clause 5.2.4

6.3 Fastening System

The rail fastening system shall provide support, guidance, resilience, and insulation between the rail and sleeper on ballasted tracks. The main components of the rail fastening system, depending upon design, shall include the following:

- Rail Pads
- Elastic steel spring clip
- Insulating Elements
- Sleeper Screws
- Plastic dowel in sleeper

The exact design and configuration of the rail fastening is subject to the technical requirements of this Clause.

6.3.1 General Requirements

The Private Party shall provide a rail fastening system with adequate resiliency, high accuracy of gauge and control of rail inclination during installation and under revenue service loading.

The fastening systems shall meet the requirements in accordance to European Norm EN 13481-2, Fastening systems, part 2, Performance requirements for fastening systems for concrete sleepers.

The fastening system has to be tested according the EN 13146-1 to 8 Railway applications Track –Test methods for fastening systems – Part 1 to 8. The results shall be submitted to the Engineer’s Representative for statement of no-objection.

If the Private Party intends to test the fastening system according another than the above-mentioned Euronorm he should submit a copy of the standard to the

Engineer's Representative. Additionally he has to show that the proposed testing standard meets or betters the EN 13146, part 1 to 8.

Test shall be performed in an institute independent from the supplier, the results from the approved test institute have to be submitted with the proposal.

The detailed design of the rail fastening system for the different purposes (ballasted track, slab track and depot track etc.), shall contain a complete fastening system drawing (with tolerances) and detailed drawings of all components. These drawings have to be submitted to the Engineer's Representative.

The Private Party shall propose a rail fastening system suitable for all service conditions on the SRT's depot and service tracks, and provide in his proposal information regarding the parameters indicated below:

- Toe Load
- Longitudinal Restraining Force
- Vertical (Uplift) Strength
- Impact Decaying Value for Rail Pads
- Torque Strength of Sleeper Screws and Inserts, if applicable
- Rail Shock Vertical Flexibility Rate
- Fatigue Strength
- Minimum Electrical Resistance Values
- UV protection of the sun-exposed non-metallic parts of the system against solar radiation.

In the detailed design of the track the Private Party shall submit the fastening system for depot and service tracks, composite fastening system drawings (with tolerances) and detailed drawings for all components.

The rail fastening system proposed for turnouts shall meet the requirements of the plain line and depot rail fastenings. For fatigue limits of turnout fastenings, the Private Party shall submit a proposed test procedure applicable for turnouts. Special rail fastenings are anticipated in the vicinity of the crossing vee area; for which the Private Party shall provide details.

6.3.2 Maintenance Building, Wash Building, Inspection, and Other Track Types

The Private Party shall include in his proposal details of the proposed fastening system for these tracks. Where appropriate a fastening system different from those in the tracks in the main line can be used.

6.4 Sleepers

6.4.1 Concrete Sleepers in ballasted Track

The rails in ballasted tracks shall be supported by concrete monoblock sleepers or sleepers from synthetic material.

The minimum length of the sleepers shall be 2.60m and the depth under the rail shall be approximately 210mm.

Concrete sleepers shall be manufactured and tested according the following standards:

- EN 13230-1 Railway applications – Track – Concrete sleepers and bearers – Part 1: General requirements
- EN 13230-2 Railway applications – Track – Concrete sleepers and bearers – Part 2 : Prestressed monoblock sleepers

If the Private Party proposes design and manufacturing of the concrete sleepers to a different standard, the Private Party shall provide a copy of this standard to show that the proposed standard meets or betters the requirements of the specified Euronorm.

The Private Party shall provide evidence that the proposed sleeper design is service proven and used in tracks under similar operational and environmental conditions as found in Thailand for at least 5 years. The minimum installation length of the reference track shall be 10km.

6.4.2 Synthetic sleeper in ballasted Tracks

6.4.2.1 Installation Location

In tracks and turnouts in the Depot, sleepers, manufactured from synthetic material, are acceptable.

The Private Party shall describe the material proposed, the manufacturing process and details of the properties of the synthetic sleeper and submit for approval.

6.4.2.2 General Requirements

Only synthetic materials, that are able to form a solid sleeper block with the same or similar properties as provided by timber sleeper are acceptable for manufacturing.

The Private Party shall compare the properties of the synthetic sleeper with those of timber sleeper made from beech or oak.

All sleepers shall delivered undrilled. The holes shall be drilled on site with a diameter and depth corresponding to the fastening used. The holes shall not penetrate through the sleeper.

The manufacturing length of the synthetic sleeper shall permit preperation of the maximum length of turnout sleeper.

6.4.2.3 Dimensions

Synthetic sleepers shall be delivered with the following dimensions:

For tracks	260mm x 160mm x 2600mm
For turnouts	260mm x 160mm x required length for the installation location in the turnout

The side surfaces of the sleeper shall be rectangular to each other and smooth. The lower and upper surfaces of the sleeper shall be parallel.

6.4.2.4 Tolerances

The track synthetic sleeper shall be manufactured with the following tolerances:

Length: +3cm / -3cm

Width:	+2cm / –0cm in the bearing area, outside the bearing area +2cm / -2cm
Thickness:	+1cm / –0cm in the bearing area, outside the bearing area +1cm / -1cm
	The difference between the thickness of both bearing areas should not exceed ±0.5cm

Turnout sleepers shall be manufactured within the following tolerances:

Length: +3cm / -3cm

Width:	+2cm / –0cm over the complete length
Thickness:	+1cm / –0cm over the complete length

6.4.2.5 Marking

Each sleeper shall be identified by means of identification plate or identification nails.

The identification shall consist of the following information:

- Type of synthetic material used / type of the sleeper
- Name of the supplier
- Month and year of manufacturing

For the name of the supplier approved abbreviations are acceptable.

The mark shall be fixed at the very end of the sleeper.

Synthetic sleeper without marking will not be accepted.

6.5 Ballast

The ballast layer distributes the loads transmitted from the sleepers in ballasted track to the sub-grade below. The ballast also must maintain the linearity of the rail alignment, and provide sufficient resistance to limit any deviation of the track to acceptable levels over time.

Ballast shall also be used as shoulder infill material at the non-ballasted tracks at embankment.

Ballast shall fulfil the requirements stated in EN13450 Aggregates for railway ballast.

The Private Party shall submit with his proposal the following information for ballast:

- Full description of the physical/mechanical and chemical properties of the proposed ballast
- Origin of proposed ballast (country, location of quarry, method of mechanical crushing, etc.)
- Proposed transportation method within Thailand from quarry to storage area
- Unloading at the storage area, loading and transportation to installation site, retrieval from the storage area, etc.

6.5.1 Ballast Material Requirements

Ballast material shall be quarried hard rock, generally consisting of granite, basalt, or other durable igneous rock material capable of being crushed into sharply faceted surfaces.

All ballast shall consist of crushed rock, and mechanical crushing of the parent rock shall form 100% of the ballast particle surface.

The ballast source for any delivery shall be from the same quarry and geological source. Blending of material from different geological sources is not permitted.

Ballast shall not contain impurities such as wood fragments, carbonaceous or organic matter, metal, plastics, or other material inappropriate for ballast. Aggregate fine graded material shall be minimised in the delivered ballast material, and limited to no more than that specified in the ballast grading requirements.

If basalt ballast material is proposed, the Private Party shall determine whether “Sonnenbrand” (sunburn) rock decay is present. This defect is characterised by the appearance of grey and/or white spots, usually with hairline cracks radiating out of the spots. As this is a potentially serious defect, all ballast sources exhibiting signs of “Sonnenbrand” shall be tested in accordance with procedure EN 1367-3 or according DIN 52106.

6.5.2 Mechanical and Physical Ballast Tests and Requirements

The ballast aggregate material shall conform to physical and mechanical qualities as indicated below.

6.5.2.1 Ballast Size Designation

Ballast grading shall be checked in accordance with EN933-1 Tests for geometrical properties of aggregates. Determination of particle size distribution. Sieving method.

The ballast size is designated by the paired minimum/maximum square sieve size (in mm), with "d" defined as the lower limit designation sieve and "D" defined as the upper limit designation sieve.

The ballast size (d/D) required for the Project shall be Grading Category ”E” according to table 1 of EN13450.

Square sieve sizes of 22.4, 31.5, 40, 50, 63 and 80 mm sieves shall be used to determine gradation limits. Additional sieves of 0.063 and 0.5 mm are required to determine undersize ballast particles as indicated below.

The amount of fines passing the 0.5mm sieve shall follow Fine Particle Category B of table 2 of EN13450. The maximum percentage shall not exceed 1%.

The amount of fines passing the 0.063mm sieve shall follow Fine Particle Category B of table 3 of EN13450. The maximum percentage shall not exceed 1%.

For the execution of testing the ballast grade a ballast sample of at least 50-kilogram has to be taken according to Sub-Clause 6.5.3 item 4

After initial sieving, either mechanically or by hand, all particles remaining on the sieves over 22.4 mm should be sieved again by hand to ensure that the ballast particles pass the proper sieves. If applicable, it has to be tested by hand whether the remains can pass the sieve.

All particles on the sieves shall be weighed to an accuracy of 0.5 g.

6.5.2.2 Ballast Shape (Flakiness)

Ballast shape shall be tested in accordance with EN933-4 Tests for geometrical properties of aggregates. Determination of particle shape. Shape index

The distribution of ballast particles with a length/thickness ratio (flakiness) of at least 3:1 shall be between 5.0% and 30.0% by weight in accordance with, using samples with ballast particle sizes of (31.5/40) and (40/50).

Ballast particles exceeding 100 mm in length shall not exceed 6.0% by weight.

6.5.2.3 Resistance to Weathering (Soundness) Tests

The water absorption test shall be carried in accordance with EN1097-6 Tests for mechanical and physical properties of aggregates - Part 6: Determination of particle density and water absorption.

The acceptance criteria is a water absorption value of less than 0.5%.

6.5.2.4 Resistance to Degradation (Los Angeles Test)

The resistance to degradation shall be carried out in accordance with EN1097-2 Tests for mechanical and physical properties of aggregates - Part 2: Methods for the determination of resistance to fragmentation.

Ballast for the Project shall follow the LA_{RB} category 16 with an Los Angeles Coefficient of ≤16.

6.5.2.5 Compressive Strength Test

The compressive strength test shall be carried in accordance with ASTM C 170-50. Minimum compressive strength for tracks shall be 1835 kg/cm2.

6.5.3 Quality Control of Ballast

The Private Party shall have a system of production control in place at the quarry that complies with acceptable practices in the country of origin of the ballast, and with procedures specified in the control documents. The Private Party shall indicate what quality control procedures are in operation during the production of ballast and maintain records for all ballast delivered to the Project.

The Private Party shall assign a checking institute for the test after approval by the Engineer's Representative.

The Private Party shall demonstrate to the Engineer's Representative, before shipping ballast to the site or works base from any source, that the rock source meets all requirements for ballast material.

A complete cycle of qualification testing shall be conducted before initial acceptance of a ballast source can be provided. The same initial tests and acceptance are required whenever the ballast source is changed.

In addition to the initial qualification testing for ballast sources, ballast samples shall be taken from the ballast:

During the production and supply process, including stockpiles at the works base or construction site prior to Trackwork installation.

The frequency of ballast sampling is indicated below. All samples taken shall include the date; sample location; person in charge of taking sample; identification of supplier; and ballast source.

6.5.3.1 Ballast Samples from Production Facility and Stockpile

The Private Party shall submit a program to the Engineer's Representative during design that will be used to satisfy the ballast sampling requirements herein. From each delivery of ballast the Private Party shall provide the Engineer's Representative with a 50kg sample from the crushing facility. This shall be used to provide a base reference from which the degradation of the ballast material due to transportation to the installation sites can be assessed.

Ballast samples shall be collected for every $1000m^3$ of ballast supplied to the Project. Samples shall be taken at the works base or construction site stockpiles.

For stockpile sampling, a minimum of four samples of at least 50kg each shall be taken at different depths of the stockpile to form a collective 200-kg sample.

For production facility sampling, a minimum of four samples of at least 50 kg each shall be taken at four different locations of the facility to form a collective 200-kg sample.

6.5.3.2 Ballast Samples from First Layer, Installed Pre-Ballast

Ballast samples shall be taken from the first layer of Trackwork every 2000 track-meters through the entire width and depth of the ballast section. A sample of approximately 200-kg is to be collected for testing.

6.5.3.3 Ballast Samples from Installed Trackwork

Ballast samples shall be taken from the installed Trackwork every 500 track-meters by the excavation of one sleeper space from the surface down to the first ballast layer. A sample of approximately 200-kg is to be collected for testing.

6.5.3.4 Test Procedure for Ballast Samples

Each 200-kg ballast sample shall be reduced to a 50 kg averaged sample by the following procedure:

The collective 200-kg single sample shall be placed on a clean smooth surface, using steel sheets, wood planks or rubber mats for support.

The collective 200 kg sample shall be thoroughly mixed by shovel, then formed into a pyramid by shovelling the ballast into a single pile, permitting ballast to flow down the sides of the pile equally until a maximum practicable pile height is achieved.

The pile pyramid is then flattened and cut into four equal sections. Two opposite quarters are removed and discarded.

The above procedure is repeated until an approximately 50 kg averaged sample is obtained.

The averaged sample shall be designated with a lot number with the ballast source or locations represented by the sample. The entire 50 kg sample is sieved to determine ballast gradation, and all ballast particles longer than 100 mm shall be weighed.

All averaged samples shall then be subjected to all tests as stated above, except for the compressive strength test.

In the event of the failure of a ballast sample in any of the above tests, the quantity of ballast to which the sample is associated shall be rejected and removed from the Project site, unless otherwise approved by the Engineer's Representative.

6.5.4 Transportation and Storage of Ballast

The Private Party shall submit a separate plan for each ballast source or production plant that is used for the ballast supply. If multiple ballast sources are used, the estimated total production from each facility, compared with the total ballast quantity required for the Project, shall be submitted to the Engineer's Representative.

Ballast stockpile storage shall be on a site where the ballast can be unloaded, stored, and loaded onto ballast wagons without contamination from deleterious material and fine aggregate.

6.5.5 Ballast Laying

Ballast positioned over 50 cm below the ballast surface in the storage stockpile shall be fully mixed before transport to the Trackwork installation site.

The ballast in the storage stockpile within the first 50-cm layer from the ground shall only be after additional sieving and testing.

The Private Party shall submit details of installation procedures and equipment proposed for the initial ballast layer installation and subsequent procedures for tracklayer raises and ballast compaction.

The Private Party shall program an initial ballast layer as soon as practicable after handover of any track sub-ballast layer, in order to minimise deformation of the sub-ballast layer surface by erosion or construction equipment. The Private Party shall restore all deformation of the sub-ballast surface or damage to waterproofing layers occurring after Private Party's access date to the individual section of Works.

6.5.6 Approval of ballast sources

The sources of the ballast shall be proposed by the Private Party and submitted for the statement of no-objection of the Engineer's Representative.

The Private Party shall engage an independent geological engineer of a professional standard to check and prepare a report regarding the following:

- Suitability of the rock in the quarry for the extraction
- Estimated amount of ballast that can be excavated from the source
- Estimated amount of ballast manufactured per day,
- Description of the equipment to crush the rock and to sieve the ballast
- Results of the tests on the ballast material including
  - ➢ Rock determination
  - ➢ Impact resistance
  - ➢ Los Angeles Test
  - ➢ Compressive strength test
  - ➢ Ballast shape (Flakiness)
  - ➢ Resistance to weathering (soundness) test
  - ➢ Ballast grading
- Method of loading and transportation of the ballast from the source to the work site.

The quarry shall carry out internal tests of the ballast quality during the manufacturing. Documentations of the results of the tests shall be prepared and handed over to the Private Party. The Engineer's Representative may request the handing over of the documents.

The achievement of the ballast requirements has to be confirmed by testing on a monthly basis by an Engineer's Representative approved organisation or company, independent from the ballast supplier.

The results shall be handed over to the Engineer's Representative.

6.5.7 Warranty

In cases where the delivered ballast does not fulfil the specific requirements herein, the ballast shall be returned to the supplier.

6.6 Trackwork in Tracks between Main Line and Depot, Stabling Yard or Maintenance Base

In the approach tracks to the depot, stabling yards and maintenance bases, non-ballasted and ballasted trackforms are acceptable.

The connecting track begins immediately at the end of the last turnout in the mainline and continues to the first turnout in the ballasted section in the depot, stabling yard or maintenance base.

The Private Party shall propose for a fastening system, suitable for a speed of 80 km/h and an axle load of 15 tons whilst maximising commonality with main line and depot tracks.

In viaduct areas the deck surface is flat and the Private Party shall propose for the connection between the deck and the slab track. A solution with holes drilled into the structural concrete and bolts with a nut at both ends, grouted into the holes, would be acceptable.

The procedure for drilling the holes into the deck and inserting the bolts into the structural concrete shall be described taking into consideration the presence of a waterproofing layer under a screed.

6.7 Special Trackwork, Turnouts

6.7.1 General

Turnout geometry shall meet the geometric requirements as indicated in the depot alignment drawings.

6.7.2 Bearers

All turnouts shall be mounted on pre-stressed reinforced concrete sleepers according sub-section or on synthetic sleepers as indicated in Sub-Clause 6.4.2

Bearers are to be manufactured in accordance with

- EN13230-1 Railway applications – Track – Concrete sleepers and bearers – Part 1: General requirements and
- EN13230-4 Railway applications – Track – Concrete sleepers and bearers – Part 4: Prestressed bearers for switches and crossings;

Sleeper design shall incorporate requirements for long turnout sleepers and impact loading particular to turnouts.

6.7.3 Fastening system

The rail fastening system shall provide track elasticity similar to the adjacent track.

6.7.4 Sliding Baseplates

The baseplates of the turnouts installed in the depot and workshop area shall be of a lubrication-free design.

The turnout design shall not impair the tamping process.

The design shall be submitted by the Private Party for statement of no-objection by the Engineer's Representative.

6.7.5 Crossings

The Private Party shall demonstrate that the proposed crossing design and materials have been proven in revenue service in depots with comparable axle loading and traffic volume. Three types of crossing designs are acceptable for depot and service tracks:

- Semi-welded crossings with post heat treated high strength rail steel
- Solid cast manganese steel crossings
- Rail steel wing rails with manganese steel inserts

6.7.6 Switch rails

Switch rails shall be manufactured from an asymmetrical rail section with tangential geometry at the switch toe. The rails shall be head hardened to grade R350HT.

The Private Party shall demonstrate that the remaining cross section of the switch rail after machining is still within the head hardened area. Otherwise head hardening of switchblades shall be executed after machining.

Switch and crossing designs shall include provisions for depot operation and shall be designed for both new and fully worn wheel profiles.

The turnout geometry shall conform to the depot alignment drawings. The Private Party shall indicate the proposed geometry through the diverging side of the turnout, as well as the applicable national code or standard used, in its initial turnout submissions.

The switch rail drive system, locking devices, and position detection devices shall comply with the chosen signal system.

6.8 Buffer Stops

6.8.1 Friction Type Buffer Stops

Friction type buffer stops shall be installed at the ends of all stabling tracks and other tracks where regular train operation is performed.

The type and design of the buffer stop shall be capable to stop an empty train, hitting the buffer stop with a speed of 10 km/h within a distance of 10 m. The buffer stop design shall be such that neither the train nor the track will incur major damage.

At the location of welding joints the weld has to be prepared such that the cross section conforms to a 54E1 profile.

6.8.2 Wheel stops

Wheel stops are to be installed at the end of all workshop tracks.

The buffer stops shall be suitable to stop a train with a maximum speed of 5 km/h within 4m.

6.9 Level Crossings

Level roadway and pedestrian crossings shall be installed in the depots.

Level crossings shall be constructed using pre-fabricated level crossing panels from concrete or rubber, or can be constructed from rails embedded rails.

The supporting structure for field side located level crossing panels and for embedded rail shall be provided by the Private Party.

6.10 Depot Building Track

The Trackwork Private Party shall install the tracks in the depot and workshop buildings which are utilised by the rolling stock.

6.11 Signs and Markers

Signs and Markers according to Sub-Clause 5.14 shall be installed in the approach tracks to the Depot and in the Depot area.

Additional Stabling Limit Markers have to be provided in the stabling tracks. They have to be affixed to the sleepers on the side, which determines their position.

6.12 Acceptance Tolerances

The following measures apply for the acceptance tolerances of the Depot and service tracks and the tracks, connecting the Main line with the Depot, for the Turnouts in the Depot and for the Rail Expansion Joints and refuge tracks:

Depot Tracks

Item	Required Tolerances	Description
Gauge (nominal 1435 mm)	+ 3 mm - 3 mm	Deviation from the nominal value
Cant/Cross Level	± 3 mm in straight tracks and circular curves ± 3 mm in transition curves	Deviation from the designed value
Vertical Alignment (level)	Max. different between adjacent versines: +3 mm - 3 mm	Related to a versine with a 20-m-chord, measured at points with 5 m spacing. versine $v=S^2/8R$
Horizontal Alignment	Max. different between adjacent versines: + 4 mm - 4 mm	Versine measured with a 20-m-chord in curves and transition curves according the calculated value. Distance between the measurements 5 m.
Designed Level	Max. deviation from designed level: + 8 mm - 8 mm	Measured at the reference points at the catenary masts, between two adjacent reference points the different should be less than 10 mm.
Designed Alignment	Max. deviation to designed position at reference points + 8 mm - 8 mm	Measured between centreline of track and reference point. The rate of change of the designed alignment should not exceed 1:2500.
Twist	1:1000	Deviation over 2.5 m ≤2.5 mm
Welding	Running surface on the railhead, max deviation: ≤+ 0.3 mm ≤- 0.2 mm Running edge, max. deviation: ≤+0.3 mm to the field side 0.0 mm to centreline of track < 1.0 mm offset of rail foot	Measured with a 1-m straight edge

Turnout

Item	Proposed Tolerance	Description
Gauge	No deviation	From allowed tolerance at measuring location according turnout inspection record
Relative Position of Stock Rail to Tongue Rail	+ 2 mm - 2 mm	In order to ensure the function of the locking device

Item	Proposed Tolerance	Description
Check-Rail Gauge (if applicable)	No deviation	From allowed tolerance at measuring location according turnout inspection record
Flangeway (if applicable)	No deviation	From allowed tolerance at measuring location according turnout inspection record
Cant/Cross Level	+ 3 mm - 3 mm	Deviation from the designed value
Designed Level	Max. deviation from designed level: + 8 mm - 8 mm	Measured at the reference points at the catenary masts, for speed > 160 km/h the max. difference of the deviation for adjacent points must not exceed 10 mm.
Designed Alignment	Max. deviation to designed position at reference points + 8 mm - 8 mm	Measured between centreline of track and reference point
Sleeper Spacing and Location	Deviation to the designed spacing: Max. ± 5 mm	Deviation from spacing according turnout supplier's shop drawing
Welding	Running surface on the railhead, max deviation: ≤+ 0.3 mm ≤- 0.2 mm Running edge, max. deviation: ≤ 0.3 mm to the field side 0.0 mm to centreline of track < 1.0 mm offset of rail foot	Measured with a 1-m straight edge
Tamping Quality of Sleepers	Max. 10 % But no loose sleeper permitted in the frog and switch area	The sleeper are loose, when they have hollows under their bottom, caused by insufficient tamping work. It can be visually checked during passing of trains.
Distance between Switch Rail and Sliding Baseplate	Max. 3 mm	
Distance between Switch Rail and Stock Rails/Heels	Max. 2 mm	

Rail Expansion Joint

Item	Additional Tolerance	Description

Gauge	No deviation	according rail expansion joint inspection report and measuring location
Adjustment of the Rail Expansion Joint	Less than 10 mm immediately after installation of the rail expansion joint	Will be compared with the bridge elongation measuring device.
Spacing between Tongue rail and Stock Rail	Max. 1.5 mm	Measured at the stock rail, attached to the tongue rail
Mobility between Tongue Rail and Stock Rail	Max. 1.5 mm	Visual check of spacing between tongue rail and supporting plate

6.13 Acceptance Test

An acceptance test according to Sub-Clause 5.16 shall be executed in all depot and maintenance base tracks where trains are running.

In depot buildings and washing plants the use of the geometry-measuring vehicle is not required.