2. SPECIFICATIONS
B) TECHNICAL REQUIREMENTS

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1 SYSTEM REQUIREMENTS

1.1 INTRODUCTION

The purpose of this document is to define the minimum Technical Requirements (ERT) for the Metro Manila Subway Project (MMSP). This ERT is supported by a General Requirements (ERG) and other tender documents. Should there be any discrepancy between the ERG and ERT, the ERT shall prevail.

This document includes the requirements as laid out in the Contract; these requirements shall be subjected to a formal verification and validation process supported by a requirements management database all of which will be supplied by the Contractor to include e.g. production, FAT, delivery, integrated testing and commissioning, acceptance including supply and delivery to Site of all related materials, spare parts, special tools, documentation, training, etc. to ensure satisfactory operation and maintenance of the new Rolling Stock fleet.

The scope of this document is to assist in the procurement of a new 30 x 8-car Rolling Stock fleet. The following shall, without limitation, be included in the Works:

1) Provision of all documentation and support materials associated with the operation and maintenance of the vehicles as specified herein;
2) Technical support and defects notification coverage until the completion of the Defects Notification Period;
3) Interfacing with other systems and contractors, which includes but is not limited to on–board communications and signaling equipment, including design, provision of equipment, components and materials as specified in all interface requirements described within these ERG and ERT documents;
4) Training for maintenance staff, engineers and operators, including all necessary training materials, training kits, demonstration equipment and training venues;
5) Supply and installation of all consumables and materials required for testing and commissioning;
6) Provision of drawings, calculations and other documents as specified herein and/or as may be required;
7) Provision of design development items, studies and reports as specified herein;
8) Recommendation and supply of spares and consumables, special tools, special test equipment and special training as specified herein;
9) Supply of any other equipment or any other service that may be required for completion of the Works; and
10) The MMSP Rolling Stock fleet shall be designed to manage interoperability with NSRP-S.

1.2 DESIGN REQUIREMENTS

The requirements listed in this ERT are the minimum levels of design conformance and acceptable functionality. They are not intended to restrict innovation and flexibility within the design process, but set parameters for that process which shall not be contravened where emphasized.

The Contractor's design process shall ensure that all systems, subsystems, assemblies and components of each consist are complementary and compatible in form and function. Other design requirements not specifically mentioned in this ERT but found and deemed necessary by the Contractor for the complete and efficient completion of the Project shall be

presented/submitted to the Engineer for review.

The Contractor shall design in consideration with the Employer's intention that specifications of Rolling Stock of interoperability section shall be unitized. At least the Contractor shall assume that systems needed for the line in which the train assumed to run need to be mounted individually, etc. requirements.

1) Radio system;
2) Train protection radio;
3) Signaling systems;
4) Running and stopping assistant system; and
5) PSD controller.

The following general design concepts shall be incorporated to increase maintainability and maximize availability and at the same time meet efficient operational and environmental requirements.

1) Use of interchangeable, modular components;
2) Use of service proven design;
3) Avoiding use of equipment that is deemed "black box";
4) Use of extensive and prominent labelling of parts and wires;
5) Use of unique serial numbers for traceability of components;
6) Focus on low life cycle cost as much as possible;
7) Environment and human friendly;
8) Minimize human error (in usage);
9) Cost efficient (energy and labor); and
10) Handicapped people responsive as per the National Council on Disability Affairs - IRR of BP 344.

1.2.1 Previous Usage

Equipment, assemblies and sub-assemblies, components and materials shall have proven record of satisfactory use in other Rolling Stock applications and shall be demonstrated as satisfactory to the Engineer.

Where design improvements can be made to enhance equipment performance, these shall be carried out and demonstrated in compliance with ERG - Section 8.

1.2.2 Codes, Standards and Requirements

Codes, Standards and Requirements specified in this ERT shall be interpreted as a requirement for compliance. But Japanese standards such as JIS, JRIS and Technical Regulatory Standards on Japanese Railways shall be basically complied, unless otherwise described.

This ERT shall be basically applied the Japan Industry Standards (JIS), the Japan Rolling Stock Industry Standards (JRIS), and the Technical Regulatory Standards on Japanese Railways of Ministry of Land Infrastructure, Transport and Tourism (MLIT).

1.2.3 Design and Manufacturing Tolerances

Where not specifically identified by statement or reference code, the Contractor shall establish

design and manufacturing tolerances reflective of best industry practice and shall be reviewed by the Engineer.

1.2.4 Design Management and Control

The Contractor shall establish, maintain and document the procedures to control and verify the Rolling Stock consist, design and all of its equipment. The Contractor shall submit a Design Submission Program for review by the Engineer.

The Contractor shall establish and maintain a documented systematic, comprehensive and verifiable system integration process throughout the execution of the Works. These processes shall ensure that interfaces and interaction between vehicles, infrastructure, subsystems, software and operating and maintenance requirements have been identified and engineered to function together as a system.

1.2.5 Design Review

1) At appropriate stages in the design process, formal documented reviews of the design and related issues shall be planned and conducted, which shall be in line with the Design Submission Program;

2) The Contractor shall ensure that participation in design reviews includes representatives of all functions, disciplines and entities concerned with the equipment and the stage being reviewed;

3) The Contractor shall at least 15 days prior to the date of each design review to submit in-progress design documents of the elements to be addressed at the meeting to the Engineer and all concerned. The Engineer reserves the right to attend any and all design reviews;

4) The Contractor shall, within 15 days after the date of each design review, submit to the Engineer Design Review Minutes, detailing all issues raised during the review, their resolution or ongoing design status and due date for resolution. These will be reviewed by the Engineer;

5) The Engineer reserves the right to carry out design audits of the Contractor periodically throughout the Contract as may be deemed necessary for validation of the design; and

6) The Engineer's response to the submission shall be made within 45 days of receipt of the submission; however, the Engineer shall endeavor to respond within 30 days, provided that the submission is made no later than the date shown on the Design Submission Program. The Engineer may extend the review period depending on the amount of documentation accompanying the submission.

1.2.6 Special Responsibility of the Contractor

No examination, review and approval by the Engineer of the design, drawings, and documents submitted by the Contractor, with or without amendment, or any approval or comment or consent given by the Engineer for any equipment or part of the Works, shall absolve the Contractor from any of their obligations under the Contract or any liability arising out of the designs, drawings and documents or equipment or part of the Works.

1.2.7 Driver's Cab and saloon Mock-up

In order to evaluate the effectiveness of the driver's cab and a part of saloon's layout and function as specified in Sub-Clause 6.15 of the ERT, the Contractor shall develop the interior design of the total length of approx. 7m, fully equipped driver's and a part of saloon mock-up. The driver's cab mockup shall be fully equipped to show completely built interior condition. The entire design of the driver's cab and saloon shall be reviewed by the Engineer. The mockup shall be strong enough to accommodate persons inside without the damage or

deformation. It shall be constructed on a substantial platform, to facilitate transportation and to prevent damage (cracking) and distortion of the hardware.

1.3 BASIC TRAIN FORMATION

1.3.1 General Vehicle Configuration

The Rolling Stocks of MMSP consists of 8 cars. The schematic diagram of train configuration is shown in Appendix A.

Under emergency conditions and/or train recovery, one train must be capable of operating with another train coupled to it for hauling or pushing.

The mass (tare weight) of the 8-cars train-set shall be 270 tons or less. Weight balance, lower center of gravity, etc., shall be taken into consideration.

On the other hand, it has possibility that the train configuration will be 10 cars in the future. In case of the above, the example of train configuration (5M5T) is shown as below, and the systems which have already equipped shall be able to be applied without making alterations.

"Tc-M-M'-T-M-T-T-M-M'-Tc"

Tc:Trailar car with Cab T:Trailar car M:Morter car

1.3.2 Power and Auxiliary Electric System Configuration

The motor vehicle shall be powered with one (1) power conversion equipment driving four AC motors each for the propulsion and the trailer vehicle shall be powered with a primary inverter to serve the auxiliary loads.

The simplified block diagram explaining this is shown in Appendix A for reference.

1.3.3 Rolling Stock Gauge

The vehicle body and installed equipment in static mode shall not exceed the Rolling Stock Gauge in the following conditions:

1) On a level, tangent track, the Rolling Stock is in a stopped state with the car body and bogies center lines aligned with the track center line;
2) The load condition is between the empty condition and the crush load condition; and
3) The car body and bogies are not tilting due to passengers or loaded material.

The Rolling Stock Gauge is shown in **Appendix B**.

1.3.4 Vehicle Physical Characteristics

1) The following physical characteristics indicate fundamental vehicle dimensions that shall be given careful consideration:
   a) Vehicle body Length: 19,500 mm (excluding coupler, overhung of leading cars)
   b) Overall length: 20,000 mm (excluding overhung of leading car)
   c) Train length: 160,000 mm (excluding overhung of both leading cars)
   d) Overall Width: 2,950 mm (excluding light on both sides of the vehicle)

e) Overall height from top of rail to roof: 3,655 mm (excluding air conditioning system on the roof)

f) Floor height: 1,130～1,150 mm

g) Pantograph lock down height: Max. 4,150 mm

h) Pantograph height working range: 4,400 – 5,415 mm

i) Wheel Diameter: 780～860 mm

j) Wheel base: 2,100 mm

k) Distance between Bogie center: 13,800 mm

l) Passenger Doors: pocket type

m) Doorway width: 1,300 mm

n) Doorway height: 1,850 mm.

o) Positions of passenger doors in the car shall comply with Appendix C. Distance between each passenger doors in train-set shall comply with Appendix C.

2) Alternative vehicle configurations and physical characteristics may be proposed and considered subject to verification of suitability of performance, capacity, network compatibility, infrastructure and facilities, etc.

1.4 TRACK STANDARDS

Main Line : EN 60 E1, Standard length 25 m.

Depot : JIS 50N, Standard length 25 m.

1.5 ROUTE DATA

1.5.1 Horizontal Curve Radius

1) For Main Line: More than 160m in MMSP, More than 300m in NSCR, More than 260m in NSRP-South, More than 350m in MCRP

2) For Side truck: More than 100m

3) For Station: More than 400m

4) For Turnout: More than 100m (Main Line, Depot),

1.5.2 Transition Curve Length

MMSP, MCRP, NSRP-South:

400Cm

300Cm (absolute maximum)

NSRP

Maximum out of L1, L2, and L3

Where Cm=actual cant, L1=800 C, L2=7.5 CV, L3=6.75 CdV

The Track work subsystem shall liaise with the Rolling Stock for the relationship between permitted train speed, track radius and track cant.

Length between transition curves: more than 20 m

1.5.3 Gradient

Main line

For Main Line: 35/1,000

For Turnout :25/1,000

Stations

Level (0)

Absolute maximum: 5/1000

Turnouts and stabling track: Level (0)

1.5.4 Vertical curve radius

3000 m (4000 m where curve radius less than 600 m)

2,000 m (6,000 m where curve radius is less than 600 m) (absolute maximum)

Vertical curve is required for more than 10/1000 of gradient change

1.5.5 Width of Formation

More than 2.75 m

1.5.6 Distance between Track Centers

More than 4.3m (Main Line),

More than 4.3m (Station),

More than 4.3m (Stabling track)

1.5.7 Width of Structure Gauge

3.4 m (Tunnel section)

4.0m (Station and not tunnel section)

1.5.8 Station Platform

Length: 210m

Width: 8 m (standard)

1.5.9 Signaling System

Communication Based Train Control (CBTC) signaling system will be adopted for the MMSP section.

1.6 ENVIRONMENTAL CONDITIONS

The general environmental conditions in the Manila area are as follows:

1) Ambient temperature : Min. + 15 °C - Max. +45 °C
2) Relative humidity : Min. 60% - Max. 100%

3) Maximum rainfall : 60 min. rating 120 mm/h
4) 30 min. rating : 180 mm/h
5) 10 min. rating : 270 mm/h
6) Maximum wind velocity: 60 m/sec
7) Maximum wind velocity at which train operations shall stop: 27.8 m/sec.

The Contractor is reminded that the alignment in Manila is near the sea coastline and runs through a relatively polluted air environment which may present a mildly corrosive atmosphere. Also, because of the generally long dry season, the air has high dust content.

The Contractor shall ensure that all equipment shall operate satisfactorily under the above conditions.

1.7 WEIGHT LIMITS

1.7.1 General

The vehicles shall be designed on the following definitions of vehicle loading with passenger weight taken as 65 kg per passenger.

A train consist of eight (8) vehicles shall have a passenger capacity of not less than 2,242 passengers (seating and standees). Maximum axle load shall not exceed 16,000 kg.

1) W0: tare weight
2) W1: W0 + seated passengers
3) W2: W1 + 4 passengers/m² standee
4) W3: W1 + 7 passengers/m² standee
5) W4: W3 + dynamic load and safety margin.

The structural design load (W3) is defined as the limit of static weight for the Rolling Stock structure before the introduction of dynamic effects and safety margin. Dynamic load and safety margin shall be added in accordance with JIS E7106.

1.7.2 Weight Penalties

The maximum weight of the 8-car trainset (tare weight) shall be 270 tons.

If the trainset is heavier than the indicated maximum weight, a penalty will be applied per train set as follows:

1) A 0.1% of trainset price (as determined by the Engineer based on the Schedule of Prices) per every 100 kg above maximum weight, for each 8-car train set; and
2) If the mass of the trainset is more than 2,000 kg above the indicated maximum weight, the Contractor shall demonstrate the axle load of the Rolling Stock under all possible conditions such as crush load (20 t/car), in-balanced load and etc., will not exceed the 16 tons axle load limit, or else the Engineer has the right to refuse the acceptance of the vehicles, on behalf of the Employer.

1.7.3 Weight Control Program

The Contractor shall tabulate the weight of all major systems and all ancillary equipment for each vehicle type, and shall provide this information to the Engineer on a monthly basis during the design and manufacturing phases of the Project.

Should the tabulations indicate that the mass of any piece of hardware shall exceed the

predicted value; the Contractor shall immediately advise the Engineer of the steps to be taken to achieve the overall guaranteed weight. During the manufacturing phase, estimated weight shall be replaced in the tabulations by actual measured weights.

The Contractor shall also provide the Engineer with the locations of the center of gravity of the completed vehicle bodies and completed bogies, plus the finished vehicle.

1.8 TRAIN PERFORMANCE

1.8.1 General

For the purpose of calculating and submitting train performance figures, train configuration and weight shall be as defined in Sub-Clauses 1.3 and 1.7 Basic Train Formation and Weight Limits, respectively. Acceleration and braking requirements shall be met under 20t/car loading condition and with half-worn wheels.

1.8.2 Performance Values

The following train performance shall be achieved, under any conditions of wheel wear, except where noted:

1) Maximum operation speed : 120 km/h
2) Acceleration : 3.3 km/h/s (starting)
3) Jerk limit under all acceleration and service braking conditions (max.): 1.1 m/s^3
4) Service brake deceleration : 4.2 km/h/s
5) Emergency brake deceleration : 4.7 km/h/s
6) Severity of service : Shall meet conditions of continuous round trip of peak operation at loads of 20 t/car or higher, without adverse effect to any system.

Acceleration and deceleration values must be maintained under all loading conditions. All braking requirements must be maintained under all loading conditions. Jerk during acceleration and deceleration shall not be more than 1.1 m/s3 (except under emergency braking condition) and in any direction. Failure of the jerk limiting system shall not limit the braking effort. Indicated speed shall be within ±2 km/h of actual speed at any speed.

In addition, the pneumatic system shall meet the following brake reaction times:

1) Full service brake application : 1.5 seconds
2) Emergency brake application : Max 1.5 seconds (less than the full service brake application time)
3) Full service brake release : 2.0 seconds
4) Emergency brake release : 3.0 seconds.

The brake reaction times of 1 and 2 are defined from the order of braking to 90% of brake cylinder pressure, and those of 3 and 4 are defined from full pressure to 10% of brake cylinder pressure.

1.8.3 Performance Characteristics

Performance curves for traction and braking shall be established on the basis of kN / metric ton versus speed for the W3 and 20 t/car loading condition. The corresponding traction motor

characteristics, and the train mass, shall be considered in the Design Performance Curve as defined in JIS E 6101 (which is consistent with IEC 60349).

1.8.4 Degraded/Emergency Performance

The Contractor shall confirm by calculation and by test that an 8-car train with 20 t/car loading condition, with the propulsion system on one of the 4 motor car units totally inoperative is capable of completing a continuous trip.

The Contractor shall confirm by calculation and test that 8 cars train-set at 20 t/car loading condition, with the propulsion system on two of the 4 motor car units totally inoperative is capable of completing one round trip. However, reduction of acceleration and restriction of regenerative braking force may be accompanied.

The Contractor shall confirm by calculation and test that 8 cars train-set at 20 t/car loading condition is capable of pushing/towing another 10 cars train-set in 20 t/car loading condition (537 ton) to the nearest station, including traversing the maximum main line gradient. If the healthy train cannot pushing or towing on the maximum main line gradient, the high acceleration mode shall be applied.

Similarly, the Contractor shall confirm by calculation and test that 8 cars train-set at W0 loading condition is capable of pushing/towing another 10 cars train-set also at W0 loading condition (337 ton), with an inoperative propulsion system, from the farthest terminal station back to Depot, including starting on a maximum main line gradient 3.5% upgrade. If the healthy train cannot pushing or towing on the 3.5% upgrade, the high acceleration mode shall be applied.

The Contractor shall confirm by calculation and test that 8 cars train-set at W0 loading condition is capable of pushing/towing 10 cars train-set at 20 t/car loading condition (537 ton) with an inoperative propulsion system on a 3.5% upgrade at the tangent track of 2.0 km. If the healthy train cannot pushing or towing on the 3.5% upgrade, the high acceleration mode shall be applied. But this requirement is under the non-slip condition, and the adhesion at this requirement doesn't need to be considered. The test can be conducted under the non-slip condition.

For the test at 20 t/car written above, it is also permitted to convert from the results of empty tests and certain loaded tests.

In case of coupling inoperable train and rescue train, emergency brake circuit shall be connected between these two trains by emergency electric coupler. These two trains emergency brake shall be controlled at the same demand synchronously from both train's operator cabs. Intercom between these trains, buzzer and any other circuit required for rescue operation shall be connected by emergency electric coupler. The specifications for rescue operation and emergency electric coupler shall be considered coupling other project trains in interoperability section and shall be reviewed by the Engineer.

1.8.5 Brake Performance at Parking

The Contractor shall confirm by calculation and by test that the friction brakes are capable of holding a 8-car train with 20 t/car loading condition on a 3.5% grade. Also, the Contractor shall confirm by calculation and test that the parking brakes are capable of holding 8 cars train-set coupled to a disabled 10 cars train-sets both trains at W0 load condition on 3.5% grade. It will be acceptable to test the friction brakes performance by loading equivalent to 10 cars train-sets. For the test at 20t/car written above, it is also permitted to convert from the results of empty tests and certain loaded tests.

The parking brake force on an individual axle shall allow wheels to rotate during emergency train recovery (pushing/pulling of defective trainset).

1.8.6 Performance Calculation

The Contractor shall calculate train performance by simulation. A running curve with speed versus distance for both directions shall be provided as a simulation result.

Rotating mass shall be calculated by the shape of the wheel, brake disc, rotor of motor etc. for the performance calculation.

1.8.7 Energy Consumption

The Contractor shall design the train to minimize energy consumption and calculate energy consumption of the train running on the entire revenue line for both directions at a loading conditions of W0 and W0 plus a load of 20 t/car. The unit of energy consumption shall be applied kWh/ton/km.

1.9 NOISE, VIBRATION AND AERODYNAMICS

1.9.1 Noise Requirements

The Rolling Stock shall be designed and tested to meet the following noise levels:

1) The interior noise level at any point in any vehicle (including the Driver's Cab), 1.6 m above floor level, while stationary on an open section of track, but with all auxiliary systems running, shall endeavor not to exceed 69 dB(A) Lmax;
2) The exterior noise level of any vehicle, measured 7.5 m from the center and 1.5 m above rail level, while stationary on an open section of track with all auxiliary systems running, shall endeavor not to exceed 73 dB(A) Lmax;
3) The interior noise level at any point in any vehicle (including the Driver's Cab) 1.6 m above floor level, with the train running at 0 to 60 km/h on an open section of track, with all auxiliary systems running, shall endeavor not to exceed 74 dB(A) Lmax. Compliance to this requirement to be validated at the Contractor's proposed facility;
4) The exterior noise level of any vehicle, measured 7.5 m from the center and 1.5 m above rail level, with the train running at 0 to 60 km/h on an open section of track with all auxiliary systems running, shall endeavor not to exceed 83 dB(A) Lmax. Compliance to this requirement to be validated at the Contractor's proposed facility; and
5) Door operation noise produced by simultaneous operation of all saloon doors on one side of the car shall endeavor not to exceed 72 dB(A) Lmax during the sliding operation and 78 dB(A) Lmax for the locking/unlocking.

The tests shall be conducted according to JIS E 4021 for the internal noise. The tests shall be conducted according to JIS E 4025 for the external noise.

Measurement of running train noise, both for the interior and the exterior case, shall be conducted on MMSP mainline track or at the Contractor's proposed facility where rail roughness is compliant with JIS E 4021/4025.

1.9.2 Vibration Requirements

All equipment, sub-assemblies and components shall be capable of withstanding shock and vibration of the Rolling Stock satisfactorily such that they do not fail prematurely within their designed life.

With the train at stationary and with all auxiliary equipment operating at rated capacity, no portion of the interior of the vehicles shall exceed the following levels of vibration:

1) 2.5 mm peak-to-peak amplitude for frequencies less than 1.4 Hz;
2) 0.01 g peak acceleration for the frequency range 1.4 Hz to 20 Hz; and
3) 0.75 mm/second peak velocity for the frequency range above 20 Hz.

1.9.3 Noise and Vibration Control

Rotating or reciprocating equipment and inductive electrical equipment (such as transformers, inductors, etc.) mounted to the rail vehicle body, which may become a source of vibration, and any equipment (bogie or vehicle body mounted) which may become a source of noise and vibration shall be adequately provided with resilient suspension and acoustically attenuated respectively.

The resonant frequency of the resilient suspension system shall be designed to avoid coupling with that of the vehicle structure. All suspensions shall be designed to provide maximum isolation for all modes of vibration. Also, resilient mounts shall be arranged in a manner such that the equipment shall be retained safely on the vehicle, and may continue operation, under all operating conditions stated in this ERT and any other applicable specification, in the event of a complete failure of the elastomeric material.

It shall be the responsibility of the Contractor to take all necessary precautions to minimize noise radiation and transmission by using up-to-date design techniques and proper acoustic attenuation materials, where required. The Contractor shall provide for review by the Engineer all pertinent details of the acoustic attenuation and any special noise reduction techniques used.

1.9.4 Aerodynamics and Pressure Effects

The modular design and construction shall ensure that passengers and/or the driver do not experience significant discomfort due to internal pressure changes when operating over the designated route, induced by infrastructure and passing trains and effects on passengers on platforms and on trackside workers.

1.10 RIDE QUALITY

The vehicle shall be designed to be free from objectionable vibration and shock. All mounted equipment shall be free from resonance to avoid undue audible and visual distraction.

The ride quality shall be evaluated according to JIS E 4023. The Contractor shall provide a vibration analysis for the Engineer's review, which shall demonstrate compliance to these ride quality requirements.

1) Horizontal steady acceleration shall be less than 0.08G.
2) Ride quality level shall endeavor not to exceed 88dB.
3) Ride quality coefficient shall endeavor to be more than "Good".

The Contractor shall implement test runs to measure the ride quality level and the ride quality coefficient. The ride quality level and the ride quality coefficient shall be calculated by Japanese manner. The results and the process of calculation shall be submitted for review by the Engineer. If the results would be worse than above value, the Contractor shall investigate the cause and shall propose the step to be taken.

1.11 MAINTAINABILITY REQUIREMENTS

In addition to the requirements specified elsewhere herein, the vehicles shall be designed to meet the following criteria:

1) On the premise that various maintenance shown in the following is to be carried out, other special maintenance work shall not be required;

Table 1.1 Basic Rolling Stock Maintenance Categories for MMSP

Category		Period	Maintenance Content
Departure Inspection		Before departure	Check in-service monitoring, visual check of major parts of cars.
Light	Weekly Inspection	Within 6 days	Check status of bogies, wheels, pantograph, doors and other items while cars are connected. Replace consumables for brakes, pantographs and other items.
Light	Monthly Inspection	Within 3 months (90 days)	Confirm the status of cars and their functions while cars are connected. Replace consumables, measure voltage of auxiliary circuits, control circuit and other circuits, inspect functioning of main circuit, etc.
Heavy	Semi overhaul	Within 4 years or Within 600,000 km	Remove bogies, wheels, wheel axles, brakes, main motors and other major parts, perform detailed inspection and replace parts
Heavy	Overhaul	Within 8 years or Within 1,200,000 km	Disassemble almost all parts, perform detailed inspection of devices. Paint car body.
Heavy	General overhaul (Renewal)	Every 10 to 15 years	General overhaul shall carry out replacement of the major electronic parts with new ones. If necessary, the interior is renewed.
Other	Unscheduled Repair	Whenever necessary	Replace broken-down parts. (bogies, pantograph, air conditioner, etc.).
Other	Scheduled Repair	Necessary period	Bogie cleaning, heat exchanger of Vac cleaning, and Roll filter of VAC exchange, etc.
Other	Wheel re-profiling	100,000 km (after starting service revenue operation)	Use wheel profiler to correct wheel shape and maintain ride comfort level. *The period of Wheel re-profiling shall be finally revised based on the condition of wheel tread and wheel flange after commercial use.

2) All units or sub-assemblies requiring replacement or off-train adjustment shall be arranged for easy unit exchange;

3) Equipment and systems shall be accessible for inspection, maintenance and repair with minimum strain to people involved and within the limitation of the existing and new maintenance facilities, including the light maintenance area;

4) The Contractor shall submit a detailed work process chart illustrating how the maintenance requirement can be achieved. The work process shall indicate work tasks, labor and material/component requirements, supplemented by a critical path analysis. The complete work process shall be subjected to a maintenance demonstration to confirm the validity of the work process model; and

5) For purposes of defining the maintenance requirement of each consist, the yearly-accumulated kilometer run assumption shall be 170,000 km.

1.12 GENERAL ELECTRICAL REQUIREMENTS

1.12.1 Electro-Magnetic Compatibility (EMC)

Conducted and radiated Electro-Magnetic Interference/Radio Frequency Interference (EMI/RFI) shall be held to a minimum commensurate with good design practices, and in no case shall signal levels be permitted to interfere with, or compromise, the operation of on-board signaling equipment, on-board intercom equipment or ultra- high frequency radio equipment. EMI/RFI or any other form of interference shall not affect the proper and safe operation of the MMSP and NSRP-S railway and any other local facilities. Electrostatic and magnetic electrical shielding methods shall be employed to minimize the effect of stray signals and transient voltages on low level interconnecting cables.

Components and functional circuits shall be grouped according to their similar sensitivities to electrical interference and power supply needs, and grouped to reduce the effects of voltage drops in the ground circuits, power and return leads, and shall be routed in a raceway or harness.

The Contractor shall submit an EMC control plan in accordance to IEC 62236 or equivalent to the Engineer for review. The plan shall include measures to reduce conducted, induced and radiated emissions to acceptable levels as specified in IEC 61000 series or equivalent.

The Contractor shall carry out measurement of the ensuing electro-magnetic environment to validate compliance to the above requirements.

1.12.2 Low-Voltage DC Control Power

The nominal system voltage shall be 1500 V dc. Unless otherwise specified, rated performance shall be provided at nominal voltage, and all equipment connected to the low voltage power supply shall not be damaged by continuous operation within the specified minimum and maximum voltage range. In addition, continuous voltages at the upper threshold shall not damage any equipment. Variation of voltage outside the limits specified in Sub-Clause 1.12.3 Operating Voltage Range shall result to system shutdown without damage.

1.12.3 Operating Voltage Range

Unless otherwise specified, equipment connected to the low-voltage power supply shall operate over a power supply (line) voltage range from 0.7 x (Vnom) to 1.30 x (Vnom). Peak-to-peak ripple voltage from a static power supply shall not exceed three percent of the nominal specified power supply output voltage, unless otherwise allowed. It is recognized that if a transformer-rectifier unit is used to generate the low voltage DC, the ripple voltage shall be substantially greater than the three percent (3%) limit. In this case, the allowable ripple voltage

shall be reviewed with the Engineer.

1.12.4 Transient Voltage Requirements

Equipment connected to the low voltage power system shall be capable of withstanding non-repetitive, transient, peak voltages by complying with IEC 62236- 3-2 or equivalent.

Low-voltage power supplied equipment shall not be damaged by under voltage of any magnitude or duration. Recovery of connected equipment from the under-voltage condition shall be automatic or by train line reset. Train line and battery supplied relays shall not drop out for under voltages as low as 0.5 x (Vnom), with a duration of up to 50 μs.

1.12.5 Reverse Voltage

Equipment, which may be powered from the battery bus, shall not be damaged by reverse polarity voltage of the same magnitude and duration as the specified positive voltage conditions.

1.12.6 Transients Generated by Equipment

Equipment connected to the low voltage power supply, including battery and train lines, shall not generate transient voltages in excess of +200 Vpk, with an energy content not to exceed 0.3 joules.

The equipment shall be designed such that the rate of change in voltage in any transient conducted from the equipment to the electrical interface shall not exceed 10 kV for up to 1 ms.

1.12.7 Overhead Line Supply System

At a minimum, equipment powered directly from the overhead line power network shall withstand transient voltages with a peak of not less than five times the maximum continuous voltage rating of the overhead line supply. The rise time from 10 to 90 percent of the peak voltage shall be assumed at 1 ms and the fall time from 90 to 50 percent shall be 40 ms. The energy content shall not be less than 1000 joules.

1.13 INSTALLATION AND MAINTENANCE REQUIREMENTS OF ELECTRIC WORKS

1.13.1 Printed Circuit Boards

All electronic printed circuit boards, the type of connector and contact material, the board material, the number of layers in a multi-layer board, use of surface mount devices and the kind of socket shall be of having sufficient practical operational record and reviewed by the Engineer. Semiconductor operating temperature rating shall meet or exceed +85°C.

Printed Circuit Boards shall be mechanically retained to prevent loosening in service. Circuit boards shall not be hard wired to the equipment, and shall be mechanically keyed to prevent insertion into the wrong rack location. Printed Circuit Boards shall be conformal coated, unless otherwise subjected to review by the Engineer.

1.13.2 Equipment Accessibility

All gauges, adjustment points, switches, etc., shall be easily accessible and clearly identified with permanent identification markings.

1.13.3 Device Reference Designators

All electrical devices on panels shall be identified with their alphanumeric designation corresponding to that used on the schematic diagrams.

1.13.4 Grounding

Safety grounding points shall be provided on all electrical equipment, unless otherwise subject to review by the Engineer. Grounding points shall be of tinned copper, clean, free from paint, and of a sufficient area to ensure proper electrical contact for the grounding cable fasteners. Un-tinned bronze grounding points and austenitic grade stainless steel grounding points are also considered acceptable. The area of any weld joining the grounding pad to a surface shall be at least equal to the cross-sectional area of the grounding cable.

Grounding points shall have either a tapped hole or, preferably, a clearance hole (with access to both sides) suitably sized for the lug attachment fasteners.

Minimum grounding cable size shall be 6 mm2, unless otherwise reviewed by the Engineer, and the size shall be equal to, or larger than, that of the largest power wire connected to that equipment. All grounding wires and cables shall utilize longitudinally striped green and yellow insulation, or heat shrinkable tubing applied over the conductor insulation.

1.13.5 Electrical Interface

All cable connectors used in exterior locations shall be rated IP65 using quick connect/disconnect couplings with positive locking and visual indication of mating. These shall be subject to review by the Engineer.

Terminal blocks, where used, shall be of a high quality, plated stud type wherever possible, with proper creepage and clearance provisions for the voltage used. Terminal blocks shall each be given a unique identification number, and each "point" on the block shall be numbered.

The current capacity rating of all wiring interface connectors and terminal blocks, shall have de-rating compensation in accordance with applicable standards for expected high ambient temperature.

1.13.6 Wire Identification

All equipment wires shall be marked with a unique wire identification number and proper color coding by means of marker sleeves located within 50 mm of each end of each wire. The identification numbering system shall correspond to the wire identification numbering system used on the schematic drawings and wiring diagrams.

The wire markings shall include the corresponding terminal block number where it is connected, placed distinctly at the far end of each wire marking.

1.13.7 Connectors

A single family of connectors shall be used for similar connections and functions within the Rolling Stock consist. Separate family of connectors may be used for power connections and control connections. The number of different connectors in the family shall be minimized.

All connectors shall have sufficient current ratings, with applied de-rating factors for expected operating temperatures of not less than 45 ℃.

1.13.8 Suppression

All relay coils, contactor coils, solenoid valve coils and other inductive devices shall be furnished with coil suppression. Contact suppression shall be provided where necessary or specified.

1.13.9 Wire and Cable Installation

Electrical wires and cables shall be run in cleats, conduit, ducts or wire trays, as the application permits, but all shall be protected from physical damage, such as chafing, ballast impact, etc. Wires and cables feeding equipment subject to the elements shall incorporate drip loops to prevent moisture from collecting around fittings.

The Contractor's attention is drawn to the requirements of Sub-Clause 23.4.8 Voltage Segregation.

All wires and cables shall have sufficient current ratings, with applied de-rating factors for expected operating temperature of not less than 45 ℃.

All wires and cable shall have sufficient spares; the wires and cable installation and number of spare wires and cables shall be subject to review by the Engineer.

1.14 FAIL SAFE DESIGN

All equipment and systems affecting train safety and the safety of train crew and passengers, and/or identified as being "vital", "safe", or "fail safe", shall be designed according to the following principles: couplers, door systems, on-board signaling systems, communication systems, wheel spin/slide systems, emergency brakes and propulsion power shut off systems shall be included as a minimum.

1) Only components having a high reliability and predictable failure modes and that have operated in similar service conditions to those in Manila service condition shall be used;
2) Components must be utilized in such a manner that ensures that a restrictive, rather than a permissive condition shall result from a component failure; for example, brakes shall apply, rather than release; train shall decelerate, rather than accelerate, etc.;
3) Circuits shall be designed such that when a normally energized electric circuit is interrupted or de-energized, it shall cause the controlled function to assume its most restrictive condition; broken wires, damaged or dirty contacts, a relay failing to respond when energized, etc., shall not result in an unsafe condition.
4) Component or system failures shall cause the train to stop or to run at a more restrictive speed than that permitted with no failure;
5) System safety equipment design must be such that any single independent component or subsystem failure results in a restrictive condition. Failures that are not independent, i.e. those failures, which, in turn always cause others must be considered in combination as a single failure and must not cause a permissive condition;
6) Any component or wire becoming grounded, or any combination of such grounds, shall not cause a permissive condition. Safety circuits shall be kept free of any combination of grounds that shall permit a flow of current equal to, or greater than, 75% of the release value of any device in the circuit.
7) Alternatively, redundancy shall be considered, which shall include not less than two entirely independent, parallel channels to perform each function. If only two channels are provided, a permissive decision shall be required from both for the system not to enter a more restrictive mode of operation. If more than two channels are provided, a more permissive decision shall be required from the majority for the system not to enter a more restrictive mode of operation; and
8) During the design review process, the Contractor shall submit analyses for review by the Engineer, which demonstrate compliance with these safety principles.

These analyses shall address the following issues:

a) Circuit design;

b) Hardware design (including failure modes, effect and criticality analysis);

c) Electrical interference;

d) Software errors;

e) Short circuit analysis (ground, other conductors, etc.);

f) Open circuits; and

g) System failures.

1.15 STANDARDS

The following are the summary of standards referred to in the Employer's Requirements. The summary is not intended to be all inclusive. In case there is the latest version, it shall be applied.

Table 1.2 JIS Standards

No.	Year	Title	Equivalent	English Ver.
JIS E4035	1995	Railway Rolling Stock -- High and low temperature test methods of parts		
JIS E4036	1998	Railway Rolling Stock components -- General rules for dust tests		
JIS E4037	2001	Railway Rolling Stock -- Components -- Test methods of weather ability		
JIS E4041	2009	General rules for the test methods of electric rail vehicle on completion of construction	MOD IEC 61133:2006	
JIS E4047	2008	Rolling Stock-Body Frame-Design methods for welded joints		
JIS E4048	2008	Railway Rolling Stock -- Spot welded joints of mild steel -- Design methods		
JIS E4051	2001	Railway Rolling Stock -- Dimension of vehicle body and bogie -- Measuring methods		
JIS E4111	2006	Clevis pins with head for railway Rolling Stock		
JIS E4115	2006	Magnet valves for railway Rolling Stock		
JIS E4118	2004	Bourdon tube pressure gauges for railway Rolling Stock		
JIS E4205	2001	Oil damper for railway Rolling Stock -- General rules for performance		
JIS E4206	1989	Spring rigging for railway Rolling Stock		
JIS E4207	2004	Truck frames for railway Rolling Stock -- General rules for design		
JIS E4208	2004	Test methods of static load for truck frames and truck bolsters of railway		

No.	Year	Title	Equivalent	English Ver.
JIS E4309	2001	Composition brake shoes for railway Rolling Stock -- Quality requirements		
JIS E4311	1999	Railway Rolling Stock -- Brake parts -- General requirement for tests		
JIS E4501	1995	Railway Rolling Stock -- Design methods for strength of axles		
JIS A1454	2010	Test methods-Resilient floor coverings		
JIS E 3313	1999	Illuminance - Headlight		
JIS E4001	1999	Railway Rolling Stock – Vocabulary	MOD IEC 60617:1991	
JIS E4010	1985	Symbols for railway Rolling Stock and railway Rolling Stock parts		
JIS E4011	1989	Measuring methods for mass of railway Rolling Stock		
JIS E4014	2007	Test methods for insulation resistance and withstand voltage of railway Rolling		
JIS E4015	1989	Measuring methods for air conditioning and heating temperature of railway		
JIS E4016	1992	Illuminance for railway Rolling Stock -- Recommended levels and measuring		
JIS E4017	2000	Railway Rolling Stock -- Graphical symbols for electrical apparatus	MOD IEC 60617	
JIS E4018	1995	Railway Rolling Stock -- Measuring methods of leakage magnetic field		
JIS E4021	2008	Railway Rolling Stock -- Test methods inside noise		
JIS E4023	1990	Vibration characteristics of railway Rolling Stock -- Measuring methods		E4023:90
JIS E4024	1994	Railway Rolling Stock -- Test methods of ventilation		
JIS E4025	2009	Noise of outside railway Rolling Stock -- Test methods	MOD ISO/DIS	
JIS E4031	2008	Railway Rolling Stock parts -- Test methods for vibration	MOD IEC 61373:1999	
JIS E4034	2011	Railway Rolling Stock parts— Test methods of resistibility for moisture		
JIS E4502-1	2001	Axles for railway Rolling Stock -- Quality requirements	MOD ISO 1005-	
JIS E4502-2	2001	Axles for railway Rolling Stock -- Dimensional requirement	MOD ISO 1005-	
JIS E4504	2004	Wheel sets for railway Rolling Stock -- Quality requirements	MOD ISO 1005-	
JIS E4603	2009	Electric speedometer equipment for railway Rolling Stock		

No.	Year	Title	Equivalent	English Ver.
JIS E4710	1995	Railway Rolling Stock -- Rubber vibration isolators -- General requirement		
JIS E5002	1991	Air compressors for railway Rolling Stock -- Test methods		
JIS E5003	2004	Test methods for direct current surge arresters of railway Rolling Stock		
JIS E5004-1	2006	Control equipment for electric Rolling Stock – General service conditions and	MOD IEC 60077-	
JIS E5004-2	2006	Control equipment for electric Rolling Stock – Electro-technical components	MOD IEC 60077-	
JIS E5004-3	2008	Control equipment for electric Rolling Stock – Electro-technical components	MOD IEC 60077-	
JIS E5004-4	2008	Control equipment for electric Rolling Stock – Electro-technical components	MOD IEC 60077-	
JIS E5004-5	2007	Control equipment for electric Rolling Stock – Electro-technical components	MOD IEC 60077-	
JIS E5008	2009	Power converters installed on board Rolling Stock -- Characteristics and test	MOD IEC 61287-	
JIS E5009	2009	Railway Rolling Stock-traction reactors -- Test methods	MOD IEC 60310:1991	
JIS E5011-1	2009	Rolling Stock – Combined testing of power converter with ac motors Part1:	MOD IEC 61377-	
JIS E5011-2	2009	Rolling Stock – Combined testing of power converter with ac motors Part2:	MOD IEC 61377-	
JIS E5401-1	1998	Carbon steel tires for railway Rolling Stock -- Quality requirements	MOD ISO 1005-	E5401-:98
JIS E5401-2	1998	Carbon steel tires for railway Rolling Stock -- Wheel centers and tired wheels --	MOD ISO 1005-	E5401-:98
JIS E6003	1985	General rules for design of driving cabs of electric commuter cars		
JIS E6004	1992	Electric Rolling Stock -- General rules for performance tests		
JIS E6005	1995	Railway Rolling Stock -- Automatic train control and automatic train stop device on		
JIS E6006	2001	Automatic train operating device for railway Rolling Stock -- Test methods		
JIS E6102	2004	Railway Rolling Stock -- AC traction motors -- Test methods	MOD IEC 60349-	
JIS E6202	1993	Electromagnetic relays for railway Rolling Stock -- General requirement		
JIS E6302	2004	Railway Rolling Stock -- Pantographs -- Test methods	MOD IEC 60494:2002	
JIS E6401	2004	Power Resistors for Rolling Stock	MOD IEC 60322:2001	
JIS E6402	1999	Railway Rolling Stock -- Static auxiliary power supply -- Test methods		

No.	Year	Title	Equivalent	English Ver.
JIS E6601	1999	Railway Rolling Stock -- Auxiliary rotating electrical -- Test methods	MOD IEC 60349:1991	
JIS E6602	2004	Cooling unit apparatus for electric cars		
JIS E7103	2006	Electric railcars for commuter use -- General requirement for design of bodies		
JIS E7104	2002	Seats for passengers of railway Rolling Stock		
JIS E7105	2006	Test methods for static load of body structures of railway Rolling Stock		E7105:89
JIS E7106	2018	Rolling Stock – General requirement of car body structures for passenger car		
JIS K1454	2010	Test methods-Resilient floor coverings		
JIS K6251	2010	Rubber, vulcanized or thermoplastics-Determination of tensile stress-strain		
JIS Q 9001	2008	Quality Management Systems Requirement		
JIS R 3213	1998 2008	Safety Glass for Railway Rolling Stock Amendment 1		
JIS R 3212	1998 2008	Test Method for Safety Glazing Materials Amendment 1		
JIS Z 8502		Ergonomics Principles		

Table 1.3 ISO Standards

International Organization for Standardization (ISO)	
1	ISO 2631 – Evaluation of Human Exposure to Whole-body Vibration
2	ISO 6385 - Ergonomics principles in the design of work systems
3	ISO 9241 – Ergonomics for Human-Systems Interaction
4	ISO 10075 –Ergonomics Principles on Mental Work load
5	ISO 9000 – Quality Management and Quality Assurance Standards
6	ISO 9355 – Ergonomic Requirements

Table 1.4 EN Standards

European Norm (EN)	
1	EN 15227 – Railway applications. Crash worthiness requirements for railway vehicle bodies

Table 1.5 IEC Standards

International Electro-technical Commission (IEC)	
1	IEC 60349 – Electric Traction – Rotating Electrical Machines for Rail and Road Vehicles
2	IEC 61133 – Railway Applications / Rolling Stock – Testing of rolling stock on completion of construction and before entry into service.
3	IEC61375-1 - Electronic railway equipment - Train communication network (TCN) – Part 1: General architecture
4	IEC61375-2-1 - Electronic railway equipment - Train communication network (TCN) – Part 2-1: Wire Train Bus (WTB)
5	IEC61375-2-2 - Electronic railway equipment - Train communication network (TCN) – Part 2-2: Wire Train Bus conformance testing
6	IEC61375-2-3 - Corrigendum 1 - Electronic railway equipment – Train communication network (TCN) - Part 2-3: TCN communication profile
7	IEC61375-2-4 - Electronic railway equipment - Train communication network (TCN) – Part 2-4: TCN application profile
8	IEC61375-2-5 - Electronic railway equipment - Train communication network (TCN) – Part 2-5: Ethernet train backbone
9	IEC61375-3-1 - Electronic railway equipment - Train communication network (TCN) – Part 3-1: Multifunction Vehicle Bus (MVB)
10	IEC61375-3-2 - Electronic railway equipment - Train communication network (TCN) – Part 3-2: MVB (Multifunction Vehicle Bus) conformance testing
11	IEC61375-3-4 - Electronic railway equipment - Train communication network (TCN) – Part 3-4: Ethernet Consist Network (ECN)
12	IEC 61377-1 – Railway Applications / Rolling Stock – Combined Testing of Inverter fed alternating current motors and their control systems.

International Electro-technical Commission (IEC)	
13	IEC 62427 – Railway Application on Compatibility between Rolling Stock and Train detection system
14	IEC 62236 – Railway applications – Electro-magnetic compatibility
15	IEC 61000 – Electro-magnetic Compatibility
16	IEC62625-1 Electronic railway equipment - On board driving data recording system – Part 1: System specification

Table 1.6 UIC Standards

International Union of Railway Standards (UIC)	
1	UIC541- 05 Ed. 2 (2005) -Brakes - Specifications for the construction of various brake parts - wheel slide protection device

Table 1.7 Other Standards

Other Standards	
1	Rolling Stock Industrial Standard (JRIS) – Japan
2	Philippine National Standards (PNS) – Philippines
3	Ministry of Land Infrastructure, Transport and Tourism (MLIT) - Japan

1.16 HALF TRAIN-SET OPERATION

Because of the efficiency of heavy maintenance shop working and PRI training, when 8 cars train-set is divided to 4 cars half train-sets, by using compact master controller, the 4 cars half train-sets shall be able to move. So, required circuit connected to compact master controller shall be prepared at the driving position. For the safety operation, the controller shall be fixed / shall be able to be fixed. This circuit shall be prepared in consideration with situation that also 10 cars divided to 5 cars half train sets. Particular attention shall be paid to the connection position of master controller, types of couplers and TMS software.

The Contractor shall prepare 6 compact master controllers which have the ATP indicator, the ATP release switch and the speed meter and so on.

1.17 DESIGN LIFE

The Rolling Stock for MMSP shall be designed on the basis of design life as shown below.

1) Body / bogie / coupler: over 30 years
2) Power conversion element, filter capacitor: over 25 years
3) General electrical parts: over 12 years
4) Some special parts: above 8 years

If electric parts with a design life shorter than 12 years are proposed, the Contractor shall submit proposals for the Engineer to review.

2 VEHICLE BODY

2.1 GENERAL

The Contractor shall ensure the design of each type of vehicle body shell to be as identical as possible, and to be designed to withstand the rigors of the Manila railroad environment for a period of 30 years, without major overhaul or rehabilitation. Vehicle bodies shall be as smooth in appearance as possible, with no untoward protrusions in evidence.

The train design shall incorporate design features, which guarantee a high level of safety for the passengers and train crew. The vehicle body, including doors and windows, shall be water tight under all operating conditions, including passage through a train washing facility. Water deflecting gutters shall be installed on the roof along the entire side of the vehicle and provided with suitable down spouts. The gutter shall be continuous to ensure controlled drainage at the corners of the vehicle. The gutter design shall ensure water shall not spill over the gutter onto the vehicle body side or onto the platform when the Rolling Stock consist is braking or accelerating into stations. Water drainage shall not directly fall/splash to underbody equipment. Rainwater downspout shall be extended just appropriately to allow water to drain down without causing any splashing to the under-floor equipment.

The Contractor shall provide suitable repair procedures for car body damage.

2.2 MATERIALS AND CONSTRUCTION

The vehicle bodies including but not limited to the roof, car body shell, flooring support sheet, etc. shall be manufactured from stainless steel or aluminum grade, which provides excellent performance in relation to:

1) Corrosion resistance;
2) Resistance to chemical attack;
3) Long term structural performance;
4) Aesthetic qualities; and
5) Low maintenance requirements.

Other materials such as steel, carbon steel or etc. that comply with the requirements specified herein, will be accepted subject to the Engineer's review.

The Contractor shall ensure that no materials are to be installed or used on the train which could be damaging to the short- or long-term health of passengers, train crew, cleaning, environment and maintenance/repair staff.

All body panels shall be free from wrinkles and other imperfections, and shall be flat within 2 mm in any 1 m span. Materials shall be suitable for current repair operations (cutting, welding, etc.). Materials shall be in accordance with the relevant standard, appropriate for the application. Particular attention shall be paid to fatigue limit, corrosion and material degradation with weather elements and time.

The use of the following materials in the construction of the train shall be restricted and only subject to prior agreement with the Engineer:

1) Ceramic fiber;
2) Rockwool;
3) Urea formaldehyde;
4) Polyethylene foam;

5) Polyurethane foam;

6) Polyurethane rigid mouldings; and

7) Encapsulated lead.

The Contractor shall submit details, including Material Safety Data Sheets (MSDS), for all proposed materials to be handled by the maintainer of the train to the Engineer for review.

The exterior of the car body shall be polished finish stainless steel or aluminum left un-painted. The doors shall also to be made with stainless steel skin or aluminum having the same finish as the car body. In case where the cab exterior is other than stainless steel, then painting shall be required. The Contractor shall submit the painting specifications for the Engineer to review.

The underframe members shall be made of stainless steel or aluminum. Any component parts of the underframe that are made of high tensile steel or aluminum shall be painted with a half gloss black paint system, which has been proven in metro rail transit and/or similar applications. It shall provide durability and good resistance to abrasion, moisture, oils, and the track work environment, to corrosion of coated metalwork and to car cleaning. The Contractor shall submit the painting specifications for review by the Engineer.

All painted surfaces shall match and display a uniformity of color throughout its service life. The paint preparation and finish shall be such as to enable a satisfactory re-coat of part of the vehicle body in the event of localized repair.

The paint system shall include the Contractor's value of the paint materials such as smoke generated in the event of fire. Surface preparation requirements, number of coats and thickness with application instructions shall be provided for the Engineer's review.

The performance of the paint finish including scratch resistance, impact resistance, chip resistance, abrasion resistance, and paint adhesion and paint elasticity shall be in accordance with recognized internationally approved standards.

The fittings and materials shall be easily cleaned (paint, graffiti, glue, etc.). They shall therefore withstand frequent use of various cleaning products (alkaline or acid detergents, petroleum solvents, mechanical action of brushes) without losing their color or a noticeable deterioration of their surface aspect.

2.3 STRUCTURAL REQUIREMENTS

2.3.1 General

The car body shells shall be of integral construction as well as designed and tested to withstand the loading conditions described herein. The Contractor shall submit a stress analysis for the review by the Engineer. The stress analysis shall include the use of a suitable Finite Element Model (FEM), supported by classical hand analysis for detailed components.

The Contractor shall ensure the entire car body structure, bogies, bogie attachments, equipment supports, doors, seats, and interior appointments, are designed in accordance with this ERT and in compliance to JIS E 7106.

The Contractor shall ensure the car body structure and all car bodies, bogie and axle mounted components have a minimum design fatigue life of at least five (5) years in excess of the declared service design life. The Contractor is required to submit supporting calculations to demonstrate compliance, with the calculations taking into consideration the MMSP's and NSRP-S'S operating environment.

For self-ventilation, total areas of openings such as openings of windows and so on shall be more than 1/20 of total floor areas. The Contractor shall comply with the requirements of the Japanese Ministerial Ordinance, Technical Regulatory Standards on Japanese Railways Chapter 8, Section 4, Article 73 (Structure of Saloon), in regard to above.

2.3.2 End Loading and Deflection Requirements

The vehicle body shell shall be designed and tested to withstand a compressive load of 490 kN and tensile end load of 350 kN applied through the draft gear attachment points, in combination with the most adverse vertical loading associated with the worst loading conditions. For all load cases, all car body members shall remain elastic, with no evidence of buckling.

The car body shell shall be designed and tested to ensure that under worst loading conditions positive camber exists between bogie centers. The Contractor shall ensure, and must demonstrate by test, that all doors operate freely under all vehicle body loading conditions, and shall not disengage from their guide ways under the lateral loading conditions exerted by crush-loaded passengers.

The Contractor shall also design and test the door posts, the corner posts and the driver's cab end structure in accordance with the latest industry practices.

The end beam shall have sufficient strength for towing another train.

2.4 CRASH WORTHINESS REQUIREMENTS

Condition of the crash worthiness design shall be head-to-head collision between two identical cab cars at tare weight, having the same mass at relative speed between them 25km/h on level and tangent track.

The Contractor shall consider the crash worthiness or the car design is in accordance to the Japanese Ministerial Ordinance, MLIT or EN 15227 C-II or equivalent, subject to the Engineer's review.

In case the Japanese Ministerial Ordinance, Technical Regulatory Standards on Japanese Railways is applied, the cab car shall absorb the collision energy by providing a controlled deformation and collapse of areas of the vehicle which are unlikely to be occupied by the train crew and passengers, to absorb the collision energy and to reduce the deceleration on the train crew and passengers. This shall be validated by the computer simulation such as Finite Element Method (FEM).

The Contractor shall submit the details of the design cases, together with the validation process to be adapted, to the Engineer for review.

2.5 JACKING AND LIFTING REQUIREMENTS

Jacking and lifting points/pads shall be provided for normal maintenance operation, sized and positioned to accept lifting equipment. In addition to these jacking and lifting points, emergency jacking and lifting points shall also be provided at all four corners and at the center of each vehicle end to allow jacking/ lifting under emergency situations, including derailment.

The locations of all jacking and lifting points shall be clearly accessible and marked on the car body.

The car body shell shall be designed and tested to allow an empty vehicle, with bogies attached, to be lifted at the extreme ends at the bolster jacking pads, or any combination thereof (particularly during re-railing operations), without exceeding the yield strength of any

portion of the vehicle body.

2.6 VEHICLE ROOF

Roof construction shall be sufficiently robust as to allow several maintenance personnel to walk over the roof at one time, without causing undue deflection or permanent deformation. Rain gutters shall run for the full length of the vehicles to prevent the spillage of rainwater over passengers when the train is entering or leaving stations. Both ends of the vehicle shall have gutters with adequate water drainpipe that runs to the lowest possible point under the vehicle.

A roof mat under and around the pantograph area shall be installed for electrical insulation and anti-slip protection. In addition, an anti-slip surface shall also be provided along the side of the roof covering the whole length of the vehicle.

2.7 FLOOR

The floor and its mounting structure shall be designed to withstand any loading condition specified herein, for over 30 years in normal operation of the train. Transverse joints shall be located over vehicle body structural members and away from doorways.

All exposed edges of the panels, including openings for ducts and conduits, and joints between panels shall be waterproofed and adequately sealed. The floor design shall allow the floor covering to be removed without damage to the floor sub-structure.

Floor covering panels shall be insulated from the metallic structure by elastomeric tape or equivalent. At all door openings, the floor shall have a weather tight connection with the threshold plates. Floor covering materials and installation shall be in accordance to the provision of Sub-Clause 6.4 Flooring of this ERT and shall be compliant to the Fire Safety requirements specified in Sub-Clause 23.8 Fire Safety.

2.8 EQUIPMENT MOUNTING

2.8.1 General

Equipment arrangement, for weight distribution purposes, on all vehicles shall be as even as possible under W0 loading conditions. Loading difference at W0 condition, between axles shall not be more than 1 metric ton and loading between wheels in an axle shall be less than 10%.

All equipment mounts shall meet the requirements of Sub-Clauses 1.9 Noise Vibration and Aerodynamics and 1.11 Maintainability Requirements of this ERT and shall have a fatigue life of not less than 30 years.

Equipment shall be logically grouped into enclosures, which shall meet the requirements of Clause 23 Material and Workmanship of this ERT. Care shall be taken to ensure that the equipment within the enclosures is readily maintainable, taking into consideration the required maintenance interval. Mounting of equipment enclosures/boxes shall be made to allow easy access and opening given the constraints of the maintenance pit/facility.

All equipment and corresponding cases shall be mounted such that removal and replacement of each is possible without requiring the removal of other major equipment or cases. Similar but non-interchangeable parts shall have different mounting arrangements, to ensure against mistakes in fitting.

The Contractor shall ensure that safety mounts are provided for all underframe mounted equipment to prevent derailment risk in the event of main mounts failure in service. Similarly,

equipment enclosures shall have the doors securely attached to prevent falling off and causing derailment or other damage.

The Contractor shall ensure that all fasteners are of the same material when attaching components to the car body and be of the same grade.

The Contractor shall design equipment arrangement in consideration with signaling system and radio system adopted or planned to adopt in NSCR, MMSP, MCRP and NSRP-South. Basically, space of under floor in leading cars shall be secured for signaling equipment, radio equipment, in addition, equipment desirable to be mounted to leading cars such as door controller and so on.

The Contractor shall confirm equipment arrangement of rolling stock in NSCR, MMSP, MCRP and NSRP-South, and equipment arrangement shall be unified as possible, paying attention to mounted side, mounted positions (especially test valves, valves and cocks used in emergency), and so on. Equipment arrangement shall be designed not to affect maintainability and emergency operation even if special operations are adopted. Example, equipment arrangement shall be designed in consideration with symmetry, when reversed train formation operation will be adopted.

Equipment arrangement shall be reviewed by the Engineer.

2.8.2 Cabin and Saloon Access Handrails and Steps

The Contractor shall ensure that a set of steps with non-slip treads and handrails are provided at each driver's door to ensure the drivers safety when boarding and exiting the vehicle when not at platform level.

The Contractor shall ensure that easy access steps with non-slip treads and handrails fit for purposed will be provided at each passenger side entrance door on both sides, this will allow passengers to easily and safety exit the vehicles during evacuation circumstances when the vehicle is not at platform level. Signages and instructions on how to align the train safety shall be provided for each passenger door.

The stiffness and strength of the handrails and their connections shall be designed and tested to ensure that they shall withstand the rigors of use and the environment. They shall be designed and tested to withstand, without permanent deformation, a load of 1.3 kN applied at the midpoint of the span.

The stiffness and strength of the steps and their connections shall be designed and tested to allow use by a person exerting a force of 1.3 kN (load applied at a 45 degree angle), without permanent deformation.

2.9 LADDER FOR EVACUATION

The Ladders for Evacuation at where there are no evacuation passages shall be mounted on the both sides of each vehicle. Two ladders shall be mounted on the one side (The total of four ladders shall be mounted). In case of evacuation from inside of vehicle to on-ground through the saloon doors, the passengers shall be able to evacuate by using these Ladders safe and quickly as possible.

2.10 STEP FOR EVACUATION

The steps for evacuation used at where there is evacuation passage along the line shall be mounted on the both sides of each saloon, because there is the gap between train and evacuation passage. It is necessary that passengers can use this easily and quickly, also steps are equipped with sufficient width and strength to walk on.

3 BOGIES

3.1 GENERAL

The Contractor shall ensure the bogies supplied with the vehicles are of service proven design.

The bogies shall be designed to operate safely and reliably for the service life of the train.

The vehicles shall be supported on twin axle bogies incorporating a primary and secondary suspension system.

The bogies shall be designed and constructed to minimize the unsprung mass including any attachment to the axle and shall provide service for a period of not less than 30 years, under normal use and maintenance.

Bogies shall be designed and manufactured such that as many components as practicable are fully interchangeable. All motor bogie assemblies shall be fully interchangeable, similarly all trailer bogie assemblies. The entire bogie shall be suitably protected against corrosion and adequately painted.

Provision shall be made in the bogie design to allow vertical mechanical adjustment to compensate for wear. It shall be possible to adjust vehicle body height for wheel wear without having to remove the bogie from the vehicle. The design shall allow for lifting the bogie with the vehicle body.

Sufficient number of shims or liners shall be supplied for adjusting body height.

Motor bogies shall utilize an individual motor driving each axle, and the motors shall be mounted on the bogie frame. Bogies shall be as light as possible, commensurate with meeting the requirements of this ERT.

The bogies shall be compatible with the underfloor wheel turning machine to be installed at the workshop without the need for removal of bogies or disassembly of any major parts from the bogie or the vehicle body or to add interfacing hardware. The Contractor shall ensure that the bogie frames are provided with lifting eyes of sufficient strength at four points to permit level lifting and transportation by shop crane of the fully assembled bogie.

Slewing rings shall be provided with an adequate number of standard grease fittings. If a bolster-less connection is used, equipped with center pin and friction plates, the material and design of the friction plates shall not cause undue noise or any residual sound during start of traction and braking. The Contractor shall submit a detailed study of the friction plate properties and performance for review by the Engineer.

The bogies shall be capable of being disconnected and reconnected to the vehicle body with minimal operational requirements. The maximum time to remove and replace a bogie with an exchange bogie shall be less than two (2) hours.

The bogie shall be configured such that equipment is positioned and oriented in a manner that facilitates access for maintenance. The bogie design shall include the mounting arrangements for the on-board signaling equipment, which shall include, but not be limited to (i) the location and mounting of tacho-generators and (ii) mounting arrangements and termination of the associated cabling.

Guard irons shall be mounted to bogies at each end of train set.

About main specifications of bogie such as wheel profile and so on, Contractor shall propose the most suitable specifications based on calculated results such as the estimated derailment

coefficient ratio described in Technical Regulatory Standard on Japanese Railway issued by MLIT including public notice and Approved Model Specification, limited speed for shunting and shall be approved by engineer. Moreover, before start of business, contractor shall measure Q/P for all running section, which include reverse running operation or single line parallel operation during emergency situation, by running actually at normal speed and low speed (necessary section), and shall confirm that ratio of the results to limited derailment coefficient, calculated by Nadal's formulation, are lower than predetermined values. If there are sections that the values are higher than predetermined values, the Contractor shall do as much as the Contractor can and report it the Engineer.

3.2 SUSPENSION SYSTEM

3.2.1 General

The suspension system shall comprise a primary and secondary suspension system, the characteristics of which shall provide good riding comfort, low transmissibility of vibration to the vehicle body and minimize impact and vibration noise. The primary suspension shall be equipped with service-proven coil springs and air springs be used for the secondary suspension. The material used in the suspension shall be ozone protected. The bogie design shall provide good performance on curves to minimize wheel noise and wheel/rail wear and unnecessary wheel unloading.

The suspension system shall be such as to ensure that the train remains within the Rolling Stock gauge under all conditions of passenger loading at static condition and maintain sufficient clearance between the structure gauge under all combinations of passenger loading, vehicle speed consistent with the system's track curvature / speed restrictions and track curvature including super-elevation. The vehicles must sustain clearance under the conditions of deflated or over-inflated air springs, broken primary springs, etc.

The rotational resistance of the bogie/vehicle body interface and the bogie suspension elements shall be such as to minimize excessive wheel flange contact and, hence, minimize wheel squeal and wheel/rail head wear, while preventing yaw instability (hunting) throughout the vehicle's speed range.

The bogies shall be designed to allow the complete vehicles to meet the ride quality requirements of Sub-Clause 1.10 Ride Quality of this ERT.

3.2.2 Primary Suspension

The primary suspension shall be designed to provide the required degree of wheel set guidance and to minimize wheel flange wear. However, wheel set yaw stiffness and damping shall not be such as to allow a yaw instability condition throughout any portion of the vehicle speed range.

Primary suspension vertical stiffness shall not be so great as to impart undue forces on the rail under dynamic conditions, and shall be sufficiently flexible to prevent the degree of wheel unloading that would cause a derailment in any level of deflection in all conditions of track irregularities, curvature, super-elevation, etc., consistent with vehicle speed.

3.2.3 Secondary Suspension

The secondary suspension shall consist of air springs, controlled via adjustable levelling valves, which shall provide a relatively constant floor height to avoid roll and yaw, and a passenger tripping hazard. Vertical and lateral dampers may be installed, if required, to control bogie to vehicle body oscillations.

The air spring pressure shall also be used to provide a signal to the load weigh system to

control vehicle tractive effort and braking forces under all vehicle-loading conditions.

Emergency secondary springs shall also be provided to support the vehicle body in the event of ruptured air springs. To prevent excessive vehicle body lean should one air spring rupture or leak, the air springs on each bogie shall be interconnected using a load compensating differential pressure valve.

3.2.4 Wheel Unloading

The bogies shall be designed to enable the safe operation of the vehicle on the most adverse track condition, with any combinations of air springs deflated. Under this condition, the maximum unloading of any wheel shall not exceed 60% of the nominal wheel load. The nominal wheel load is defined as each individual measured wheel load with the vehicle standing on a straight and level track.

3.3 BOGIE FRAME

The bogie frame shall be welded steel construction, manufactured from weather- resistant high tensile carbon steel compliant to JIS E4207, capable of withstanding heavy duty, with the design incorporating adequate safety margins. The bogie frame construction shall be consistent with good mechanical design and be as light as possible. Use of cast steel inserts of acceptable grade in fabrication of the bogie is permissible.

The frame shall be of a simple design requiring a minimum of machining. All frame attachment points shall be readily accessible for inspection and maintenance purposes. The bogie frame shall be suitably protected against corrosion and adequately painted.

The composition and physical and mechanical properties of the steel shall be fully documented and reviewed by the Engineer.

The bogie frame shall be fabricated of steel construction made of cold or hot rolled plates and forged and cast parts. It shall be a welded hollow girder construction and designed in shape of an H.

Structural design shall be considered to reduce any stress concentration. If possible, measures shall be taken to remove welding stress of bogie frame.

The welded design shall also be fully substantiated by the Contractor through analysis and test particularly regarding limitation of fatigue stresses in welded zones.

3.4 WHEELS, WHEEL SETS AND AXLES

Wheels shall be of a proven design from a reputable manufacturer.

The wheels shall be compliant with the requirements for JIS E4502 for 1435 mm gauge.

Wheel sets shall be protected using a paint system, which shall protect the wheel sets from damage by corrosion for at least the period between bogie overhauls without maintenance.

The Contractor shall submit comprehensive details of the wheel set design. The submission shall include, as a minimum, axle detail drawings, axle design calculations, wheel detail drawings, wheel design calculations and wheel sets assembly drawings and procedures.

Easy access shall be provided to both ends of all axles to allow ultrasonic testing of the axles. It shall be possible to carry out ultrasonic testing with the wheel set in situ under the vehicles.

The Contractor shall submit procedures for testing of a free-standing assembled wheel set and

for testing of a wheel set in situ under a vehicle. It shall include the location of testing and refer to test standards.

The wheel set shall be in compliance with requirements as per JIS E4504. The axle shall be designed in accordance with JIS E4502.

Wheels, axles, drive gears and axle bearings shall be assembled on axles by an interference fit method.

The Objective is that the cars shall basically achieve approximate of 100,000km before re-profiling of the wheels is necessary.

The Contractor shall carry out bearing life calculations to demonstrate that the selected size of bearing is adequate for L10 bearing life of 1,200,000 km.

The housings shall incorporate seals to prevent leakage of grease and infiltration of water and dirt and maximize lubricant life. Bearing lubricant shall not, in any circumstances, be allowed to leak or discharge onto the wheel or rail surface. Axles shall be provided with mounting arrangement for disc brake and electrical current return assemblies.

Axles shall be designed to withstand the maximum axle load of 16,000 kg and have a fatigue life of not less than 30 years.

Full details of the axle, wheel and gear machining details shall be provided, together with process details, including the specific type of lubricants used. The Contractor shall provide the pressing records of all wheel sets in the Vehicle History Books.

The wheel back-to-back dimension shall be between 1,359 and 1,362 mm.

Pair of hand-scotches shall be equipped on under floor near the bogie, each side.

3.5 AXLE BOXES

Axle box bearings shall be of the grease self-lubricated roller type, sealed for life.

Bearings shall be sealed by labyrinth seals and if replenishment of grease is required between overhauls, this shall be possible without removing any other equipment. Suitable standard grease fittings shall be provided for this purpose.

Any design incorporating a wearing surface between the axle box and the bogie frame shall not be accepted.

3.6 TRACTION MOTOR INSTALLATION

Attention is drawn to the requirements of Sub-Clause 3.1 - Bogies General of this ERT. The design of the motor installation shall also be configured such that should the motor mounting hardware fail, the motor shall not fall from the bogie and cause a derailment.

The motor mounting installation shall allow dismounting and mounting without removal of the gearbox from the bogie. The traction motor shall be equipped with an appropriate bearing on the gearbox coupling connection side to assure independent stability and support of the traction motor in all conditions.

3.7 BOGIE-MOUNTED BRAKE EQUIPMENT

Pneumatic brake actuators with integral automatic slack adjusters shall be mounted to the bogie frame. One actuator per disc shall be used.

3.8 MISCELLANEOUS BOGIE-MOUNTED EQUIPMENT

The bogies shall be equipped with all pertinent equipment needed to meet the requirements of this ERT, including, but not limited to: on-board signaling equipment, speed sensors, dump valves, lifting lugs, piping, cabling, etc. Regarding the speed sensor, two type shall be equipped, one type is for ATP, and another type is for devices of Rolling Stock such as TMS and Brake system, propulsion and so on. Circuits of each speed sensors shall be separated. Speed sensors for devices of rolling stock shall be equipped to two axles at both leading cars. Wires or cables of speed sensors for device of Rolling Stock shall be equipped through 4 cars, and this speed information shall be utilized by various devices of Rolling Stock. Speed sensor for ATP shall be supplied, and details shall be determined by Signaling Contractor.

All resiliently mounted equipment on the bogie shall be designed to avoid resonance with all bogie suspension frequencies.

On-board sensors shall not be installed near a rotating electrical equipment, to prevent electrical interference.

The Contractor shall supply lubrication-free and maintenance-free parts of subcomponents. However, for moving parts where lubrication is necessary, the Contractor shall supply low maintenance parts minimizing lubrication activities.

All fasteners of the same material used to attach components to the bogie shall be of the same grade.

All grounding shall be in accordance to the provision of Sub-Clause 1.13.4 - Grounding of this ERT.

3.9 BOGIE-TO-VEHICLE BODY CONNECTION

The Contractor shall ensure that the bogies are retained by the vehicle body when the vehicle body is lifted, and the bogie-to-vehicle body connection must also retain the bogies in the event of a collision.

Bogie/vehicle body connections shall be designed to avoid the transmission of noise and vibration. It shall be physically impossible for connections to be mismatched.

3.10 BOGIE-TO-VEHICLE BODY CLEARANCE

Under all conditions of movement between the bogies and the vehicle body, including fully inflated and deflated air spring conditions, there shall exist a minimum clearance of 50 mm between bogie-mounted and vehicle body-mounted equipment. This shall include any end of the vehicle having fully inflated air springs, with the opposite end having deflated air springs.

3.11 STRUCTURAL REQUIREMENTS

Unless otherwise specified, bogies and bogie-mounted equipment shall comply with the industry standard requirements. The Contractor is encouraged to indicate different load cases that would be more appropriate according to their previous experience; supporting data shall be submitted to the Engineer for review.

A stress analysis of the entire bogie structure shall be performed using a Finite Element Model (FEM). The model, its type and number of elements, and the criteria used for the acceptability of stress levels shall be subject to the Engineer's review.

In addition, the Contractor shall provide a proof load case and fatigue load case for all bogie and axle-mounted equipment and parts.

3.12 BOGIE MAINTAINABILITY

The bogie frame shall be fitted with suitable lifting locations for lifting it off the wheels and axles, for lifting the complete bogie frame during maintenance in the workshop and for re-railing a car or bogie. Jacking pad location shall be provided to match the workshop equipment.

In addition, the design of the bogie frame shall incorporate horizontal and vertical pads at diagonal positions for re-railing operations following derailments.

The bogies shall be capable of being cleaned using high-pressure hot water or steam jet cleaning equipment, with or without detergents. All closed sections and pockets shall be self-draining or sealed against water ingress. All bearings shall be adequately sealed to ensure that water and cleaning fluids do not enter during the cleaning process.

Bogies shall be capable of being disconnected and reconnected easily and with a minimum number of operations by personnel working in pits or alongside the bogies. It shall be possible to easily inspect for correct reconnection without the need for special tools or instruments.

It shall be possible for personnel working in pits or alongside the bogie to visually inspect the condition of bogie components, such as brakes and wheel treads, easily and without the use of special tools.

The bogie shall provide easy and safe access for all maintenance, including access for the train driver to operate the isolating cocks for bogie-mounted equipment and parking brake manual release.

The attachments between the body and the bogie shall be such that if the car is lifted without disconnecting the bogies, the bogies, traction drives and wheel sets shall be retained captive to the car without the need for additional restraints at the time of lifting. No damage shall result to any of the connections as a result of this action.

4 OIL INJECTION

4.1 GENERAL

The Contractor shall provide a suitable on-board wheel flange lubricator to reduce wheel wear and to prevent undue noise, and also to leave the same effect for the following non-injection train as well. Flange lubricators shall be provided at the leading axle of both ends of the train on both sides. 10 train-set shall be installed with flange lubricators. Flange lubricator shall surely provide appropriate amount of dedicated oil accuracy at appropriate spot on wheel flange from specified injection nozzle, in the arbitrarily set section.

4.2 SYSTEM

The Contractor shall provide oil injection system to achieve suitable lubrication between wheel flange and rail. Oil injection system shall include control unit, shall be interfaced with Train Management System to get necessary information for oil injection control. Oil injection system shall provide oil based on direction of train and running distance, train velocity, train running number and so on, which are sent by TMS. Validation/invalidation of this function and injection sections, frequencies of injection shall be changed through TMS.

Oil used by this system shall be approved by other related Contractors, and then Material Safety Data Sheets of oil shall be submitted for comments and approval by the Engineer.

5 COUPLER AND DRAFT GEAR

5.1 GENERAL

The end vehicle in each train shall be fitted with an automatic coupler. The automatic coupler shall be placed in a readily accessible position under and near either side of the end vehicle. The position (right side or left side) of parts operated shall be consistent for all end vehicles. It shall be possible to connect with the train of MCRP and NSCR, NSRP-S without any adapter.

In both leading cars, an electrical connecting plug which is necessary for rescue operation by connecting trainsets shall be equipped. Also, an emergency connection cable that connects this electrical connection plug shall be supplied. By using this connecting cable, required functions such as brake command, broadcasting, buzzer etc. shall operate properly. The position of this plug shall be consistent with other trains that run on the same lines. Length and diagram of cable shall be also consistent with other trains that run on the same lines, particularly length of cable shall be determined in consideration of the severest deviations during coupled with other train. Basically, utilization of adapter shall not be acceptable.

The Contractor shall provide the required cabinet for housing the emergency connection cable on the train. Alternatively, the Contractor shall provide proper mechanism for retaining the emergency connection cable when it is not in used.

All electrical connections shall be made to terminal blocks in junction boxes compliant with IP 65, via jumper cables, using quick connect/disconnect couplings securely locked with wire.

Cable hoses shall be made out of high quality, weather and abrasion resistant insulated rubber.

The connectors for each cable, if of the same size, shall be keyed differently to prevent misconnection, and shall be color coded to enable connectors to be easily distinguished.

In all cases, care shall be taken to ensure that strain relief is provided for all cables leaving the junction boxes, and that all cables are properly supported in suitable cleats, and that no chafing of the cabling takes place under all possible movements of the coupler.

The arrangement shall prevent damage from coupling with misaligned couplers, and shall minimize damage to the vehicle body wiring, should excessive tension be applied to the cables in the event of an accident.

The couplers shall be designed to prevent the coupler swinging transversely when it is not coupled.

"Semi-permanent" coupler shall couple the vehicles within each 8-vehicle consist except between car No.4 and car No.5. Coupler between car No.4 and car No.5 shall be tight coupler in consideration of maintainability and PRI demand. Please refer Appendix. A.

The couplers and draft gear shall be capable of withstanding all coupling, buffing and draft loads to be expected in normal and emergency conditions. The draft gear shall be suitably damped and be designed to prevent the occurrence of unduly large dynamic deflection and associated forces under the above condition.

The coupler height, measured from the center of the coupler to the top of rail, shall be within 880 mm +10/-15 mm.

The Contractor shall provide six (6) units of couplers and deliver to the CP106 Contractor. The delivery location and timing shall be determined during the CP107 and CP106 interface meetings.

5.2 SEMI-PERMANENT COUPLERS

The semi-permanent couplers shall only be coupled or uncoupled in depot. Pneumatic connections shall be made when coupling the semi-permanent couplers.

5.3 DRAFT GEAR

Each coupler type shall utilize rubber, double acting draft gear capable of withstanding all of the loads described in this ERT, and which shall not transmit undue vibrations into the vehicle body.

6 VEHICLE INTERIOR

6.1 GENERAL

The interior of the vehicles shall be aesthetically pleasing and the arrangement and materials used shall reflect the current best industry practice and standards. All materials used must meet the fire safety requirements of Clause 23.8 - Fire Safety - of this ERT. The interior arrangement shall allow for easy maintenance, and all edges shall be rounded to the extent possible to preclude passengers, train crew and maintenance personnel injury and to facilitate cleaning.

The Contractor shall provide a selection of colored artist's renderings for review by the Engineer. Using these as a basis, the Contractor shall work with the Engineer to supply a final set, which shall be used for the color and configuration of the interior arrangements of each type of vehicle.

Visible fasteners in the passenger saloon and the driver's cabs shall be avoided. Fasteners shall be of the tamper-resistant type, manufactured from stainless steel.

The Contractor shall also provide design drawings and passenger seating and flow analysis of a floor plan incorporating the use of longitudinal seats for review by the Engineer.

The train shall be designed to transport all sectors of the population, including children, passengers with luggage, senior citizens, slightly disabled people, blind or deaf people, handicapped persons, including non-ambulatory persons in wheelchairs.

6.2 INSULATION

6.2.1 Thermal Insulation

The vehicle body side walls and roof shall be insulated with a suitable grade of fiberglass insulation, which shall have been treated to resist fungus and mildew. The fiberglass insulation shall be installed so as to prevent shakedown in service and where accessible shall be suitably protected/covered.

6.2.2 Acoustic Insulation

Where found necessary by the Contractors' noise analysis, visco-elastic sound damping material shall be installed in the vehicle to damp noise-generated vibrations.

6.3 INTERIOR FINISH

Interior finish panels shall be lightweight and of balanced construction to minimize warping under differing temperature conditions. They shall be vandal resistant (impact, graffiti, etc.) and shall have a proven record in rail transit service. The panels shall not fade nor discolor over time.

The surfaces of interior finish panels shall be smooth, and no edges shall be created which shall cause dust traps.

The interior close-off panels on the side of the vehicle shall be designed to accept information/advertisement cards.

Stainless steel kick plates of 150 mm depth with radius curving shall be provided on all exposed vertical surfaces above floor level.

6.4 FLOORING

The interior flooring shall be supported by the vehicle body underframe structure, which shall be constructed to minimize floor deflection under W3 passenger loading.

All floors including floor coverings shall withstand a force of 1000 N applied over an area of 25 mm² without suffering any deformation or marking. The interior flooring shall cover the entire passenger saloon area with transit grade floor covering.

To prevent noise due to vehicle deflections, the flooring composition shall be insulated from the metallic structure by a suitable material.

The floor design and bonding process shall allow the floor covering to be removed and replaced without damage to the floor sub structure.

All saloon floor to wall interfaces shall have a radius to allow easy cleaning and avoid dirt traps.

The floor covering shall be required to continue up the side walls by the degree that have enough service proven record, to provide a sanitary cover.

It is preferred that floor covering is seamless. Where seams do exist, they shall be fully sealed and shall not create a tripping hazard.

The Contractor shall offer a contrasting floor covering for vestibule areas compared with the passenger saloon area.

The floor covering material shall meet the following performance requirements:

1) Slip resistance of 0.75 dry and 0.62 wet in accordance with JRIS J0745;
2) Hardness of Shore A Hardness 85-90;
3) Resistance to chemicals in accordance with JIS A 1454 with noticeable variation; and
4) Tensile strength in accordance with JIS K 6251 - 7.3 MPa.

The entire floor construction shall be required to comply with the requirements of the Japanese Ministerial Ordinance, MLIT Chapter 8, Section 5, Article 83 (Countermeasures for Fire of Rolling Stock).

All floor penetrations (for piping, conduit, etc.) shall be suitably sealed against the elements, and be required to comply with the above requirements of MLIT.

6.5 CEILING

The vehicle ceiling shall present an aesthetically pleasing smooth surface, and shall incorporate lighting fixtures, air-conditioning air outlet grills, public address speakers, etc. The ceiling panels and fixtures shall not vibrate, rattle or squeak during normal service conditions.

6.6 DRAUGHT SCREENS

Draught screens shall be provided at each passenger door portal to protect seated passengers from a draught and adverse weather conditions when the doors are opened.

The draught screen shall be a safety glazed panel, designed to withstand the in-service forces and shock loads. The draught screen shall have through visibility and be graffiti resistant.

6.7 PASSENGER SEATS

The Contractor shall propose a longitudinal seating arrangement.

All seats shall be installed cantilevered off the side wall with no floor support, to facilitate cleaning of floors and storage of passenger belongings underneath.

The seats shall be designed and manufactured to MLIT Chapter 8, Section 5, Article 83. Details of the specification and testing requirements are to be supplied by the Contractor to the Engineer for review.

The materials used in the seat design shall be fire and vandal resistant. Fire performance testing shall be undertaken by the Contractor with review by the Engineer. The seat design shall eliminate gaps that shall trap dirt or liquids.

The seat design shall eliminate gaps that shall trap dirt or liquids, and the artificial leather sheets shall be applied on the seats or ergonomic, water-proof, vinyl seats that can be scratched but not cut, and can be easily cleaned.

The Contractor shall be required to supply documented evidence that the proposed seats have demonstrated trouble-free service in a similar operating environment.

6.8 ACCOMMODATION FOR DISADVANTAGED PASSENGERS

The Contractor shall provide space on all vehicles to cater for people in wheelchairs and people with prams. The prospective wheelchair space shall be prominently labelled on the floor with the appropriate standard sign. Additionally, fully retractable and non-obstructive wheelchair tie downs shall be made available for ready installation for each wheelchair space.

A total of six (6) seats shall be designated for disabled and elderly passengers per car. The disabled and elderly passenger seats labels shall be prominently displayed.

6.9 STANCHIONS AND HANDHOLDS

Suitable stanchions and handholds shall be provided to allow passengers to stand comfortably at all times. All stanchions and handholds shall be seamless, corrosion resistant, round stainless steel tubing.

The location and type (size) of stanchions and hand holds shall be submitted to the Engineer for review.

The stiffness and strength of the stanchions and handholds and their connections, shall be designed and tested to ensure that they shall withstand the rigors of service and environment.

All stanchions and handholds shall have high visibility and in a contrasting color to the internal décor.

Vertical stanchions and horizontal hand holds shall be designed and tested to withstand without permanent deformation, a load of 1.5 kN applied in any direction at the midpoint. Horizontal handholds shall be designed and tested to withstand, without permanent deformation, a load of 1.5 kN applied at the midpoint of the span.

All attachments shall be stainless steel fittings properly cushioned to prevent rattling and shall be such that unauthorized removal or vandalism shall be minimized. All fittings shall permit easy removal and installation for maintenance purposes.

6.10 STRAP HANGERS

The Contractor shall provide strap hangers to the handrails. The strap hangers shall be selected of suitable strength and durability, industry proven.

The Contractor shall submit the location and quantity of strap hangers distributed along the handrails to the Engineer for review.

6.11 WINDOWS AND GLAZING

All side windows (except windows in the doors) shall be single glazed with toughened/tempered glass to current railway industry standards. Windows shall be suitably mounted to the car body window frame. The color and degree of tinting shall be reviewed by the Engineer during the design process.

The size of the passenger side windows shall allow the maximum entry of natural light into the passenger saloon while maintaining the structural integrity of the car body.

Windows shall be capable of withstanding the pressure differentials associated with head-on pressure, passing trains, prevailing winds, etc. The windows and mountings shall also be able to withstand the loads imposed by passengers leaning on them under crush loaded conditions.

The mounting of windows shall be able to absorb undue shock without breaking or cracking on the glass.

The side windows shall be the openable (with an option to be locked) and flush mounted type, consisting of two sections, with an upper section which can be opened inward and fixed lower section.

Window design shall allow all passengers (sitting and standing position) to have good vision on the outside and especially for station information.

The body-side and door windows shall be designed to minimize solar gain and provide a level of thermal insulation consistent with the requirements of the air- conditioning system.

Glazing shall be readily removed and replaced from outside the car without removal of the interior linings. The Contractor shall provide the related repair procedure.

Each window, including glazing, shall have sufficient strength when tested in accordance with JIS R 3213.

All side windows shall transmit less than 5% of the incident ultra violet radiation. Body side and door glazing shall be capable of rejecting 50% to 70% solar energy with visible light transmission of 50% to 55%.

Glazing of windows on body-side and doors shall resist vandalism. The windows shall be high enough to prevent easy breakage.

Window seals shall be designed to prevent ingress of water to the inside of the body sides. The sealing material shall be so selected that it lasts at least until the mid-life interval of car body overhaul.

Door windows shall have a window similar to the windows provided in the car body as far as possible in respect of solar gain, thermal insulation, replacement criteria, strength, resistance to pressure, and the transmission of light, and solar heat gain, etc.

Door windows shall be replaceable without removal of the door leaf.

6.12 DRIVERS CAB WINDSHIELD

The cab front windshield shall be of tempered safety glass meeting the requirements of JIS R 3213. The mechanical and optical properties of the windshield shall meet the requirements of JIS R 3212.

The cab windshield shall be bonded directly to the car body window frame. The design shall ensure that, in the event of breakage, sufficient visibility is maintained to operate the train safely for the remainder of the service.

Windshield shall be replaceable within a four-hour period at the depot. Glue and sealant shall be of a type to cure to a level sufficient for the train to re-enter revenue service 8 hours after the completion of the installation of the windshield.

Sun visor(s) shall be installed to provide protection from direct and reflected sunlight over as large an area as possible.

Windshields shall be provided with external electric wiper/washer units and defogger unit. The driver shall be able to control the Cab windshield wipers, washers and defogger via the Driver's Desk. A fan defogger shall not be acceptable. This system shall have no adverse effect on the windshield including overheating in direct sunlight.

The windshield wipers, washers and defogger equipment shall not impair the driver's line of sight. The windshield wipers shall include adjustable speeds of operation with intermittent function and "park" position. At least 80% of the width and 60% of the height of the windshield shall be swept over a complete cycle. The washer unit shall be provided with at least 10 liters of water reservoir, with visual water level gauge, located for easy filling from ground level outside the car.

The driver's cab side windows shall be capable of being opened and positioned so the driver can view the length of the train. An open window shall maintain its set position at all times that the train is in motion. The driver's cab windows shall also meet all the requirements of Sub-Clause 6.11 - Windows and Glazing - of this ERT.

6.13 SIGNS AND DECALS

Signs and decals shall be provided in both Filipino and English languages.

All decals shall be vandal and graffiti resistant, and shall be edge-sealed. The art work shall be submitted to the Engineer for review prior to manufacturing. The Engineer will prepare the complete list of signs and interact with the Contractor during the design stage. The number and location of the signs and decals, and the decal materials used, shall be reviewed by the Engineer.

6.13.1 Passenger Saloon

Decals shall be installed inside the passenger saloon, as follows but not limited to:

1) No smoking decals;
2) No eating, no drinking;
3) System route maps (including places of interests);
4) Door warning notices;
5) Elderly/disabled seats;
6) Emergency notices;

7) Vehicle body number;
8) Emergency intercom;
9) "No Littering" notices;
10) Hold to handrail/hand grip notices;
11) Door number;
12) Fire extinguisher marker; and
13) Wheelchair space.

6.13.2 Vehicle Exterior

Decals shall be installed on the vehicle exterior, as follows but not limited to:

1) The service livery;
2) Vehicle number;
3) MMSP logo;
4) Identification of lifting and jacking points;
5) Identification of maintenance requirements;
6) Door gap and height reminders; and
7) Safety reminders.

The Engineer will prepare a complete list of signs and decals, and liaise with the Contractor during the design stage.

6.14 MISCELLANEOUS EQUIPMENT

Fire extinguishers of the approx. 3.5L chemical water type, or equivalent, shall be provided. One shall be fitted in each driver's cab and two shall be fitted in each passenger saloon. Those in the passenger saloon shall be recessed in a breakable glass cabinet, but shall be readily accessible.

6.15 DRIVER'S CAB

6.15.1 General

A driver's cab shall be provided at each end of the train. The driver's cab shall be equipped with an interior door and two side doors. Each door can be locked inside and outside by a key. The doors shall be manufactured as provided for in Sub-Clause 8.2 - Cab Doors - of this ERT.

As part of the design process, the Contractor shall manufacture a full sized, fully equipped cab mock-up for the purpose of evaluating the design.

The driver's cab layout shall be agreed between the Contractor and the Engineer.

The Contractor shall finish the driver's cab in neutral tones to create a pleasant environment without visual distractions and it shall be designed to reduce glare and the effects of sunlight at low angles on screens. Low gloss levels shall be provided in the design of the driver's cab console.

The layout shall comply with the requirements of international standards, including but not limited to:

1) MLIT Article 72 Ergonomic principles in the design of work systems;

2) ISO 9241 (parts 2, 5 and 11) Ergonomic requirements for office work with visual display terminals (VDTs) or equivalent; and

3) JIS Z 8502 Ergonomic principles related to mental workload.

Driver cab shall be designed taking into consideration that some equipment is necessary for each line individually. So, the Contractor shall design the arrangement in the cab from point of view of easing through-operation, expecting some equipment is needed individually, regarding to following equipment at least;

1) Signaling systems;
2) Radio systems; and
3) Train protection radios.

6.15.2 Driver's Seat

The Contractor shall place the driver's seat to ensure that the driver's sighting requirements are achieved. The cab size and crew seat locations shall ensure un- restricted movements to and from the cab access doors.

Each driving position shall be fitted with a fully adjustable, ergonomically designed, railway service proven gas cylinder suspension equipped driver's seat.

The seat shall have as a minimum the following adjustments:

1) Vertical seat height;
2) Horizontal distance from console (forward/backward):
3) Backrest angle;
4) Lumbar support;
5) Head rest; and
6) Revolving movement with locking system.

An additional folding seat shall be provided inside the drivers' cab for the use of other service staff.

6.15.3 Cab Air-Conditioning System

Conditioned air shall be ducted from the passenger compartment air supply, through adjustable diffusers in the cab ceiling, to maintain the specified vehicle interior temperatures and humidity. The driver's cab air supply design, arrangement and calculations shall include the increased solar load through the cab's windshield and the heat load produced by the equipment inside the driver's cab.

6.16 CAB CONTROLS OF DRIVER'S CAB

6.16.1 General

The driver's controls shall be incorporated into a modern, ergonomic console design located at the cab front end structure. All controls, instruments, displays and gauges shall comply with the requirements of ISO 9355 ergonomic requirements for the design of displays and control actuators.

Any control operation and train condition shall be recorded in the event recording device of Train Management System (TMS) in both leading cars. The memories of the event recorder shall be physically located in a position on the train such that it shall be extremely unlikely to receive damage during a train collision. The Contractor shall ensure the security of the data.

The data stored in the memory shall be readily available to support any accident investigation.

The Contractor shall demonstrate by using cab mockup that the display panel and lamps are located where sunlight will not affect the display.

The following driver's controls shall be provided on the console as a minimum:

1) Communications cluster, consisting of a telephone handset, voice synthesizer, etc.;
2) Door controls cluster;
3) Train management system HMI, (TMS monitor that can be operated by touch);
4) Driver's controls cluster, consisting of the master controller, driving mode switch, reverse lock switch and master key switch;
5) On-board signaling cluster;
6) Speedometer;
7) Security brake push button, for the application of emergency brake, automatic lowering of pantograph and opening of line circuit breakers;
8) P.A. cluster, consisting of passenger alarm lit push button and microphone;
9) Windshield washer/wiper cluster, with wiper speed control (high speed, low speed, intermittent-infinitely variable);
10) Vigilance alarm buzzer;
11) Loud speakers;
12) On-board signaling buzzer;
13) Fault buzzers;
14) On-board signaling selector;
15) ATP cut-out switch; and
16) Miscellaneous switches - headlight (high/low beam), gauges/voltmeter - such as line voltage and horn, brake cylinder pressure, main reservoir pressure, etc.

6.16.2 Master Controller

The master controller shall control motoring and braking in several steps in an adjustable linear manner, as follows:

Table 6.1 Master Controller

No.	Handle Position	Function
1	Vertically upright	OFF position
2	Forward from the vertical position until the handle reaches its end position with a spring return device.	Propulsion, with acceleration increasing according to 4 steps with handle movement.

No.	Handle Position	Function
3	Backwards from the vertical position until the handle engages a spring-loaded detent.	Normal braking, with the effort increasing according to 7 steps with handle movement.
4	Backwards from the spring-loaded detent in 3, until the handle reaches its end position.	Emergency braking.

The master controller shall be ergonomically designed to minimize unnecessary physical strain and fatigue to the operator.

The Master Controller shall have a control system for keeping the constant speed in case of powering.

The master controller shall be locked/unlocked by the driver's key and reversing switch.

When the driver's key is in the "ON" position and reversing switch is in the forward or reverse position, the master controller shall be unlocked.

The driver's key shall itself be captive when the master controller is not in the predetermined position.

The driver's key shall itself be captive when the reversing switch is not in the predetermined position.

Only one cab on the train consist shall be able to be activated at any one time.

6.16.3 Reversing Switch

The reversing switch has 3 positions, as follows.

Table 6.2 Reversing Switch

No.	Reversing Switch Position	Direction of the train
1	Vertically upright	OFF position
2	Forward from the vertical position	Forward
3	Backwards from the vertical position	Reverse

When the driver's key is in the ON position and the master controller is in the predetermined position, the reversing switch shall be unlocked. The Contractor shall assume to add 1 or 2 positions to the above 3 positions as the result of coordination with other relating contractors.

6.16.4 ATP Mode

The ATP mode shall be locked by the Driver's key and a sealed switch for ATP cut- out shall be provided.

The train shall be designed to make provision for an additional on-board signaling system.

Details of the signaling system will be provided by the CP106 (if needed, CP NS-01) Contractor during the interface meeting as described in Section 18.

6.16.5 Driver's Vigilance System

Within the master controller handle or in its vicinity, there shall be a button which must be

pressed and released on a regular, predetermined basis, to prevent the application of emergency braking.

The feature shall be coordinated such that either action described as follows prevents brake application.

1) If within a certain period of time there is no master controller operation by the operator, the alarm sounds; and
2) Within 5 seconds after the alarm sounds, if there is no operation of the confirmation button, or no master controller operation, the emergency brake is operated.

The idling time limit for alarm shall be able to be adjusted by the maintainer.

6.16.6 Miscellaneous Cab Equipment

The cab shall incorporate a locker for storing emergency equipment (first aid kit, flashlight, emergency connection cable, etc.) and another one for storing the driver's personal belongings (baggage, etc.) All emergency equipment shall be indelibly marked with the name or logo as instructed by the Engineer.

Crew keys and equipment box keys shall be identical and preferably exchangeable.

6.16.7 Line-Recognition Circuit

Four (4) kinds of line-recognition circuit which is able to be selected by the master controller key shall be equipped. Each of line-recognition circuits shall be activated by a master controller key which is suitable for the designated line, therefore each of the master controller keys shall not be the same shape.

Each of the line-recognition circuits shall have two functions as below:

1) Activated only when the master controller key is inserted.
2) Continuously activated after the master controller key which has already been inserted is pulled out.

Assuming the line-recognition circuit cannot be selected by the master controller key, forcibly selecting function shall be equipped.

In addition, the above, the circuit which can recognize the line information from CBTC shall be equipped. Regarding the number of this circuit, the same number (4) as that of the above circuit shall be equipped.

The structure of 4 recognition key block shall be of having the enough service-proven in Japan.

6.17 VEHICLE FIRE SAFETY AND PROTECTION

Materials to be used for vehicle construction shall provide fire propagation resistance complying with relevant requirements in the Japanese Ministerial Ordinance, MLIT Chapter 8, Section 5, Article 83 (Countermeasures for Fire of Rolling Stock), Fire Code of the Philippines or equivalent.

A fire hazard assessment for each vehicle shall be submitted by the Contractor for review by the Engineer. Assessment shall reflect the "worst" three-minute release rate values of the materials that are specific to the vehicle.

7 LIGHTING

7.1 GENERAL

The lighting circuits shall include at least:

1) Driver's cab lights;
2) Passenger saloon lights;
3) Passenger saloon emergency lights; and
4) Exterior lights.

The Contractor shall ensure all lighting fulfills the mandatory requirements of JIS E 4016 – Illuminance for Railway Rolling Stock – Recommended levels and measuring methods.

All interior lights shall have a level of protection of at least IP54. All exterior lights and switches shall have a level of protection of at least IP65.

Care shall be taken to ensure that flickering does not occur during train starting or normal running.

Individual lights circuits shall be protected from abnormal currents via separate miniature circuit breakers. Each light circuit shall be controlled by separate switching.

The lighting functionality and operation shall be agreed through the design review process.

7.2 DRIVER'S CAB LIGHTS

Lighting in the driver's cab shall be able to be controlled by the driver. In addition to general lighting a driver's spot light shall be provided for the purposes of reading.

Lighting in the driver's cab area shall be powered via the battery system when the auxiliary power supply is not working.

The Contractor shall provide LED lighting which is no less than 100 lux measured on vertical plane 500 mm above driver seat level.

7.3 PASSENGER SALOON LIGHTS

The driver shall be able to control the lighting in a train consist. The lighting arrangement shall be configured to provide continuous uniform lighting, to eliminate glare and to minimize the creation of shadows.

The Contractor shall provide LED lighting in the passenger area that is modern and aesthetically pleasing with a mass production of over 5-year service proven history. The lighting minimum declared life shall be 50,000 hours. The lighting shall be powered by 220 V ac supply.

The lighting intensity at passenger sitting reading level (500 mm above seat level) shall be no less than 400 lux and at 850 mm above floor level no less than 200 lux. Passenger saloon lighting shall have no significant dark areas behind the diffusers. The main passenger lights circuit shall be protected from abnormal currents via a separate circuit breaker.

7.4 PASSENGER EMERGENCY LIGHTING

A reduced level of passenger saloon lighting shall be powered from batteries if the overhead power is not present or the auxiliary power supply has failed.

Emergency lighting at a minimum average illumination of 10 lux shall be provided by LED lighting with the capacity to allow lighting to be provided within all passenger saloons, at all inter-car locations and in the doorway areas, which shall be powered from the battery for at least 90 minutes.

The emergency passenger lights circuit shall be protected from abnormal currents via a separate miniature circuit breaker.

When the Auxiliary Power Supply Equipment (APSE) stops, appropriate pieces of these LED lights in one vehicle shall be powered from the battery. Namely, this means these LED lights have also the role of emergency lights.

7.5 EXTERIOR LIGHTS

The Contractor shall provide LED-type headlights.

The headlight shall have two functions. One is down lighting mode; another is high- beam mode. The Contractor shall ensure that TMS monitor displays when the light is in either state.

The Contractor shall ensure that a headlight fault detection system is provided for each train cab, providing fault indication and status information to the driver by TMS monitor.

The light intensity of headlights shall comply with Table.7 in the item 5.2.1 of JRIS R 1645.

Headlight lamps shall be capable of being replaced, aimed correctly from the outside or inside of the driver's cab easily. The optical axis of the head lamps shall be capable of being adjusted easily.

The Contractor shall ensure that the red tail lights or white marker lights are automatically activated based upon the cab activation status as follows:

1) Red tail lights displayed - associated cab is not activated, or non-activated cab is at rear of the train, or when both cabs in the train are inactive, also when tail light switch is operated; and
2) White marker light displayed - associated cab has been activated, indicating this shall be the front of the train. The white marker lights on the inactive end cab shall be lit when vehicles are driven in reverse direction.

LED type marker lights shall be provided and combination red/white units may be proposed.

The Contractor shall ensure that inspection lights are provided in the vicinity of the underframe mounted equipment. The inspection lights shall be push-button activated from the cab and underframe and shall incorporate design features to ensure that the lights are not inadvertently left on when the train is in operation.

Locally switched maintenance/inspection lights shall be installed in the equipment boxes which may need to be accessed periodically (i.e. equipment boxes containing circuit breakers, switches).

The Contractor shall basically ensure that two indicating lights are installed above each door, one inside and one outside. The lights shall be illuminated when the doors open while not lit up when the doors are closed. The lights shall be blinking during the opening and closing cycle of the doors. The lights shall be illuminated together with an indication on the driver's panel or the TMS monitor when the door is faulty and/or isolated. The Contractor shall assume that details of these indicating lights, which include numbers and colors etc., may be coordinated with other lines in consideration with interoperability.

The Contractor shall ensure that all lights are powered from the low voltage DC power supply system. Should the auxiliary power supply equipment not be operational, the lights shall be powered from the batteries.

8 DOORS AND DOOR CONTROL

8.1 PASSENGER SIDE ENTRANCE DOORS

The side entrance-door design and functionality shall be based on a "fail-safe" principle and incorporating high standards of safety and security for the passengers. Design, safety and testing of the passenger doors shall be compliant with MLIT Article 74. Four bi-parting doors shall be provided on each side of every car. All doorways shall have a clear opening of 1300 mm and a clear height of 1850 mm. The doors shall be the sliding pocket doors, constructed to prevent hands/finger pinning at the pocket section during operation. Door positions in the car and door pitches shall be complied with bottom picture of Appendix C.

The Rolling Stock shall be a high-floor design, with level boarding from platforms. Wheelchair and mobility-impaired boarding shall not require the use of bridging or lifting devices. The horizontal distance of the passenger door thresholds shall be 1,475 +/- 25 mm from the track center.

Doors shall be vibration free and sufficiently insulated against heat and sound transmission. Exterior and interior surfaces of the door leaves shall be finished to match the adjacent surfaces of the car. The doors shall be free from dimples, warping, spot welding depression and any other blemish.

When closed, the door leaves shall be capable of withstanding loads imposed by passengers leaning on them under crush loading conditions. The doors shall be designed and tested such that the door leaves sustain such pressure with no permanent deformation. The Contractor shall submit test procedure and results based on best international practices.

It shall not be possible for a door to become detached from the vehicle under any operating conditions, including heavy side load from standing passengers or sudden pressure transients.

No single defect or failure of any part of any door system shall produce a situation capable of causing injury to passengers.

Door guides and supports shall be mounted within the section of doorway protected by the door seals and shall not allow ingress of dirt, debris, or any other foreign matter likely to result in excessive wear or incorrect operation of the door equipment.

The Contractor shall indicate the amount of time required to replace a door leaf, adjust it and test it.

The doors shall be constructed to withstand the loads imposed by passengers leaning on them under crush loading conditions. The Contractor's attention is drawn to the requirements of Sub-Clause 2.3.1 - Structural Requirements General of this ERT. Also, the doors shall be designed and tested that when normally installed, one leaf can sustain a concentrated load of 900 N applied to the plane of the door, at the center of the front edge, with a maximum deflection of not more than 6 mm, but with no permanent deformation; and shall not exceed a force of 250 N when closing.

The door operating system at each doorway shall be capable of being isolated electrically and mechanically. When isolated, the doors shall be kept closed by mechanical means. The door operating system shall include damping, to smoothly arrest door leaf motion, at the end of the open and close stroke.

All doors shall open and close simultaneously. Doors shall fully open within 2.0 to 2.5 s of the door open command, and shall fully close and lock within 2.5 to 3.0 s of the door close command. During normal door operation, the maximum velocity of each door leaf shall not

exceed 1.5 m/s. When closed, all passenger side entrance doors shall be automatically mechanically locked in the fully closed position, preventing the doors being opened beyond a limited push back facility. When closing, the force shall not exceed 250 N.

The doors shall be manufactured from the same material used in the construction of the vehicle body shell, with a honeycomb core or equivalent, and shall incorporate the same exterior finish. All joints shall be sealed against moisture ingress, and drain holes shall be provided in the bottom of the doors to allow the escape of condensation, water from rain or as a result from cleaning the vehicle. Internal metal reinforcement shall be provided for the attachment of door hardware. The doors shall be appropriately insulated to meet the noise requirements. Each door leaf shall be equipped with a full-length male/female rubber nosing, which shall provide a weather tight seal, be capable of withstanding the rigors of service, and prevent injury to passengers trapped between closing doors.

The bottom of the doors shall be provided with stainless steel kicking plates and with easily replaceable door guides, which shall be adjustable in the vertical direction, and shall be manufactured from a wear-resistant, low friction material such as high- density high molecular weight polyethylene.

The doors shall be glazed with a fixed glazed window of toughened glass to current railway transport standards. The glass tinting shall be according to Sub-Clause 6.11 - Windows and Glazing. The window assembly shall be free from rattles, and the mounting shall be capable of withstanding the pressure differentials associated with head-on pressure, passing trains, prevailing winds, etc.

All door mounting hardware and door actuation hardware must be readily accessible for adjustment and removal through the aforementioned access panels. A door leaf shall be capable of being removed and replaced within 60 minutes.

One set of passenger side entrance door production hardware (door leaves, operators, local control units, etc.) shall be subjected to an accelerated life cycle test, whereby the doors are installed in a simulated door frame and operated for a minimum of 1.5 million cycles. This test shall be completed before the first vehicle is ready for shipping, and must ensure that the specified reliability is met.

A door for gangway shall be provided at each end of each vehicle. A door for gangway shall have heat and fire -resistant tempered glass and structure and function to prevent scattering at breakage shall be applied. It shall be used stainless steel for the rim and applied a collision prevention film to the glass surface. The gangway shall be a self-closing type with a normally closed structure, but a sliding door on one side shall be a mechanism that can hold the door and can easily solve it or normally closed structure. The gangway shall be able to maintain and continue constant braking force during opening and closing operation and shall be robust. The width of gangway shall be more than 900 mm. The gangway specification shall be submitted to the Engineer for review and comments.

8.2 CAB DOORS

A sliding or both side open type hinged door shall be provided in between the driver's cab and the passenger saloon to allow ingress/egress of the train crew.

In addition, a hinged door or sliding door shall also be provided on both sides of the driver's cab to allow direct ingress/egress of drivers to and from the station platform and at the depot. The side door shall contain a vertical sliding window. The side door shall open inwards only if hinged door is provided.

The side door shall be manufactured from the same material used in the construction of the

vehicle body shell and shall incorporate the same exterior finish.

The cab door from the passenger saloon and the side doors shall be able to be locked manually using the same key. Similarly, these doors shall be able to be locked and unlocked from inside the driver's cab without a key.

The side door lock shall be accessible from both ground level and platform level. The door design shall be submitted to the Engineer for review.

8.3 PASSENGER DOOR, OPERATORS AND CONTROLS

Passenger door operators shall be service-proven in tropical condition and in similar environment to that of the Manila area. The passenger door system shall be applied the electrical type.

There shall be local audible and visual indications to passengers (to be submitted by the Contractor for the Engineer's review), during the door release sequence as well as prior to and during the door closing sequence, and there shall be a delay of 1 second prior to opening or closing the doors.

No part of any door, door installation, door control system or any other components for use within the door systems, shall be capable of causing injury to passengers or personnel as a result of door operation. Particular attention shall be paid to trapped obstacles in the passenger doors.

No spurious electrical signals shall cause any door to be released or opened unintentionally, particularly when the train is in motion.

All saloon doors shall be provided with interlock switches incorporated in the door control circuit to prove that doors are closed and locked. When the door control circuit is not proven closed, train movement shall be inhibited and brake shall remain apply. Saloon door interlock status shall then be interfaced to the TMS.

The body side doors are equipped with the following safety system:

1) Passengers are informed that the doors are being closed by sound and visual devices;
2) Starting of the train can only be authorized when all doors are closed and locked; and
3) That a door is prevented from closing when a passenger or object is located between the two closing door leaves and after attempting to close, that particular door will reopen and attempt to close again repeatedly until the object is cleared and the door can close and lock.

Detection of small objects, hands, clothes shall be detected by sensitive edge door devices. The obstruction detection shall be tested with a rigid 15 mm diameter object placed perpendicular to the door panels at any three (3) vertical locations along the leading edge of the doors (except the lowest 75 mm and the upper most 100 mm).

On detection of an obstruction the doors shall behave in the following manner (or similar):

1) If, during the first attempt to close, a door is obstructed, the door shall reopen by at least 100 mm for each leaf and remain open for 1 second before attempting to close again. The driver shall be notified of the door obstruction and its location by the TMS;
2) If, on the second attempt to close, the door is obstructed, the door shall reopen by at least 100 mm for each leaf before attempting to close again. There shall be the ability

to manually push the door back further;

3) If, on the third attempt to close, the door is obstructed, the door shall open to full width and remain in this state until reset; and

4) To reset the door, the crew shall operate the door close control to restart the closing cycle.

The push-back feature shall be operative after the door leaves have been locked. It shall be possible to manually push back each closed-door leaf to enable entrapped objects such as clothing and other articles, to be withdrawn, even after the mechanical lock has engaged. The force required to push back each door leaf shall not be less than 80 N more than 120 N.

The door system shall continue to operate correctly within the defined car battery voltage range.

The above gaps and timings are notional, and shall be capable of being adjusted after experience in service has been gained. The initial settings shall be determined from an investigatory trial undertaken using the door test rig.

Time delay of door motion shall be adjustable from 0 to 3 seconds.

Door warning shall be clearly audible to both internally and externally to the cars at all door passenger portals.

The volume of door warning tones shall be adjustable by maintenance staff only. The opening and closing of doors shall only be possible from an operative cab, and it shall not be possible to energize the door open circuits if train speed is greater than 3 km/h. Door closing or opening time shall be adjustable between two and five seconds.

Propulsion power shall be inhibited until all doors have closed and are locked; the Contractor shall provide the function that does not enable brake release and train start if all doors are not closed and locked.

It shall be possible to isolate a defective door on any vehicle from the door open command, at which time the yellow fault lights on that side of the exterior of the vehicle shall illuminate. The isolated door (s) of a vehicle (s) shall be identified in the TMS and marked "X" to denote it has been isolated.

The driver must reset the device before the train can proceed. The device shall be recessed and suitably sealed to prevent accidental actuation.

8.4 EMERGENCY DOOR RELEASE MECHANISM

All passenger doors shall be equipped with an emergency door release mechanism to allow passengers to manually open the door without the use of special keys or tools.

The manual emergency release shall however be shielded from unintentional use by passengers, whilst still being available in an emergency.

In the event of activation of the emergency door release mechanism, warning message and audible signal shall be displayed on the TMS HMI to alert the driver. The driver shall have 5 seconds (time period shall be able to be adjusted from 0 to 10 seconds) to acknowledge the event. If the driver fails to react within the time period, the emergency brake shall be applied.

Clear and unambiguous signage in both Tagalog and English giving instructions on the use of passenger door emergency facility shall be provided.

The internal and external emergency door opening device which can open all or the several doors shall be included. The position and function, numbers of emergency door opening device shall be reviewed by the Engineer.

8.5 DOOR ISOLATION AND ACCESS – INTERIOR/EXTERIOR

The power supply to an individual doorway can be switched-off/isolated whereby the door is permanently closed and locked out-of-use.

Access through the left and right passenger doors nearest the driver's cab shall be able to be opened from the outside by a key.

8.6 INTERFACES

The Contractor shall consider in his design the following interface requirements:

1) TMS / Status monitoring;
2) Chime;
3) Light;
4) Signaling system; and
5) PSD Controller.

Doors shall be part of the safety loop and shall be interlocked with the brake system.

8.7 DOOR OPENING AUTHORIZATION IN DEGRADED OPERATION

In case of unavailability/failure of door authorization signal from Signaling system, adequate safeguards shall be provided and also incorporated in control circuit to minimize the probability of error of opening of doors on wrong side (other than platform side) during revenue service.

In this case, the opening can be controlled by the train driver by the action on a right opening button or a left opening button placed on the desk.

8.8 INTERLOCKS RELATED TO PSD (PLATFORM SCREEN DOOR)

Door control units shall be interfaced with CBTC and PSD controller to get data or signals of PSD such as platform side, stop position, state of the PSD (open/close/trouble) etc. Interlocks for door control shall be ensured to be accomplished by using above. Also, interlock for propulsion, which not allow the train to move if train cannot start safe, shall be ensured to be accomplished. Rolling Stock Contractor shall be coordinated with related Contractor (CP-106 and CP NS-01) to develop interlocks for the best possible safety above.

Though above interface and circuits shall be completed for preparation, interlocks shall be changeable valid or invalid easily.

PSD control circuits shall be interfaced with TMS for recording events and indicating necessary information of PSD.

This system shall have the redundancy and the below function in case of any trouble.

Forcibly doors open function:

In case of no door enables, the doors can be opened. And if this function is activated, the status shall be interfaced to CBTC, PSD Controller, Space and TMS.

Forcibly train acceleration enable:

In case of PSD trouble, train can accelerate by using this function. And if this function is activated, the status shall be interfaced to CBTC, DSR and TMS.

Forcibly changing function whether PSD interlock function is activated or not.

In case interlocks are not necessary, all interlocks related to PSD shall be invalid when this function are activated.

Details of interlocks related to PSD shall be submitted for review and comments by the Engineer.

9 VENTILATION AND AIR-CONDITIONING

9.1 GENERAL

Each vehicle shall be provided with two units of ventilation and air-conditioning (VAC) system complete with relative humidity control. The air-conditioning units (ACU) shall be controlled independently such that if there is a failure in one unit, the other units shall continue to operate normally. All system components must be service-proven, and must be tested to demonstrate compliance with the requirements of this ERT.

The Contractor shall submit a complete design of the air handling and diffusing system along with air flow and velocity calculation for the Engineer to review. Upon installation on the vehicle, the complete air supply/diffusing system shall be measured and balanced and the air flow and velocity confirmed. Air-balancing on each vehicle shall be performed by a qualified VAC technician. Measurements shall be conducted in accordance with American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) requirements or equivalent.

The Contractor shall provide test and service equipment necessary for the maintenance and repair of the VAC units. This shall include but not be limited to an off-board test bench, refrigerant recovery/recycling equipment and portable vacuum pump.

In order to cater for an unexpected stoppage of the VAC system, there shall be a reset breaker installed in the driver's cab.

9.2 VENTILATION SYSTEM

Blower fans supplied as part of the overhead evaporator units shall be capable of providing vehicle ventilation. Fresh air shall enter the vehicle through screened openings in the roof on each side, pass-through stainless-steel ducts (sloped downwards to drain), and pass through a filter into a plenum chamber adjacent to each overhead evaporator unit. The design shall prevent blown rain from entering the plenum and leaking into the vehicle interior.

Re-circulated air shall be drawn through grills in the ceiling and mix with the fresh air. This air mixture shall then pass through another filter into the evaporator unit, from where the blower shall force the air through the evaporator coils into the main air ducts. The ventilation system shall ensure that the inside pressure be positive value with all doors and windows closed with a pressure range of 20 to 40 N/m2.

Means shall be provided to adjust the volumes of fresh and re-circulated air. A minimum of 2,500 m3/h of fresh air per vehicle shall be provided.

The main air distribution duct shall be manufactured from anodized aluminum or service-proven material, and shall be constructed to ensure that the exiting air velocity is constant along its length.

Air filters shall be washable/re-useable and shall be well supported to prevent passing air from dislodging them should the filters become blocked; they shall seal well at all edges. The filters shall be easily replaced and shall be sized such that they shall be serviced monthly.

In order to reduce the frequency of maintenance of the filter, roll filter shall be used. The roll filter is furnace material wound around the core, and when the set time has elapsed, a new furnace material portion is automatically set. Setting time of the winding is able to be changed arbitrarily by maintenance people. The length of the roll filter shall be reviewed by the Engineer.

Active-ventilation system actuated by the battery supply shall be necessary. Active ventilation system shall be operated at least one (1) hour by the battery supply.

The entire ventilation system shall be submitted to the Engineer for review.

9.3 COOLING SYSTEM

The VAC shall be thermostatically controlled and shall be service-proven and shall automatically maintain the specified interior temperature conditions. Relative humidity in the vehicle shall not exceed 60% under stabilized conditions. The capacity of the VAC shall be calculated considering basically W3 condition. The calculated capacity shall be reviewed by the Engineer. The outside units of VAC shall be mounted on the roof of the vehicle into two separate units.

In order to lower the center of gravity, the weight of one outside unit shall be as light as possible. The Contractor shall, for example use aluminum or any equivalent material that is rust-resistant and selecting the most adequate compressor, etc.

Air flow over the evaporator coils shall be no more than 2.5 m/s. Evaporator coils shall preferably be manufactured from copper, and shall have copper fins; however, aluminum elements are also acceptable provided they are sufficiently protected from the elements. A condensate pan shall be provided beneath the evaporator coil. The pan shall be made from stainless steel with suitable drain lines and shall be easily removed for cleaning. The condensate drain lines shall be insulated to prevent condensation.

The refrigerant used shall be environmentally friendly such as R407C or equivalent; the use of refrigerant containing fluorocarbons shall not be allowed. To avoid issues of moisture and water, connectors in outside units shall be waterproof.

The evaporator unit shall include all required components, such as the liquid line, solenoid valve, modulating solenoid valve, thermal expansion valves, liquid line strainer, liquid line sight glass/moisture indicator, etc. Appropriate gauge ports to aid troubleshooting shall be provided.

Blowers shall be direct-driven by a motor, which shall be powered by the 440 V ac auxiliary power supply system.

The compressor-condenser unit shall be heavy duty transportation grade, service- proven combined hermetic compressor/condensing unit. The compressor motor shall be powered by the 440 V ac auxiliary power supply system. Cylinder unloaders shall be easily adjusted, and shall provide stages of unloading.

Sequential starting of compressors on a train shall be provided. Condenser coils shall preferably be manufactured from copper, and shall have copper fins; however, aluminum elements suitably protected from the environment are also acceptable. The coil shall be designed with adequate capacity to provide a condensing temperature no greater than 16 °C above the condenser cooling air temperature, under full rated load conditions.

VAC units shall be easily removed by lifting without the need to break any connections in the refrigeration circuit.

Intermediate car, 6 units Line Flow Fan shall be incorporated. In leading car, 5 units Line Flow Fan shall be incorporated. One unit consists of two fan devices. In driver cab, adequate fun shall be incorporated. Line Flow Fan has a swing mechanism and can change the direction of the wind. The strength of the wind shall be changeable. So the strength of wind shall be controlled by controller according to ride rate and the temperature inside the vehicle etc,.

The VAC units shall be capable of cooling down an empty car, which has stabilized throughout the surface design temperature without sun radiation, to the control temperature of 25 °C in the passenger saloon within 30 minutes.

Full details of the entire VAC system shall be submitted for review by the Engineer.

9.4 OPERATION AND CONTROL

9.4.1 Operation

The VAC system shall automatically maintain the interior temperature of the vehicle (including the driver's cab) at the setting temperature to the controller with any exterior ambient temperature ranging from 20 °C to 45 °C. If the exterior ambient temperature is above 40 °C, the interior temperature shall be maintained at 15 °C below the exterior ambient. Temperature overshoot shall be limited to 1 °C. These temperatures must be maintained with or without the heat loads from the various sources, human, equipment and solar gain. Relative humidity shall be maintained at not more than 60%.

9.4.2 Controls/Testing

Standard programmable logic controller of industrial grade shall be provided for the control and monitoring of the VAC system. Temperature sensors shall be located to ensure that they are not unduly affected by local sources of heat, such as motors, and shall be readily accessible for maintenance and replacement. The settable interior temperature to the controller shall be from 18 °C to 30 °C. The setting-temperature of each vehicle shall be able to be temporarily changed by the maintainer, by operating the TMS monitor in the driver's cab. The temporary changed setting temperature shall revert to the original setting-temperature when the power supply of the controller is turned off and on once.

The temperature control unit shall be interfaced with the TMS and shall incorporate local LED display, indicating the status of the temperature control functions. The unit shall also indicate the fresh air temperature and the return air temperature, etc. Indicators shall also be provided to verify normal operation.

The equipment shall also include an embedded fault indication and fault diagnostic system, and shall be connected to the TMS. A portable test units (PTU)/PC, including the necessary interface programs, shall also be provided to isolate temperature control problems and allow downloading and analysis of recorded faults. The VAC system shall operate with moderately reduced power when it receives signal from TMS that APSE stops to operate.

Control of the VAC shall be operated via the TMS monitor in the Cab. The operating state of VAC and the passenger room temperature, etc. shall be displayed in the TMS monitor.

10 BRAKING SYSTEM

10.1 GENERAL

The trains shall be supplied with brake equipment and functions specified herein, such that a complete, fully integrated and fully functioning friction brake/electric braking system is provided. In addition, all equipment shall be specified in conjunction with the provision of Clause 3.7 - Bogie Mounted Brake Equipment and Clause 11 - Pneumatic Equipment of this ERT. All equipment shall be supplied by an experienced braking equipment manufacturer with documented proven satisfactory experience with similar equipment to that specified herein.

Braking actions including the service and emergency brakes shall be controlled by the master controller in the driver's cab. The Emergency system shall be fail-safe (energize to release). Emergency braking shall be friction only, protected by the wheel slide protection system, but shall not be jerk limited. Propulsion power shall be inhibited when braking in any levels. The propulsion circuit line breaker (LB) shall be opened when the emergency brake is commanded.

The service brake demand from CBTC, ETCS (if needed), Running and Stopping Assistant System and PSD controller shall be transmitted from TMS to BCU by control transmission of TMS. The emergency brake demand from CBTC and ETCS shall be applied by Emergency train line with fail-safe.

The braking equipment shall be tested to demonstrate compliance with the requirements of this ERT. The Contractor shall perform tests to confirm specified train deceleration from various speeds in all braking modes, including emergency brake and friction brake only (degraded cars).

Another emergency braking system in addition to the above shall be equipped. This braking system is called a security braking system. The security braking system shall be operated under the same conditions as the emergency braking system and it shall be enabled with a simple switch. The role of security braking system is a backup braking system in case the emergency braking system does not operate properly. The security braking system, supplied from the dedicated air tank to a pneumatic action device shall have a function that is totally independent from the service and emergency braking system. The security braking system shall not be linked with the variable loading of the train but shall be supplied with a dedicated air tank with sufficient capacity and a check valve.

The braking system shall satisfy the following deceleration under any conditions (incidentally, the deceleration referred to herein means the instantaneous deceleration at any velocity.) e.g., considering the decrease of deceleration due to rain, the core braking system shall control the proper torque corresponding to the load; however, the security braking torque shall be same as emergency braking torque at W0 because the security braking system is not linked with the load.

1) Service brake deceleration shall be 4.2 km/h/s;
2) Emergency brake deceleration shall be 4.7 km/h/s; and
3) These decelerations shall be defined as 'design deceleration' and shall not be used by calculation within the on-board signaling system.

Additionally, as soon as the regenerative braking torque is varied, including revocation of regenerative brake, the friction braking torque shall be supplemented. But, in very short time up to being supplemented, the instantaneously deceleration may be reduced and braking distance may be extended. In addition, in rainy condition the reduction of friction brake deceleration is usually a little larger than that of the regenerative brake. So, considering these,

the deceleration of friction braking shall be a little higher than that of regenerative braking under normal condition.

For the service brake, the loaded braking ratio must be 70% or more. For the security brake, the empty vehicle brake ratio must be 70% or more. The Rolling Stock shall comply with all relevant requirements in Japanese Ministerial Ordinance, MLIT Chapter 8, Article 69 (Brake unit related).

In addition, the above, the balance of deceleration of regenerative and pneumatic shall be finally adjusted considering Automatic station stop accuracy. Interface between BCU and CBTC or Running and stopping assistant system about service brake step (via TMS control transmission) shall be at least 31 steps.

Several sensors shall be incorporated to braking system. Sensors shall be equipped to each brake cylinders and each air suspensions, as a minimum. These data detected by sensors shall be transmitted to Braking control unit, and shall be utilized for control of propulsion, brake and ATO and so on.

In case the pressure of Main Reservoir Tank is lower than the certain value, the Emergency Braking System shall not be released. The Contractor shall propose this certain value appropriately.

10.2 FRICTION BRAKES

The Contractor shall design the friction braking system to accompany the electrical braking and provide all the service and emergency braking to meet the deceleration requirements, the friction braking system design shall be provided to the Engineer for review.

For Trailer car and motor car, tread brake shall be installed. The Contractor shall select the adequate brake shoe that enables to keep the tread proper state and to realize constant deceleration as possible if brake shoe is used. Here the proper state means that the wheel tread is moderately attacked by brake shoe and it has moderate irregularities when viewed at the micro level. So it is less likely to occur spin/slide. The Contractor shall obtain the permission of the Engineers for the selection of the brake shoe.

The brake shoe shall be designed and manufactured not only with extremely small changing characteristics with respect to watering, lubricating oil, fade, pressing pressure, speed and so on, but also with suppression of occurrence of spark caused by friction. The contractor shall submit these bench test data and obtain approval.

The friction brake shall be fully capable of performing all braking duties, without the assistance of the electric brakes. The brake material shall not contain any asbestos or other equivalent health concerning materials, and the Contractor shall provide the Engineer with full details of the material composition to allow health hazards assessment. The brake disc shall be the ventilated split type.

The Rolling Stock shall be equipped with parking brakes. The parking brake shall incorporate a spring-applied function achieved through air release brake actuators, and must be capable of holding an 8-car train in W3 loading condition on a 3.5% grade.

By design, as air pressure is released from the brake cylinders, the spring brakes shall apply. Should air pressure not be available, the driver may release the brakes electro- mechanically from the cab by pressing a switch. This action shall actuate an electrical solenoid which shall apply pressure to the brake cylinder release lever. The brakes may also be released manually by actuating a lever on both sides of each bogie. The system shall automatically reset upon reapplication of main reservoir air pressure.

Suitable slack adjuster shall be provided for the brake cylinders. It shall be possible to isolate the friction brake system individually in each car. The Contractor shall carry out a performance test of the friction brake and submit the result to the Engineer.

10.3 ELECTRIC BRAKES

Regenerative braking shall be supplied, with the priority being given to regenerative braking over mechanical braking. The electric brake shall have the capacity to produce all service braking effort and shall be fully effective down to 0.5 ~ 1 km/h. Regeneration shall be inhibited when the catenary voltage is above 1,850 V dc or below 900 V dc.

Performance of the regenerative brake shall achieve at least the following:

1) Under condition of catenary voltage:1650 V dc, load: 20 t per vehicle and velocity: 0~80 km/h, regenerative braking capability (including trailer car's brake torque) is the brake torque corresponding to deceleration 3 km/h/s;
2) Under condition of catenary voltage:1650 V dc, load: 20 t per vehicle and velocity: 0~64 km/h, regenerative braking capability (including trailer car's brake torque) shall be equivalent to deceleration of 3.7 km/h/s;
3) Under condition of catenary voltage:1650 V dc, load: 0 t per vehicle and velocity: 0~84 km/h, regenerative braking capability (including trailer car's brake torque) shall be equivalent to deceleration of 4.2 km/h/s; and
4) Under condition of catenary voltage:1650 V dc, load: 0 t per vehicle and velocity: 0~99 km/h, regenerative braking capability (including trailer car's brake torque) shall be equivalent to deceleration of 3.0 km/h/s.

Regenerative performance for ATO recovery mode load may be acceptable, the Contractor shall refer Sub-Clause 12.1.

10.4 WHEEL SLIDE CONTROL SYSTEM

Trailer cars shall be equipped with a wheel slide detection system to maximize the utilization of available wheel/rail adhesion under low adhesion conditions, to eliminate damage and unnecessary wear to wheel treads. In the trailer cars, slide shall be detected on a per axle basis and commensurate protection also shall be provided on this basis.

The hardware and software which is mounted in each trailer car shall reliably detect all wheel-slide conditions that may occur on any axle in that trailer car, and shall initiate actions that minimize or terminate these conditions, whether they occur randomly or synchronously.

The system shall compensate for wheel size differences. The detection of axle speed differences up to 3 km/h shall initiate the required reduction of braking effort to eliminate this speed difference.

During friction braking, brake cylinder pressure shall be modulated in proportion to the axle speed differential, assisted by rapid pressure reduction (dump) valves when differentials or accelerations are large. In emergency braking, the dump valves shall be used.

The system shall incorporate monitoring features to detect both failure of sensor inputs, and system performance indicative of failure of that function. Detection of sensor or system malfunction shall disable the system so as to guarantee braking. All faults shall be logged in the train's TMS.

The wheel slide control system shall operate normally with the speed sensor.

The wheel slide control system shall not allow the axle speed differential to be over 5 km/h. The operation of the sliding control shall be based on the operation at about 3 to 5 km/h with the aim of re-adhesion within 1 km/h. The following performance shall be achieved:

1) Digital wheel slide protection with gradual slide correction shall be provided in all braking modes. The slide detection in a trailer car shall be performed per axle and the correction per axle. The correction of slide shall operate independently on each vehicle;
2) The sliding effect shall be maintained during a relevant period of time, in order to increase the available adhesion at the wheel-rail contact with permanent control, in minimizing the air consumption and optimizing stopping distance;
3) The Contractor shall demonstrate that the correction process for wheel slide shall not cause infringements of the signaling compatibility requirements;
4) The performance of the wheel slide protection equipment shall satisfy the relevant requirements of Japanese Technical Standards and Guidelines for Railway and testing shall be carried out in accordance with Section 2 of the UIC 541- 05 or equivalent;
5) The wheel slide system shall detect the onset of slide by either an axle deceleration exceeding a pre-set parameter, or detection of a difference between the relative speeds of the axles of any one axle of any bogie;
6) The Contractor shall incorporate the complete compatibility for slide with the signaling scheme and interfaces. The Contractor shall submit full details of the wheel slide protection scheme and equipment; and
7) Wheel slide indication shall be made available in the driving cab through the TMS system.

The complete wheel slide control system shall be reviewed by the Engineer.

10.5 BRAKE CONTROL/BRAKE BLENDING

The brake control/brake blending system shall be a service-proven system.

The braking force control in the vehicle shall be performed by comparing the required brake amount with the actual brake amount, etc. via the control transmission between these devices in addition to the calculation and operation of the PECE, BCU and TMS.

By using this function, the opportunity presents itself to utilize energy saving regenerative braking coupled with minimal brake-pad wear.

When the regenerative braking force is insufficient with respect to the required braking force, the trailer car's friction brakes shall be initiated. If the braking torque is still insufficient, the motor car's friction brakes shall be initiated. Distribution of the friction braking torque derived from the trailer/motor cars shall be controlled by the TMS.

If a shortage of friction braking torque occurs in one vehicle, this shall be compensated by other vehicles contributing to the overall brake torque for the entire train.

In case of complete electrical braking failure, brake control shall allow instantaneous substitution of friction braking without loss of braking power.

When the electrical brake switch is off and any other electrical brake effectiveness condition is not satisfied the braking system shall be exclusively friction braking only.

The various braking mechanisms work together in a balanced way to optimize deceleration, ride comfort, jerk and these systems will be set up during commissioning.

10.6 (NOT USED)

10.7 BRAKE CONTROL UNIT (BCU)

The brake of each car shall be controlled by the brake control unit (BCU) performing the following functions:

1) On receipt of a brake demand from the control transmission of the TMS, the service brake shall be applied at the correct and corresponding level having regard to the vehicle weight (from information provided by the pneumatic suspension system);

2) When a change in braking effort is demanded, the control system shall control the rate of change to be in accordance with the specified levels of jerk and response times;

3) Any shortfall in the effort provided by the electrical brake shall be achieved using the friction brake. Service proven design in accordance with international standards may be submitted for Engineer review;

4) The BCU shall contain fault diagnostic facilities, which records all the relevant fault information and status of the equipment at the instant of failure to facilitate maintenance;

5) The fault diagnosis function shall be compatible with the TMS to enable fault log information to be accessed through the TMS. A comprehensive set of indications shall be available on the BCU to display major faults. The fault indications shall be electrically latched when the faults are detected and shall illuminate whenever the supply to the electronics is switched on. The information contained within the fault log shall be stored on non-volatile memory;

6) In case of a brake shortage during braking by the ATP, the vehicle in which the brake shortage happens shall be assisted with the emergency brake. Also, in case of brake seizure, the braking system shall be equipped with the function to forcibly to release the brake by remote operation from the cab;

7) In case of brake release, acceleration command shall be cut off. However, in this function, a short circuit switch shall be supplied;

8) The friction brake at zero speed shall be coordinated with the door control system. When all the doors are not closed, the BCU shall not release the brake;

9) When a brake seized occurs on a certain bogie, the brake on that bogie shall be able to be remotely released from the driver's cab. The remote brake release action shall not affect the subsequent braking performance; and

10) Gradient starting brake function to prevent roll-back shall be equipped.

11) ATO mode and manual mode shall be equipped. In the ATO mode, at least 31 steps of brake step shall be able to be transmitted with TMS.

12) In case ATP is cut off, maximum service brake or emergency brake shall be actuated when train speed exceed 15km/h in MMSP section.

13) Wheel diameter correcting shall be made by BCU.

The associated brake unit shall contain all the pneumatic items necessary to control all applications of the friction service brakes and emergency brakes on that vehicle. The emergency brake control valves independent of the service brake control valves shall be controlled directly from the emergency brake train control lines. The friction emergency brake shall be failed safe and of an "energize to release" type.

The emergency brake loop shall be a high integrity fail safe hard wired circuit and shall in no way be allowed to be bypassed due to an error in operation.

The mechanism of brake force/vehicle weight adjustment employed shall ensure a full proportional adjustment is achieved through the braking range between tare loading (W0) and loading conditions (W3).

The method by which the passenger load-sensing signal is processed shall be arranged to ensure that absence of the signal, for any reason, shall result in a brake force being applied corresponding to a dynamic (W4) loading condition on that vehicle.

11 PNEUMATIC EQUIPMENT

11.1 GENERAL

The train shall be supplied with the equipment and functions specified herein, such that a complete, fully integrated and fully functioning friction brake and pneumatic system is provided.

A complete pneumatic system shall be maintained, which shall consist of the air compressor assembly and all associated piping, reservoirs, fittings, etc., to provide a fully functional system capable of supplying all air requirements for the friction braking system, air suspension system, horns, etc. for the complete trainset.

Compressed air shall be sufficiently filtered and dried prior to entering the pneumatic lines. All feeds from the main supply line shall be protected by check valves to prevent the rapid loss of air should a rupture or leakage in the line occur. Flexible connections from the air compressor to the main supply line shall be likewise protected by check valves. Suitable automatic drain valve and manual drain valve shall be fitted.

The pneumatic equipment, including the compressor shall have a maximum operating pressure of 10 bars. The compressor shall be adequately protected, including from an over pressure situation.

11.2 AIR COMPRESSOR ASSEMBLY

The Rolling Stock shall be equipped with a pneumatic system consisting of service- proven air compressor assemblies, with air compressor units directly driven by electric motors, air filtration and a twin tower air drier equipment, inter cooler, safety valves, etc. The assembly shall be installed under the vehicle via resilient mounts, and care shall be taken to minimize the amount of noise and vibration transmitted into the vehicle body structure and to the wayside.

The air compressor motor shall be powered from the Auxiliary Power Supply (APS) system.

The design of the pneumatic system shall be capable of supplying all of the air requirements for a train consist in the event of failure of one compressor unit.

The capacity of air compressors shall be sufficient for the simultaneous operation of all pneumatic devices. Calculations for the capacity of the air compressors shall be submitted for review by the Engineer.

11.3 PNEUMATIC SYSTEM

Stainless steel piping or an equivalent service-proven material for the pneumatic system shall be used throughout the cars, unless otherwise specified, subject to review by the Engineer. Joints shall be made using rail industry approved compression fittings. Joints shall not be made to connect straight runs of pipe work, unless otherwise specified, subject to review by the Engineer. Inaccessible runs of pipe work shall not utilize joints. All piping shall be installed to keep fittings to an absolute minimum.

Cut-out cock handles shall be installed so that in the open position they are parallel to the flow of air, and in the closed position they are perpendicular to the flow of air. Cut-out cock handles shall be readily accessible for use in an emergency. All cut-out cocks shall be of the vented type, unless the function prohibits their use. The function of all cut-out cocks shall be clearly identified by means of engraved stainless-steel plates riveted to the structure adjacent to the valve, the lettering on which shall be filled with black epoxy paint and suitable color coded.

All pneumatic tanks or reservoirs shall have drain cocks to remove condensation. Separate systems within the pneumatic system shall be supplied via a vented cut-out cock and a strainer, and shall be provided with separate air reservoirs, supplied through a check valve to protect against the sudden loss of air pressure. The air brake reservoir shall be sized to provide at least three emergency brake operations under W3 loading conditions. Reservoirs shall be tilted to assist moisture collection, and shall include automatic/manual drain valves.

The main air reservoir shall have sufficient capacity for the simultaneous operation of all pneumatic devices. Calculations for the capacity of all reservoirs shall be submitted for review by the Engineer.

All flexible hoses shall be date stamped, and their full life indicated. All flexible hose connections on removable assemblies shall be of railway service proven standard and quick-connect coupling.

The device and air pipe from the last tank as the source of the braking force to brake cylinder used to service brake and emergency brake shall be placed within the width of bogie.

The device and air pipe from the last tank as the source of the braking force to brake cylinder used to security brake shall be placed within the width of bogie frame.

A cut-off valve shall be provided at a place required for maintenance or abnormality.

12 PROPULSION SYSTEM

12.1 GENERAL

A modern and well service-proven three-phase alternating current propulsion system shall be provided for 4 vehicles of all 8 cars and shall have the following features:

1) Four DC to AC inverter packages (self-cooling power conversion equipment), one in each motor car powering the sixteen (2 per motor bogie) traction motors in a vehicle. For the purpose of the energy conservation improvement and low center of gravity, the material of the filter reactor shall be copper or aluminum; or other service-proven material, subject to review by the Engineer.
2) The propulsion equipment including the inverter shall be cooled by external heat exchangers without the requirement of air filters;
3) A vehicle level microprocessor based control system (power electronics control equipment), which shall perform all propulsion of acceleration and regenerative braking;
4) The magnetic flux caused by filter inductor shall be less than 1mT at 1.0 m of the just above of filter inductor from the floor level;
5) Each AC squirrel cage traction motor shall drive a gear unit. Traction motor insulation shall be tropicalized and shall be Class 200 insulation or better; and
6) In the event of propulsion failure occurs on any car, that propulsion unit shall be automatically disabled (or by manual disable from the driver's cab) to allow the train set to be operated by the rest of the healthy propulsion units.
7) In case ATP is cut off, propulsion shall be inhibited when train speed exceeds 15 km/h in MMSP section. For this control, contractor should use directly information of speed detected by speed sensors mounted to both end cars.
8) The propulsion system shall be able to apply the two (2) kinds of tractive performance shown in Appendix D. Tractive performances shall be changed on condition of information from TMS. Basically, tractive performances shall be changed when stopping at the boundary stations between NSRP-South and MMSP, though, where the train does not stop at boundary stations, performances shall be changed during coasting;
9) About the blending between friction brake and regenerative brake when brake starts, the dummy signal of regenerative brake shall be short as possible considering ride effort. In case catenary voltage is higher than the voltage which regenerative brake is effective, the dummy signal of regenerative brake shall not be used.
10) Lowered regenerative performance applied except for ATO normal mode may be acceptable in case it is difficult to achieve reasonable design in consideration with capacity and size, weight and so on. It shall be necessary to be reviewed by the Engineer when above performance will be adopted.
11) Wheel diameter correcting shall be made by this device.

Performance of acceleration shall not be less than that stated as follows:

In the following conditions, the propulsion system shall have sufficient capacity. The Contractor shall simulate acceleration power consumption, regenerative power amount, RMS current, maximum drawn current during acceleration, maximum return current during regenerative braking to OCS and the temperature rise of each equipment etc. Total power consumption of a round trip (Quirino Highway-Bicutan, etc) for the following minimum

conditions shall be submitted for review by the Engineer:

1) Load condition: W3 loading and 20 t/car (round trip);
2) Wheel diameter: 820 mm;
3) In case of normal operation (ATO all out condition);
4) Self –cooling system;
5) The maximum operational speed limit in the main line of NSRP is 120 km/h

   The maximum operational speed limit in the main line of MMSP Phase 1 is 80 km/h;
6) Operational headway is 4-minutes;
7) When 25% loss of the on-board traction motors total power, train can run all day; (with restriction on regenerative brake at a load above a certain load)
8) When 50% loss of the on-board traction motors total power, train can run 1 round trip; (with restriction on regenerative brake)
9) Catenary voltage: 1350 V (acceleration), 1650 V (regenerative);
10) Acceleration use by simulation: the maximum performance;
11) Deceleration use by simulation: the maximum performance;
12) Unladen mass: to be calculated by Bidder;270 t;
13) Start resistance: to he calculated by the Bidder;
14) Inertial mass: 10% of unladen mass (motor car), 5% of unladen mass (trailer car);
15) Running resistance: $R = (1.65+0.0247V) * m_M + (0.78+0.0028V) * m_T + 9.81*\{0.028+0.0078*(n-1)\} * V^2$

    Where, R : Running resistance [N]
    V : Train speed [km/h]
    m_M : Total load of motor-cars included in tare weight and passenger load [kN]
    m_T : Total load of trailer-cars included in tare weight and passenger load [kN]
    n : Total number of cars per train-set
16) It is possible to push a failed train set with the same load; and
17) Propulsion capacity (continuous and 1-hour rating) to be calculated by the Contractor.

All other simulation parameters not included in the listed conditions shall comply with the Employer's Requirements.

Load weighing shall be provided for all vehicle weights up to crush loading condition. The failure of electric braking to provide the requested performance shall initiate supplemental friction braking.

The traction power circuit shall be cut out if pressure of main reservoir is below the minimum required working pressure. In this case, the emergency brake shall be operated at the same time, and the line breaker (LB) shall be open when the emergency brake is operated.

The propulsion system design shall automatically compensate for wheel diameter variations between axles on the same vehicle of no less than 6 mm. The Contractor shall incorporate the function that each vehicle wheel diameter is input from the TMS. If this function is not used or used incorrectly, the propulsion system shall operate recognizing the wheel diameter as 820 mm.

The Contractor shall be required to perform a combined propulsion system test in accordance with a procedure which shall be reviewed by the Engineer. This test shall consist of installing the entire propulsion system, including the power conversion equipment (PCE), traction motors and associated cabling. The temperature of critical components, amongst other parameters, shall be monitored to gauge suitability for the intended service.

The equipment to be supplied shall require minimal maintenance, and any items requiring periodic attention shall not require such at intervals less than monthly.

The propulsion system shall be provided by a supplier having had a minimum of 5 years of demonstrable experience in supplying service-proven, considerably reliable 3-phase AC propulsion equipment in a similar operating environment to that in Manila.

Speed estimation during the initial stage of both acceleration and deceleration shall be within 200 ms after motor current begins to flow. In particular, even in the case of low speed range and the recession starts, speed estimation shall be completed successfully to prevent unnecessary vibration, overcurrent to the motor. In addition, the speed sensor design shall prevent unnecessary vibration in the event of start-up during roll-back.

For the parts that shall be considered exothermic, thermal simulation shall be performed, e.g. switching device module, HSCB, LB, and main circuit wires. This simulation shall be performed based on the run curve at the most severe riding rate, taking into account the heat dissipation environment inside the box. Simulation results shall be validated during testing and commissioning with and without load.

The design life of the main circuit semiconductors and the filter capacitors shall be 30 years or more, PECE shall have the design life of 12 years or more.

Constant speed and low-speed operation function shall be provided.

The capacity of propulsion system shall be determined at 20t/car load condition provided following table. The Contractor shall calculate capacity based on data shown in **Appendix H, I, J, and K**, expressing MMSP, and **Appendix L～O,** expressing data of through-operation from MCRP to NSRP-South. Provisions of calculation shall be determined based on discussion between the Engineer and the Contractor.

Alignment	Running Pattern	Traction Performance
MMSP	All-Out Re-propulsion when train speed downed under predetermined values (-5km/h) from speed limited	For MMSP Appendix D fig.1
MCRP	All-Out Re-propulsion when train speed downed under predetermined values (-5km/h) from speed limited	For NSRP-South Appendix D fig.3

Alignment	Running Pattern	Traction Performance
NSCR	All-Out Re-propulsion when train speed downed under predetermined values (-5km/h) from speed limited	For NSRP-South Appendix D fig.3
NSRP-South	All-Out Re-propulsion when train speed downed under predetermined values (-5km/h) from speed limited	For NSRP-South Appendix D fig.3

The tractive and regenerative performances for considering the capacity of propulsion system are as below, also shown in **Appendix D**.

12.2 POWER CONVERSION EQUIPMENT (PCE)

The PCE, and the PECE shall consist of all necessary equipment to condition the power supply from the catenary system into a fully useable power supply to drive the traction motors under fully controlled conditions, meeting the requirements with respect to speed, acceleration, torque, and regenerative braking. Such equipment shall include, but not limited to:

1) Inverter equipment – Hybrid SiC module;
2) Inverter self-cooling equipment;
3) Inverter controls;
4) Inverter protection equipment, except the main circuit breaker;
5) Propulsion system interface with the door control, on-board signaling systems, Running and stopping assistant system, PSD controller, emergency brake circuit and TMS;
6) Propulsion system control interface with the train lines; and
7) High Speed Circuit Breaker (HSCB).

PECE shall be equipped to detect the onset of wheel slip and slide, and shall regulate the PCE to control the event. The PECE shall provide the regenerative brake feedback signal to the TMS to ensure smooth brake blending.

The PCE equipment shall be sufficiently convection cooled (self-cooling). The PCE enclosure shall be integrated with the vehicle design to ensure that the motion of the vehicle produces sufficient air flow across the cooling fins to produce the required heat transfer. The Contractor shall be required to demonstrate by calculation and by test, the maximum thermal stress upon the equipment that shall not result or contribute to reduction of PCE service life, under expected service conditions.

The inverter power semiconductors shall be housed in watertight, dust proof enclosures meeting IP55 requirements and shall be convection cooled. The devices shall not be protected by fuses.

The output of the propulsion inverters shall incorporate ground fault protection. Upon detection of a ground fault, the affected inverter shall be shut down. Three successive detections of ground faults within a predetermined time, to be reviewed by the Engineer, shall cause the locking out of the inverter system and shall only be reactivated by authorized personnel. A ground fault shall be displayed in the driver's cab and shall be registered in the

TMS.

The PCE shall be provided with over-temperature protection, which shall initiate a reduced level of performance from the affected unit. Upon temperatures returning to normal, the PCE shall automatically reset. PCE over-temperature shall be displayed in the driver's cab and shall be registered in the TMS.

The propulsion equipment shall be of very high reliability, low maintenance and fit for purpose in a harsh operating environment to that in Manila.

The design of the entire propulsion system shall be submitted for review by the Engineer.

If the load to regenerative power is insufficient, PECE shall limit the regenerative braking torque to the proper regenerative braking torque, whilst making maximum use of the regenerative braking torque considering not only catenary voltage but also the electric load. However, to prevent catenary voltage from becoming too high, the upper limit of the catenary voltage shall be maintained. This function shall be able to be adjusted in consideration of the operating situation of regenerative electric power absorbing equipment installed in the substations, ride comfort, cooperation with friction brake, deceleration difference from normal time, etc.

12.3 WHEEL SLIP/SLIDE CONTROL SYSTEM

The propulsion system shall be equipped with a wheel slip/slide detection and control system to maximize the utilization of available wheel/rail adhesion under low adhesion conditions, to eliminate damage and unnecessary wear to wheel treads. Slip/slide on motor vehicle shall be detected on per the average velocity of four axle basis estimated, and protection shall be provided on a four-axle basis.

The hardware and software which is mounted in the propulsion system shall reliably detect all-wheel-slip/slide conditions that may occur on any axle in the motor car, and shall initiate actions that minimize or terminate these conditions, whether they occur randomly or synchronously.

The system shall compensate for wheel size differences. The detection of average four axles speed differential to body shall initiate the required reduction of torque to eliminate this speed difference. Usually, the wheel slip/slide control system shall operate so that the average axle speed differential to body speed is within 1 km/h.

In rainy condition, it is necessary to make maximum use of the regenerative braking torque by the appropriate adhesion limiter and slide control, and try to control the deceleration lowering, suppress the wheel damage, and prevent the ride comfort deteriorating.

The operation of the sliding control shall be basically based on operating within 1 to 3 km/h with the goal of re-adhesion within 1 km/h.

12.4 PROPULSION EQUIPMENT

12.4.1 Traction Motor

The traction motor shall be a mass produced totally enclosed AC squirrel cage induction machine over 5 years' service proven history with a good reliability service proven record, and shall be reviewed by the Engineer. Traction motor bearings shall be equipped with sufficient and easily accessible standard grease fittings. Traction motor bearings lubricated by grease shall be able to be changed in a non-disassembling within 30 minutes. The non-disassembling system shall be proven. The attachment of a traction motor cooling fan, if equipped, shall be robust to withstand all levels of traction motor operation in any service

condition. The traction motor shall be rated and specified to meet all of the performance requirements according to clause 1.8 of the Technical Requirements.

In addition, as a minimum, the traction motor shall have the following characteristics:

1) The efficiency in the rating shall be more than 94%;
2) The continuous and 1-hour rating shall be rated to meet the performance requirements; to be calculated by the Bidder;
3) Three-phase four-pole totally enclosed squirrel cage induction;
4) Insulation performance shall be Class 200 or more;
5) The grease used shall be Unimax-R2 or the equivalent with similar features;
6) There shall be no speed sensor;
7) Insulated bearings shall be applied at both the drive side and the non-drive side;
8) The non-disassembling system shall be applied at both the drive side and the non-drive side for changing bearings easily;
9) Bearings shall be lubricated by grease; and
10) The basic design of the bearing shall be refilling without decomposition at 600,000 km and exchange at 1.2 million km

12.4.2 Gearbox and Coupling

Each traction motor shall drive its axle via a parallel drive, reduction gearbox and coupling arrangement from a design derived from system with extensive, successful rapid transit history.

The performance of the gearbox shall be fully compatible with the remainder of the propulsion equipment. The gears shall be oil lubricated, and an inspection cover shall be provided in the gear case for visual inspection. The gearbox shall incorporate sufficient baffles, oil passageways, etc. to ensure adequate lubrication under all service conditions and in any rotational direction. It shall not be necessary to check the oil level at intervals less than 65,000 km, nor add oil at intervals less than 130,000 km.

The gearbox shall utilize labyrinth seals between rotating components, which shall not require replacement between major overhauls. Adequately bolted and gasketed inspection openings shall be provided to enable all gears to be inspected with the vehicle body on the bogie. A magnetic drain plug shall be provided. A sight glass shall be provided to visually check the oil level in the gearbox at any given time. An inlet port shall be provided for refilling gear oil, if necessary.

12.4.3 Maintenance Requirements

No component in the PCE and the PECE except for cover packing, power supply unit, gate IF, contacts of HSCB and LB shall require removal or replacement for at least 12 years.

Any fault in the PCE or the PECE shall be logged and into the event recorder of the TMS and PECE. Any fault intervention shall be displayed in the TMS monitor. Logged faults into the TMS and PECE shall be stored and remain until a certain number of faults is contained. PECE shall have an ordinary and high-speed trace function. In high-speed trace function, logged faults related to the switching of the element and behavior of instantaneous current and voltage, etc. shall be required to be available for fault diagnostic analysis.

Means shall be provided to automatically discharge capacitors whose voltage might present a

hazard to a maintenance worker opening any enclosure. Discharge time shall not be more than 5 minutes.

13 PRIMARY POWER SYSTEM

13.1 CURRENT COLLECTION

The 1500 V dc power shall be collected from the overhead line system using electrically operated pantographs. The pantograph assembly shall permit all necessary movement, taking into account the overhead line installation tolerances/clearances, vibration of Rolling Stock, deflation of suspension etc. and maintain the complete and effective collection of electrical power. Sintered alloy shall be used as the material of the contact strip. The pantograph within the train shall be equipped with both the function to raise and lower all at the same time and the function to raise and lower individually.

The upper structure of the pantograph shall be equipped with a pair of parallel guide bars for supporting the current collector and to provide a higher guidance function to prevent shaking of the catenary. Spring structure shall be designed to suppress the current collector from leaving the overhead catenary.

A lightning arrester shall be installed on the appropriate position adjacent to the pantograph.

The rigid overhead conductor shall be used. For rigid overhead conductor, since detachment tends to occur easily, the spring structure to suppress detachment shall be equipped.

A function shall be provided to judge whether the pantograph is rising or descending and informing the TMS.

The pantograph shall be mounted on the roof with double insulation.

The pantograph shall be in compliance to JIS E 6302.

The compatibility of interoperability section shall be considered.

13.2 INPUT PROTECTION (HSCB)

The power supply shall be protected by a heavy duty, transit proven, ultra-high-speed circuit breaker, which shall be capable of handling the short circuit capacity of the PCE. The High-Speed Circuit Breaker (HSCB) shall be installed in a dedicated explosion-proof enclosure.

The Contractor shall select the HSCB with sufficient capacity to break the short- circuit current. The set value to trip shall be appropriate so as not to trip unnecessarily when the catenary voltage changes rapidly in actual operation. The Contractor shall submit the technical specification of the HSCB including tripping performance for the review by the Engineer.

Tripping of the HSCB shall be displayed in the driver's cab and shall be registered in the event recorder of the TMS and PECE. The HSCB shall be resettable from within the driver's cab.

Sufficient attention about HSCB, conductor to be connected, the performance of the grease to be used and fastening torque of conductor, etc. shall be given to the heat generated by the current which is assumed in the maximum actual operation current pattern.

13.3 CURRENT RETURN

The negative return current from the 1500 V dc circuits shall run to an insulated common point located under the vehicle and shall be submitted for review by the Engineer. The insulated common point shall be connected to 4 axle ground brushes per vehicle through removable jumper cables. The cable and cable arrangement shall be carefully chosen and installed to withstand all vehicle service conditions and shall not be subject to induced premature failure.

The vehicle body grounding shall be separated from the power return circuits and the vehicle structure shall not be used as normal circuit return path for any electrical equipment. Separate current return assemblies shall be provided for the 1500 V dc and vehicle body ground respectively.

Any dirt build-up shall not affect the insulation and performance of the current return assembly. Suitable air vent and drain holes shall be provided to avoid accumulation of dust and water. Carbon dust shall not in any way contaminate the axle bearing lubrication or restrict carbon brush movement.

The ground brush housing shall allow ready access to the brushes and electrical contacts by maintenance technicians.

The ground brush arrangement and details shall be reviewed by the Engineer.

The Contractor shall produce a complete earthing scheme, which shall prevent traction return current passing through motor and axle bearings, gearboxes, bogie center bearings, couplers, or any path other than the designated path. The earthing scheme shall be submitted to the Engineer for review.

13.4 HIGH VOLTAGE TRAIN LINE

13.4.1 Traction Motor

The rigid overhead conductor shall be used in MMSP. For rigid overhead conductor, since detachment tends to occur easily, high voltage train line shall be equipped to suppress the influence in case of the detachment.

The simplified block diagram is shown in Appendix E.

13.4.2 Function and requirements

Appropriate rate fuse, switch and line breaker shall be incorporated into this line. The circuit breaker shall be openable and closeable by the demand from TMS, Propulsion system. The condition of open and close will be decided considering the condition of stop or running, all pantograph raising and the place in the running, etc.

14 AUXILIARY ELECTRICAL SYSTEMS

14.1 GENERAL

The Rolling Stock shall have independent auxiliary power feed at each required voltage. The AC output shall be sinusoidal under all conditions of load. Emergency loads shall include:

1) Emergency lighting;
2) All exterior lights;
3) Communication systems, AP system and CCTV system;
4) TMS and brake controls;
5) Door controls;
6) On-board signaling equipment;
7) Cab console indicators;
8) Horn;
9) Wiper control/system; and
10) Ventilation system

All electrical equipment on the train, other than the PCE and the supply to the auxiliary power supply equipment (APSE), shall operate using the following nominal voltages, respectively:

1) 440 V ac, 3-phase, 60 Hz;
2) 220 V ac, 1-phase, 60 Hz;
3) 100 V dc; and
4) 12/24 V dc.

The AC output shall be regulated within ±3% for all variations in input voltage and output load.

The DC output shall be regulated within ±1% for all variations in input voltage and controlled not to damage the battery that has a floating charge.

The Contractor shall submit the required capacity calculation considering 10 cars train-sets in the future extension and reviewed by the Engineer.

The design of the auxiliary electrical system shall have sufficient capacity to provide backup power for normal operation of the emergency loads even in the event of lost overhead power. The design of the auxiliary electrical system and its capacity, including the backup power, shall be reviewed by the Engineer.

14.2 AUXILIARY POWER SUPPLY EQUIPMENT (APSE)

The train shall be equipped with APSE capable of supplying all loads continuously. The failure of an APSE shall be displayed in the driver's cab and shall be recorded in the TMS and APSE. At least one dead battery start feature shall be incorporated in the train set, which shall be located in the driver's cab.

The APSE shall consist of an auxiliary power inverter (Si-IGBT or Hybrid-SiC Technology, self-cooling), to supply all AC power, and a Low Voltage Power Supply (LVPS) to provide low voltage DC power. And APS shall have HSCB and Fuse to protect from over current.

When designing the auxiliary power inverter, particular care must be taken to account for the simultaneous starting of large auxiliary loads, such that rapid cycling is avoided (particularly the VAC compressor). The inverter shall use a control scheme that contains extensive self-diagnostic logic, and receptacles shall be placed in the vehicle interior and exterior to allow the connections to any necessary test equipment.

The auxiliary power inverter output transformer shall be galvanically isolated, and the secondary windings shall incorporate a ground fault protection system. Upon detection of a ground fault, a fault message shall be transmitted to the TMS.

The LVPS shall provide the power to all system controls, including the PCE, friction brakes (computer, brake control units, dump valves, etc.), VAC equipment, lighting, communication equipment, doors, radio, on-board signaling, etc. The LVPS shall be solid-state and shall contain appropriate transient suppression and protective circuitry. The LVPS shall also incorporate appropriate fault and operation indicating lights and test switches. The failure of an LVPS shall be recorded in the TMS and APSE. Logged faults into the TMS and APSE shall be stored and remain until a certain number of fault are contained. APSE shall have an ordinary-speed and high- speed trace function. In high-speed trace function, logged faults related to the switching of elements and behavior of instantaneous current and voltage, etc. shall be required to be available for fault diagnostic analysis.

The output of the LVPS shall be routed to the low voltage distribution panel/cabinet inside the car. The negative return current from each subsystem shall run individually to the Engineer's approved insulated common point located in an enclosure under the car.

The entire APSE and controls shall be reviewed by the Engineer.

If APSE stops to operate by a serious failure, a switch which can reset from the driver's cab shall be installed.

14.3 REDUNDANT SYSTEM

Each of the APSE shall perform in parallel and synchronous operation with the adjacent APSE(s). In the event of fault on any APSE, the adjacent APSE(s) shall not be affected and shall supplement the load under the failed APSE. A signal of VAC degraded mode shall be transmitted to the VAC(s) of the affected area through TMS.

14.4 CIRCUIT BREAKER PANELS AND ISOLATING SWITCHES

The following distribution panels shall be provided:

1) Low voltage (100 V dc) circuit breaker panel;
2) 220/440 V ac circuit breaker panel;
3) All 220/440 V ac circuit breakers shall be located in a separate enclosure, and shall individually protect the circuits;
4) Panel for auxiliary power supply equipment;
5) Spare circuit breakers for all panels; and
6) All isolating switches and circuit breakers necessary for vehicle intervention shall be placed inside the driver's cab, under the dashboard for easy access and use.

All circuit breakers and switches necessary for vehicle revenue line fault intervention shall be located inside the driver's cab. The final list of circuit breakers and switches shall be subject to review by the Engineer. All circuit breaker panels shall be reviewed by the Engineer. Attention shall be paid that arrangement of the panels are coordinated in consideration with

operations in NSRP-South.

14.5 EMERGENCY POWER SUPPLY

When battery capacity decreases, pantographs cannot be raised and APSE cannot operate. For this time emergency power supply shall be equipped to be able to raise the pantograph and to start APSE.

When APSE starts to operate, the circuit breaker should not be tripped by an inrush of current to the reduced capacity battery.

The way in which the emergency power supply raises the pantograph and starts APSE shall be reviewed by the Engineer.

14.6 BATTERY

The battery shall have sufficient capacity to supply all low voltage power loads during failure of the low voltage power supply for a minimum period of one (1) hour of normal train operation and for a minimum period of 90 minutes of passenger emergency lighting. The Contractor shall submit the battery capacity for the Engineer to review taking into account not only this requirement but also an appropriate allowance rate.

The functions necessary for power failure for calculating the battery capacity shall comply with all relevant requirements in Japanese Ministerial Ordinance, MLIT Chapter 8, Article 85 (Functional relationship of equipment at power failure).

All cells shall be standard size, and the battery cases shall be made of a material having good thermal stability and suitable chemical resistance, and shall be translucent.

The battery shall be designed to withstand the shock and vibration conditions associated with a rugged rail-service environment.

The battery has a floating charge relative to the DC output from APSE. In such usage, the battery shall operate normally with no maintenance intervention for 12 years. The Contractor shall select such a service-proven battery and APS.

In float charging, the output voltage of the APS and the charging characteristics of the battery shall be completely compliant, and insufficient charging and overcharging shall not occur.

The battery shall be sintered Alkaline battery.

The Contractor shall submit the required capacity calculation considering 10 cars train-sets in the future extension and reviewed by the Engineer.

14.6.1 Battery Installation

The battery shall be installed under the vehicle and shall be accessible from the side of the vehicle. The battery box shall be ventilated by natural air convection and have drain holes. The batteries shall be mounted in a stainless-steel roll-out tray, with positive stops when pulled out and a lock in the stored position. Alkali-resistant paint shall be applied to the battery box and tray.

The roll-out tray shall have resinous wheels so as to insulate the box and the carriage.

Wiring in the box, even if the carriage is moved, shall be considered so that unnecessary slack does not occur, especially when the carriage is moved or the lid is closed; wiring in the box shall be fixed appropriately so as not to be squeezed.

Fall prevention stopper shall be provided so as not to allow the carriage to fall when the carriage is being pulled out.

14.6.2 Battery Contactor

The battery contactor shall be a non-contact contactor for the opening and closing control of the 100 V dc circuit from the storage battery in the control voltage 100 V dc system and shall be composed of a control unit, the main circuit unit in which a semiconductor shall be incorporated and the circuit that shall be operated from the driver's cab.

The circuit to confirm whether the storage battery contactor is ON or OFF shall be incorporated, and the actual condition of the storage battery contactor shall be displayed in the TMS.

14.6.3 Battery Circuit Open Switch

The battery circuit open switch shall be equipped to work safely for maintenance, replacement or construction, etc. When this switch is opened, it shall be necessary to make it clear that the state is clear, for example that the lid is not closed.

15 HIGH VOLTAGE TRAIN LINE

15.1 GENERAL

The rigid overhead conductor shall be used in MMSP. For rigid overhead conductor, since detachment tends to occur easily, high voltage train line shall be equipped to suppress the influence in case of the detachment.

The simplified block diagram is shown in **Appendix E**.

15.2 FUNCTION AND REQUIREMENTS

Appropriate rate fuse, switch and line breaker shall be incorporated into this line. The circuit breaker shall be openable and closeable by the demand from TMS, Propulsion system. The condition of open and close will be decided considering the condition of stop or running, all pantograph raising and the place in the running, etc.

16 TRAIN MANAGEMENT SYSTEM

16.1 GENERAL

The Train Management System (TMS) shall centrally manage information and has functions such as transmission of operation control commands e.g. powering and service braking, failure monitoring, function inspection, crew support etc. by utilizing a transmission line, and shall be designed to improve vehicle function and maintenance efficiency. Basic transmission, transmission with some mounted equipment and between the vehicle and the next vehicle shall be by Ethernet connection, and large data sets shall be transmitted and collected at high speed. In normal operation, with no equipment failures, the TMS shall be the primary command and control system for each consist. The TMS shall not be critical to the safety of each consist.

The TMS shall be sufficiently service-proven deal with control command and information within the train which are extremely important, but not safety critical.

Hardwired train lines in addition to the TMS shall be provided for the basic train operation functionality for the following critical systems as a minimum:

1) On-board signaling control, except for the part rerated to the maximum service brake;
2) Emergency brake control;
3) Door enable;
4) Door open/close;
5) Battery control;
6) Pantograph control; and
7) Radio/public address system.
8) CCTV
9) LCD between doors

The arrangement shall allow for basic consist operation in the event of a TMS failure.

The TMS shall be capable of performing a bi-directional communication with the on- board signaling equipment for control function if required under the ATO mode.

The Contractor shall ensure that all signal inputs received from on-board signaling equipment and output signals exported to the on-board signaling system shall be recorded and shall be available for retrieval for analysis/record purpose. All signals (input/output between the Rolling Stock and the on-board signaling equipment) shall generally be routed through the TMS. The CP106 Contractor will provide the requisite interface signal to the Contractor during the interface meeting.

The TMS shall be connected to two reasonably wide LCD screens mounted in the driver's cab console for fault indication, alarm monitoring, control initiation and data entry, etc.

The date of TMS shall be interfaced with communication system provided by CP106. And the same images of TMS monitor in operator cab can be watched at OCC or maintenance office PC monitor, etc. The CP107 Contractor shall provide the software of PC in OCC or maintenance office, etc.

16.2 FAULT INDICATION

The TMS shall include a fault indication function, which shall display critical faults to the driver and any further abnormal conditions recorded in the event recorder. When a critical fault is detected in the train, the TMS shall automatically change the screen to fault indication mode. The list of critical faults that shall be catered for shall be submitted to the Engineer for review.

16.3 DESIGN REQUIREMENTS

1) The TMS shall perform control initiation including acceleration and deceleration (except emergency brake and security brake), data acquisition, data processing, data communication and data presentation functions. The TMS shall be able to automatically identify the car it is installed in. Control transmission related to acceleration / deceleration shall correspond to manual operation, CBTC and Running and stopping assistant system. In particular, the command step number from the CBTC (ATO) and Running and stopping assistant system shall be capable of handling at least 31 steps or more. Regarding the information about service operation such as train number and train type etc., it shall be capable of setting not only by TMS but also by OCC through signaling system;

2) Interfacing capability shall be provided with twenty percent (20%) spare unallocated vehicle system input/output capacity for future use and when utilized it shall not produce any adverse performance impact on data throughput performance;

3) The transmission mode and protocol of the TMS shall be of industry standard and maintain reliable operation and shall be immune to interference or performance degradation in the environment influenced by electro-magnetic interference (EMI) and harmonics generated from the traction power converters, variable voltage variable frequency (VVVF) inverters and static inverters;

4) A single point failure of any individual part shall not cause any adverse performance impact or cause loss of data in control transmission;

5) The TMS shall perform fault analysis, event log fault occurrence, determine the health of the vehicle systems, failure management actions and present alarm and condition status to the train operator. The event recorder shall be configured to sum repetitive faults, and when the memory is full, the next fault shall result in the oldest fault being dropped and the newest added;

6) Fault analysis algorithms, data acquisition routines and data storage logic shall be programmed and presented using a Windows type of user interface, using the latest windows Operating System (OS) or other equal industry OS;

7) On-board fault occurrences logging and degraded performance condition monitoring logging shall be provided as an integral part of the TMS. The Contractor shall nominate the key indicators of degraded performance of the principal vehicle systems for review by the Engineer;

8) The TMS shall always display a warning message on a per vehicle system overview basis for any consist system detected with an active fault alarm condition. Train operator selectable screen page listing of active fault alarms for the total consists shall be provided;

9) The TMS programming shall allow for easy data entry and function changing and upgrading throughout the life of the system;

10) The TMS display shall use back-lit colored LCD technology and shall be software driven by the TMS. Commands shall be entered by the train driver via touch screen;

11) Two TMS monitors shall be prepared. Normally, each piece of information shall be appropriately sorted and displayed on the two units. In the event of failure of one unit, it is necessary to have a backup function to automatically display all information on the remaining healthy one;

12) The TMS display shall provide the train driver with information regarding the operating status of the vehicle consist, vehicle/system health and failure management actions performed by the TMS. The display shall provide the facility for train operator to input railway operations information (e.g. staff number, train run number, etc.);

13) The TMS shall have the function to calculate running distance for trip meter;

14) The TMS shall get time and date information from either Communications or the on-board signaling system and linked equipment shall get the time from the TMS;

15) TMS configurations and options shall be reviewed by the Engineer;

16) The display shall provide the facility for maintenance personnel to input maintenance information (e.g. wheel diameter,);

17) The master clock system shall provide to the various train borne systems an accurate source of time and date information;

18) In transmission concerning functions related to driving and devices with high importance, that is, control transmission, the backbone transmission line shall have two systems, so the Ethernet system has redundancy. These two main transmission lines shall be a loop type or a ladder logic type to have higher redundancy. Each vehicle shall have vehicle switch (VS) for 1 system and 2 systems. End Device (ED) shall be connected to VS. A central unit shall be installed in both leading vehicles. Here VS is the vehicle switch and ED is the End Device. The simplified block diagram is shown in Attachment;

19) In transmission concerning functions related to CCTV, monitor information, information not directly related to driving, the backbone transmission line shall have one system as the Ethernet system. Each vehicle shall have a VS. The simplified block diagram is shown in Attachment;

20) The transmission lines shall be capable of network isolation by V-LAN. The communication speed shall be maintained for the application possible speed. I/O shall be digital input/output. The storage method shall be a large capacity disk method. The control method shall be a high response processing method;

21) The TMS shall comply with IEC 61375 (including branches excluding 2-6 and 3-3) or equivalent. Moreover, careful consideration shall also be given to global standards, redundancy systems, compactness and weight reduction;

22) Based on the release state information of the propulsion system or the brake system, the required acceleration / braking force of the whole formation shall be computed, and backup control shall be performed so as not to interfere with operation as much as possible;

23) Various information recorded in the TMS shall be able to cooperate with MMS (Maintenance Management System). Details shall be discussed with the CP106 (DEPOT) Contractor;

24) As departure inspection, in addition to the motoring test, the door test, the brake test, the function to judge whether there is no abnormality in the vehicle shall be equipped; and

25) Accumulated traveling kilometers, power consumption, operation status of the air compressor, number of times of operation of the line breaker, statistics of station

stopping position at ATO mode, etc. shall be recorded of a record of vehicle condition, monitoring and inspection.

26) The Information of the train place shall be transmitted to required system. At least, air conditioning system, propulsion system, brake system and auxiliary power supply system are included.

27) The Contractor shall prepare parts list (incl. the name, model number, serial number and quantity, etc.) of rolling stock for MMS according to a conclusion that shall be discussed with the Depot contractor about parts list. Details shall be discussed with the Depot contractor.

28) TMS shall transmit necessary information to related equipment if special operation such as reversed train formation operation, running operation or single line parallel operation during emergency situation, will be adopted.

29) Passenger load information from BCU(second suspension pressure) shall be interfaced with communication system and signaling system which is provided from CP NS-01.

16.4 EVENT RECORDER

The event recorder can either be incorporated its function into TMS or as a separate device and shall comply with IEC62625-1 or equivalent. The TMS shall also be capable of recording, with sufficient memory capacity to store more than 30 days operation, which shall include, but not be limited to, the following:

1) Speed;
2) Status of train control mode;
3) Power controller position and power equipment response;
4) Brake controller position and brake equipment response;
5) Traction motor current;
6) Main airline pressure / brake cylinder pressure;
7) Emergency brake events;
8) Brake events under Manual Operation;
9) Driver safety device;
10) Status of doors and control;
11) ACU events;
12) Wheel slide;
13) Operation of safety related cut-out switches;
14) Wheel slide;
15) ATO condition;
16) PSD condition;
17) Overhead line voltage;
18) Battery voltage;
19) Date and time;
20) Location; and

21) Battery contactor status (on/off).

16.5 MASTER CLOCK

The TMS shall be able to communicate with the Communication or the on-board signaling systems to obtain the time and date details to provide the master clock information to other on-board systems.

16.6 ELECTRICAL JUMPER WIRE

The electrical jumper wire that is necessary for transmission between the vehicles shall be specified by the TMS supplier and shall achieve 1 million cycles of performance and deviation test.

17 COMMUNICATION SYSTEM

17.1 GENERAL

The Rolling Stock shall be equipped with communications equipment to provide voice, video and data services.

The place where Radio system of the interoperability section operation is installed and the IF with each equipment shall be taken into consideration.

Preparation for Wi-fi system for passengers with all cars. Space for attachment and materials shall be considered so that passengers can get various information through Wi-fi system wherever passengers are within the train. It shall be assumed that individual systems of two companies are introduced.

This section describes the requirements for the CP106 (Communication System) Contractor, and the CP107 (Rolling Stock) Contractor.

Both Contractors shall ensure that all requirements of the specification pertaining to interfaces are comprehensively fulfilled. Below is a brief outline of responsibilities between the CP107 and CP106 Contractors. Further details are specified in succeeding sections:

Table 17.1 Responsibility Matrix

SOW	Item Description	By Contractor
1	Public Address (PA) System to broadcast speech messages to train passengers from the driver's cab. Facility to broadcast over the train PA System from the Operations Control Center (OCC) with the associated message content relayed to the train via the Train Radio System.	CP107 CP106
2	Guidance display for the customer shall be placed above the door in the passenger coaches (or saloons). Guidance display shall be digital signage to present on dedicated TV-style color monitors using 17-inch or more LCD displays, and it shall be possible to display the destination, the next station, the side of opening door, transit information, line map, time to arrive at each station, the guidance of the next station and attention, etc. One monitor shall be installed on one door. Securing space and supplying the wiring shall be prepared so that another screen can be added for advertisement. Advertisement display for the customer shall be placed above the window between doors in the passenger coaches (or saloons). Advertisement display shall be digital signage to present on dedicated TV-style color monitors using 21.5-inch or more LCD displays.	CP107

SOW	Item Description	By Contractor
3	Passenger emergency intercom to provide audio communication between carriages and the driver's cab to enable passengers to talk to the driver should an emergency situation occur within the train carriage. In case the driver does not pick up the passenger emergency intercom within a predefined time, it automatically connects to the OCC, using the onboard radio.	CP107 CP106
4	Driver's intercom system to allow full-duplex audio communication between driver's cabs.	CP107
5	Train radio system to allow full-duplex audio communication between the driver and the OCC. Additional interfaces shall be provided within the OCC to relay to the trains PA audio messages.	CP106 CP NS-02
6	Outdoor display (mounting on the train) consisting of a full color LED to display destination stations for the passengers on the platform.	CP107

17.2 GENERAL REQUIREMENTS

The CP107 Contractor shall equip each driver's cab with the necessary Human Machine Interface (HMI) facilities for the operation, control and monitoring by the driver of the on-board communications systems. The number of handsets required for driver use shall be rationalized and kept to a minimum. In particular, the CP107 Contractor shall utilize the TMS monitor with respect to the display.

Subject to any reliability constraints, both CP107 and CP106 Contractors shall consider the integration of all communication operator functions into a single HMI to minimize space requirements.

All of the cab-mounted equipment shall be fit for purpose and ergonomically designed taking account of human factor issues.

Unless otherwise stated, the equipment shall be controllable from the operational driver's cab and must be fully functional over a length of 8 and 10-car trains. The on-board communications equipment shall be fed via individual circuit breakers from a fully regulated low voltage power supply equipped with a battery back-up.

The design shall incorporate the latest proven technology, which shall be highly scalable and reliable, avoiding common mode failure.

The entire installation for each system shall include a comprehensive diagnostic and fault management facility and shall be interfaced to the TMS to log events/incidents and major fault data, to send and to receive a variety of information necessary for control.

Suitable security measures and firewalls shall be employed comprising standardized state-of-the-art authentication mechanisms to block unwanted data traffic and access to the on-board

communication systems.

The equipment shall be robustly constructed and shall be resistant to tampering, vandalism and exposure to liquid spillages, etc.

The equipment devices within carriages shall in appearance be aesthetically pleasing and their fitment shall be flush mounted into the carriage body and installed in positions to minimize their exposure to vandalism.

The CP107 Contractor shall perform a study to ensure that, within the train carriages all of the communications equipment is positioned, as appropriate, so as to achieve ease of passenger use and passenger viewing without creating an obstruction to passenger flow and without obscuring other facilities such as signs, notices and other displays, etc.

The CP107 and CP106 Contractors shall ensure that the required number of antennas be minimized and be positioned taking into account the following:

1) The effect of the geometry of the installation location on the radiation/reception performance of the antenna and without exceeding the rolling stock gauge;
2) The effect of any protrusions which might affect the radiation/reception performance of the antenna;
3) The effect of any adjacent aerials on the performance of the radio system;
4) The risk of being struck or otherwise damaged;
5) Electrical safety in relation to proximity to exposed HV lines; and
6) Diversity for improving reception sensitivity.

The systems shall, where appropriate, be interfaced to the TMS for provision of accurate time and date information.

Suitable automatic test routines shall be available to the driver in the active cab in order that the operational integrity of the on-board communications equipment is verified prior to the train entering passenger service.

Externally mounted equipment shall be dustproof and weatherproof and shall be sufficiently robust to withstand frequent train washing involving continuous exposure to high pressure water jets, associated chemical cleaning and mechanical rotary scrubbing brushes.

The communications systems shall be fully compliant with industry recognized railway standards, international standards such as ITU-T and ITU-R and applicable national standards.

Special attention shall be given to the shielding of all communications equipment and wiring along with any HV protection required.

17.3 PUBLIC ADDRESS (PA) SYSTEM

The train carriages shall be equipped with public address speakers, which shall enable voice announcements to be broadcast relating to emergency, safety and information messages.

For speech intelligibility purposes, the design shall achieve an STI (Speech Transmission Index) in excess of 0.6 under the worst case ambient noise conditions.

In the internal design of the train carriages, the CP107 Contractor shall give due consideration

to the selection of suitable materials in order that their acoustical properties are complimentary to achieving the specified STI.

Consideration shall be given to the installation within carriages of ambient noise sensors to maintain, under varying ambient noise conditions, a more uniform signal to noise ratio for PA broadcast coverage.

The driver shall be able to make live announcements over the PA system and shall also have the facility to initiate the broadcast of pre-recorded speech messages accessible from an on-board message library.

The OCC operators shall be capable of making live speech broadcasts and initiating the broadcast of pre-recorded speech messages via an interface between the train radio system provided by the CP106 Contractor and the on-board PA system.

The PA message library shall be solid state and shall be developed by the CP107 Contractor, with agreement with the Employer.

Library messages shall be in both English and Tagalog. Selected messages shall be broadcast firstly in English followed by the same message in Tagalog; each with a pre-set dwell time, the duration of which may be adjusted as an engineering function.

The library shall be suitable for being updated at regular intervals, as the situation demands. The CP107 Contractor shall propose an efficient method by which multiple trains may be updated.

The message library shall be dimensioned with a minimum storage capacity of 1TByte.

Message categories shall include service status, places of interest, safety messages, emergency messages, details of train start location and train destination along with next station details, etc.

The PA system shall be interfaced to enable selected safety and emergency messages broadcast on the train PA system within each train.

Within each train cab a PA Control unit shall be supplied.

PA broadcasts initiated by the train driver shall have priority over other broadcasts.

17.4 INTERNAL GUIDANCE DISPLAY

The guidance displays shall be digital-signage to present on dedicated TV style color monitors, (17-inch or more LCD), a display to show typically, the destination, the next station, which side door opening, transit information, line map, time to arrive at each station, the guidance of the next station, etc. The displays shall be mounted above each door. This system shall be interfaced with communication system provided by CP106. The date from the communication system shall be displayed in these guidance monitors. The Contractor shall provide dynamic train route displayed on the LCD above the door. The display shall indicate live train position and estimated time of arrival to all and or part of the proceeding stations. Interfacing with CBTC and/or TMS system, as required shall be considered for the updating of the train position and estimated time of arrival on LCD.

The displays for advertisement (21.5-inch or more LCD) shall be installed between doors on both sides (total 6 displays per car). These displays shall be mounted above the window. Advertisement contents shall be installed into this system directly. Also, it shall be prepared to be able to be installed remotely by interfacing with the wireless another system.

17.5 EXTERNAL DESTINATION SIGN SYSTEM

The destination sign located at the end of the consist shall provide, as a minimum, information on the train running number along with the start and destination locations of the train service and any special information such as 'Not in Service', etc. The destination sign shall be installed externally on each cab vehicle above the windshield and two units on each side of each vehicle above the window.

A hinged panel shall be installed in the driver's cab to provide ready access to the destination sign unit.

The destination sign shall be suitably sized with text colors such that passengers waiting on platforms shall be able to see clearly the information displayed on the train approach to the platform under all conditions.

The destination sign shall be programmable from the TMS in the driver's cab.

The destination sign in the non-active cab and on the side of the vehicle shall automatically indicate the same destination as in the active cab.

The design of the destination sign shall allow manual override in the case of a defect in the electronics system.

The Contractor shall propose options for the electronic destination display sign system for the Engineer's review.

Choosing optimal colors according to train type, guidance content and display that is easy for the user to understand shall be implemented.

Display contents, colors, fonts, etc. shall be reviewed by the Engineer.

17.6 DIGITAL SIGNAGE FOR ADVERTISING

Space and power supply provision shall be made available with one more door above position to enable digital signage as described in Sections 17.1 item 2 and 17.4 herein

17.7 PASSENGER EMERGENCY INTERCOM

A full-duplex and highly reliable intercom and alarm facility shall be provided to enable an emergency call to be established between passengers in each carriage and the train driver.

Quantity of four (4) intercom units shall be provided per carriage and the location shall be reviewed by the Engineer.

The intercom communications shall provide high voice quality free from distortions, audible noise and other audio impairment. The carriage intercom unit shall be bulkhead mounted and protected by a break-glass cover.

The unit shall be positioned in a readily accessible location and at a suitable height for customer use.

The intercom unit shall consist of a switch to initiate a call along with a flush mounted noise-cancelling microphone and loudspeaker.

Operation of the emergency switch shall result in the following actions on-board the train:

1) An audible and visual alarm by TMS (monitor) shall be made in the driver's cab also

indicating location of actuation;

2) The driver shall be able to communicate via a separate dedicated handset for this purpose;

3) The emergency voice recorder shall record the conversation for the duration of the call; and

4) The event recorder in TMS shall record details of the intercom unit location together with the time and date of the emergency call.

17.8 DRIVER'S INTERCOM SYSTEM

A full-duplex and highly reliable intercom facility shall be provided to enable personnel within the driver's cab at each end of the train to establish voice communications.

The intercom communications shall provide high voice quality free from distortions, audible noise and other audio impairment.

17.9 TRAIN RADIO SYSTEM

The Train Radio System for the Rolling Stock shall be designed and supplied by the CP106 Contractor for the CP107 Contractor to install on the Rolling Stock. The CP106 Contractor shall provide supervision for the first Train Radio System installation on- site. But Train Protection Radio system for MMSP, and through service section shall be supplied by the CP107 Contractor.

In addition to the communication devices mentioned above, at least the Train Operator Control Panel (TOCP) and the radio transceiver unit shall be included.

The TOCP shall be equipped with all facilities necessary for driver operation of the on-board radio facilities and other on-board radio communication equipment and shall typically include:

1) Integral flush mounted loudspeaker;

2) Volume control;

3) Gooseneck microphone;

4) Press to talk (PTT) switch; and

5) System selector switch.

The TOCP shall, as a minimum, enable the following functions to be performed:

1) Communication between the cab driver and the OCC via the train radio system;

2) Communication between the leading and trailing cabs via an intercom system;

3) Driver announcements from the cab to passengers within the train via the train PA system; and

4) Display of major telecoms system alarms.

The design shall enable the OCC to communicate with train passengers via the Radio System by broadcasting audio announcements within carriages via the train PA system and this function can be utilized both when emergency intercom activated and OCC intend to announce.

The CP106 Contractor shall be responsible for the configuration, set-up and optimization

adjustment of the on-board train radio equipment to ensure full inter- operation with the line side train radio network and facilities within the OCC.

The CP106 Contractor shall determine, in conjunction with the radio equipment manufacturer, all of the necessary interfacing requirements to the various sub- systems.

Within each train cab a hand-portable radio with battery charger and integral cradle shall be equipped. The hand–portable radio shall be supplied by the CP106 Contractor for the CP107 Contractor to install securely in a housing when not in use.

To protect against on-board radio system failure, each cab shall be equipped with a robustly constructed hand-portable radio which shall allow the driver to communicate to the OCC via the line side radio network.

At each boundary of each line, the exchange of system shall be seamless. Regarding this specification, the Contractor shall consider applying to the future projects such as extension of lines and interoperability with NSRP-S as well. If necessary, the line-recognition data of each train shall be available for this exchange. In this case, the CP107 contractor shall provide the line-recognition data with the CP106 contractor.

The Rolling Stock Contractor shall suppose that several radio systems will be adopted, and requirements for each system shall be satisfied by cooperation between the Rolling Stock Contractor and the Communication System Contractor. At least CP107 contractor shall assume that the systems needed for the line in which the train run will be mounted.

17.10 OPERATION OF THE MOBILE COMMUNICATIONS DEVICES

The train structure shall be designed so as not to impede the operation of mobile phones and other similar radio communications devices within the train carriages whilst accessing public operated mobile communications networks such as GSM (2G), UMPS (3G), LTE (4G) or other more advanced network.

In particular, for such signals the attenuation (penetration loss) of the side windows shall not exceed 3dB when the train is on straight track with the side windows perpendicular to the rail.

17.11 TRAIN PROTECTION RADIO

The radio system which is provided from CP106 (and CP NS-02) Contractor shall include this function.

In case a train has any trouble, this train shall be protected from any other train which is running towards the own.

If the trains receive this signal, the emergency brake shall be operated immediately or manually, and the alarm shall be activated.

The dedicated battery shall be needed because train protection radio is capable of using whether train power is on and off.

17.12 PREPARATION FOR WI-FI SYSTEM

Preparation for Wi-Fi system shall be designed in consideration with follow but not limited to:

1) Space and position for attaching;

2) Materials of interior near the attachment;

3) Capacity of powering;

4) Preparation of circuit; and

5) Preparation of interface.

Care shall be paid to assume that two individual systems of two companies are introduced.

18 TWO SIGNALING SYSTEMS, RUNNING AND STOPPING ASSISTANT SYSTEM AND PSD CONTROLLER

18.1 GENERAL

This section describes the requirements as required for the two Signaling System Contractors, Running and Stopping assistant system Contractor, PSD controller Contractor and the Rolling Stock Contractor. The CBTC shall be in compliance to IEEE 1474.1 or an equivalent standard.

The four devices described in this chapter are:

a. CBTC and PSD controller for MMSP (provided by CP106)

b. ETCS Level 2 for NSRP-South (provided by CP NS-01)

c. Running and Stopping assistant system for NSRP-South (provided by CP NS-01)

d. PSD controller for NSRP-South (provided by CP NS-01)

In this chapter, the four devices refer to the above a,b,c and d.

All Contractors shall ensure that all requirements of the Specification pertaining to interfaces are comprehensively fulfilled.

The CP107 Contractor shall provide additional space for the another on-board signaling system for future signaling requirements (if required). The additional space will be similar (with some margin) to the space occupied for the CBTC signaling system.

The Rolling Stock Contractor shall coordinate with other Contractors for the design of all appurtenances. The Rolling Stock Contractor shall install all cabling free mating connectors, plug couplers and mounting fixtures for the other equipment on all the new trains according to the other Contractors installation specifications.

The CP107 Contractor shall provide a report and validate the installation of the CP106 Contractor's equipment for each train, for the Engineer's review.

The CP107 Contractor shall provide adequate and stress-relieving provisions for the cabling of the signaling equipment after these are mounted to ensure that cables are not fouling other equipment, chafing or unduly stressed.

The CP107 Contractor shall coordinate with the CP106 Contractor and shall be responsible to provide all supports, brackets, braces, mounting holes, etc. to ensure proper mounting and to allow adequate access to the train-borne signaling equipment.

When trains stop inaccurately, this means rate of achieving stop within range fixed point ±350 mm shall be less than 99.8%, related Contractors and related subcontractors shall investigate the causes, and the contributing equipment shall be modified and rectified to achieve above stop accuracy.

18.2 INTERFACE REQUIREMENTS

The requirements specified herein are not totally definitive and it remains the responsibility of among the four devices and Rolling Stock Contractors to develop appropriate plans during the execution of the work to ensure that:

a) All interface issues between the two contracts are satisfactorily resolved;

b) All equipment and software is supplied, installed and tested and is fully coordinated;

c) All safety related functions shall be designed and tested to the relevant standards; and

d) ATO/ATP/ROS/RM mode of operation is achieved with all its inherent features.

The ATP system provided by the CP106 and CP NS-01 Contractor shall issue the braking commands to the Rolling Stock when safety limits are exceeded or when overspeed is detected. The removal of traction power and the correct application of brakes shall be the responsibility of the CP107 Contractor. The on-board signaling system provided by the CP106 and CP NS-01 Contractor shall monitor speed and issue braking commands when safety limits are exceeded.

Two (2) separate radio systems shall be provided by the CP106 Contractor. The first radio system (including on-board equipment) for train radio traffic and the second radio system (including on-board equipment) for transmitting CBTC information, and other data pertaining to control, alarm, events etc. Details of sharing of the two radio systems for sending control and data information, levels and protocols thereof, will be jointly agreed during the interface meeting between CP106 and CP107, CP107 and CP NS-01 Contractors.

The event recorder within the TMS shall monitor and record data on train speed, direction of motion, time, distance, throttle position, brake applications and operations (including service brake, emergency brake) equipped, cab signal indications, etc. Details of the signals will be jointly agreed and finalized during the interface meeting between CP106 and CP107, CP107 and CP NS-01 Contractors.

The CP106 and CP NS-01 Contractors shall provide the CP107 Contractor with a comprehensive list as applicable of equipment to be installed on the Rolling Stock; e.g. the sizes and weights of the on-board signaling cubicles, odometer's, HMI, monitor, train-borne on-board signaling antenna, accelerometers, doppler radar, etc.

The CP106 and CP NS-01 Contractors shall deliver to the CP107 Contractor all on-board signaling equipment, as applicable, and data to enable installation and testing.

The CP106 and CP NS-01 Contractors shall supply to the CP107 Contractor pre-wired equipment racks with appropriate connectors for all wiring terminating inside on-board signaling enclosures. Ease of access to the wiring and connectors shall be maintained.

For compatibility purposes, the Rolling Stock and the train detection system shall conform to IEC 62427 or an equivalent international standard.

Vehicle control circuits developed by the CP107 Contractor shall incorporate the identified interfaces and shall be made available to the CP106 and CP NS-01 Contractors, as applicable. The CP106 and CP NS-01 Contractors shall provide any specific observations, to the CP107 Contractor. Once agreed, the CP107 Contractor shall suitably incorporate these observations into the design.

The CP106 and CP NS-01 Contractor shall provide the CP107 Contractor with the number of wires/Ethernet connections required between cars to transmit signals from one end to the other end of the train. Provision of redundancy and spares shall be catered for by the CP107 Contractor for train lines /Ethernet connections as deemed necessary by the CP106 and CP NS-01 Contractors.

The CP107 Contractor shall provide an on-board signaling mode(CBTC) selection switch. The mode selector shall have at least following positions:

a) Automatic Train Operation (ATO) Mode;

b) Automatic Train Protection (ATP) Mode; and

c) Restricted Manual (RM) mode.

Under the above modes, the vehicle speed shall be monitored and restricted by the on-board signaling equipment.

The CP107 Contractor shall provide an ATP cut-off switch next to the on-board signaling selector. The ATP cut-off switch shall be a sealed switch and the seal position set at the ATP mode. When activated to the 'cut-off' position, the seal must be broken and the activation shall be logged into the event recorder. Under the ATP cut-off mode, the train speed shall be restricted by the vehicle overspeed device and restricted to be under 25 km/h.

The CP107 Contractor shall provide the following facilities:

a) Coupling detection, e.g. by means of coupler switch;

b) Detachment detection e.g. by means of train integrity relay;

c) ATO (illuminated) button, to activate the ATO mode;

d) ATO door by-pass sealed button, to be activate if manual passenger door opening is required;

e) Running-on-Sight (ROS) e.g. by means of push button; and

f) Any other facilities required to fulfill the interface requirements.

The above functions shall be available on the on-board signaling equipment.

18.3 ROLLING STOCK CHARACTERISTICS TO BE USED BY THE FOUR DEVICES CONTRACTOR

The model for calculating the Safe Braking Distance (SBD) by the CP106 and CP NS-01 Contractors shall identify and take into consideration the various systems response times and train operator's reaction times. The CP107 Contractor shall provide the assured braking rate at the normal braking efficiency, and at the lowest braking efficiency permitted in service, including brake deterioration, and response times of both service brake and emergency brake, to the CP106 and CP NS-01 Contractors. The CP107 Contractor shall provide the speed/acceleration and tractive effort curves, for all loading conditions.

In the title of this section, four devices mean as below.

a. CBTC and PSD controller for MMSP(provided by CP106)

b. ETCS Level 2 for NSRP-South(provided by CP NS-01)

c. Running and Stopping assistant system for NSRP-South (provided by CP NS-01)

d. PSD controller for NSRP-South (provided by CP NS-01)

The safety critical braking system of the Rolling Stock shall be of vital fail-safe design and the CP107 Contractor shall provide all documentary evidence required to demonstrate the safety of the braking system to achieve the required safety level.

The deceleration used for the SBD shall be coordinated with the CP106 and CP NS-01 Contractor's standard which is to be agreed during the interface meetings. The CP106 and CP NS-01 Contractors shall coordinate with CP107 Contractor, under the supervision of the Employer/Engineer.

18.4 DETAILS TO BE USED BY ROLLING STOCK CONTRACTOR

As a minimum, the following data shall be provided:

a) The maximum current and power consumption by the four devices of the Contractor's equipment under all specified operating conditions;

b) The number of train wires required, and the function of each;

c) All control logic outputs and signal protocols;

d) Electrical characteristics and setting requirements of the interconnection cabling and wiring;

e) Sensitivity levels, and frequencies, which must be avoided;

f) The specific heat load for air conditioning purposes; and

g) Characteristics and Requirements of Antennas.

18.5 CBTC EQUIPMENT

18.5.1 CBTC Equipment Cubicles

The CBTC Contractor shall supply the ATP equipment cubicle enclosure(s). All supports, braces, mounting holes, cabling apertures, etc. required for mounting the cubicle and its equipment shall be correctly coordinated between the CBTC and Rolling Stock Contractors to ensure secure mounting, and ease of access.

The CP107 Contractor shall supply cubicle enclosure for housing the rack(s) and the cubicle enclosure shall suitably be protected to IP52 standard as it is mounted inside the cab or saloon.

To achieve the CBTC control functions, the CBTC Contractor shall identify any interfacing circuits specifically required for CBTC operation and liaise with the Rolling Stock Contractor. This shall include acceleration, service braking and emergency brake commands.

For train control circuits, the CBTC Contractors shall identify any voltage-free contacts that are to be provided by the Rolling Stock Contractor, including the number and type of I/O's required between the ATP equipment and the equipment provided by the Rolling Stock Contractor. The two Contractors shall co-ordinate to agree on I/O's and protocols for all such data.

18.5.2 Fixtures and Fittings

The CBTC Contractor shall provide the Rolling Stock Contractor with complete mounting details, apertures, fixing holes, etc.

The CBTC Contractor shall supply the necessary disconnection and terminal blocks, device mounting brackets and plates, flexible conduit assemblies complete with connectors and cables from speed measurement devices to the junction boxes. The CBTC Contractor will supply all the mechanical fixing items and cables for ATP Cubicles, DMI, Monitor, Odometer, Train-borne ATP Antenna, Accelerometer, Doppler Radar,etc in a timely manner.

Both contractors shall consider setting of ATP equipment so as not to affect the cabs and saloons. Basically, it shall not be acceptable to set up ATP equipment over the floor except for necessary parts.

Also, both contractors shall consider position of on-board antennas to correspond with MCRP, Limited express for MCRP, NSRP-S, NSCR, and MMSP lines.

18.5.3 Power Supply and Earthing Arrangements

Power supply circuits, including positive and negative poles, for the on-board signaling equipment shall be provided by the CP107 Contractor. Both the CP107 and CP106 Contractors shall coordinate and agree the power supply requirements.

The CP107 Contractor shall provide dedicated earthing arrangements for the CBTC on-board signaling equipment. The CP106 Contractor shall specify the earthing requirements and impedance values for their supplied equipment.

Both Contractors shall work together to ensure the power supply cable between the train power supply and the power equipment for the on-board signaling equipment is as short as possible.

18.5.4 Factory Installation and Testing

All the special equipment associated with the CBTC onboard equipment shall be designed by the CBTC Contractor and forwarded to the Rolling Stock Contractor's assembly premises. Each contractor shall be aware of the locations of manufacturing plants.

The CBTC Contractor shall be responsible for providing all data and training to Rolling Stock Contractor's staff in all aspects of CBTC installation and testing where applicable. The CBTC on-board equipment shall be installed by the Rolling Stock Contractor, under the supervision of the CBTC Contractor's Engineer, including the wiring for the interface of the CBTC equipment with Rolling Stock.

The CBTC Contractor shall coordinate with the Rolling Stock Contractor for design of all appurtenances. The Rolling Stock Contractor shall provide a report and validate the installation of the CBTC Contractor equipment for each train.

The Rolling Stock Contractor shall provide adequate and stress-relieving provisions for the cabling of the CBTC equipment after these are mounted to ensure that cables are not fouling, chaffing or unduly stressed with other equipment.

The Rolling Stock Contractor shall be responsible to provide all supports, brackets braces, mounting holes, etc. to ensure proper mounting and to allow adequate access to the train-borne CBTC equipment.

The CBTC Contractor shall be responsible for the testing of equipment (or initial supervision of Rolling Stock personnel until suitably trained), inclusive of its subsequent functional test.

The testing of each car shall comply with the accepted international standards agreed between the two Contractors and the Engineer.

The first train shall be fitted with all the required equipment at the Rolling Stock Contractor's facility under the supervision of the CBTC Contractor. Initial Integration tests (static and dynamic) shall be carried out at the Rolling Stock manufacturer's premises and performed by the test personnel of both Contractors jointly. Further main line integration tests shall be carried out to ensure all train control functions between OCC and Trains, are done jointly by both the Rolling Stock and CBTC Contractors on site in Manila. The test certificate for the on-board equipment shall be issued jointly (and duly signed) by both the Rolling Stock and CBTC Contractors. As a result of the examination of the first train, if modification occurs, then they shall also be carried out for the remaining trains.

The Rolling Stock Contractor shall provide facilities including a test track for comprehensive static, dynamic, and interface testing between the Rolling Stock and CBTC systems at their

premises. If it is difficult to implement it at their premises, then it is acceptable to use the test line or main line. The CBTC Contractor shall be responsible for the provision of special test equipment and instrumentation.

The CBTC Contractor shall provide wiring looms as an intermediate for connection of CBTC cubicle connector and train wiring and externally mounted CBTC equipment (including antenna readers, radar, tachometers, monitor, accelerometers etc.), to be installed by the Rolling Stock Contractor during vehicle manufacture. The Rolling Stock Contractor shall then provide an Installation Report to confirm the completion of the installation works for acceptance by the CBTC Contractor.

Upon delivery of the Rolling Stock's to Manila, the CBTC Contractor shall then install the remaining signaling equipment using the pre-wired loom.

Should the need arise for any alterations in the configuration of the respective equipment or systems as a result of the integration test or otherwise, the scope of work and division of responsibility shall be jointly agreed amongst the two Contractors and a detailed procedure developed prior to the introduction of the modification.

All modifications shall be carried out at the Rolling Stock factory before shipment, wherever possible.

18.5.5 Operational Modes

The following operational train modes shall be adopted for the MMS line:

a) Automatic Train Operation (ATO) Mode;

b) Automatic Train Protection (ATP) Mode;

c) Running-on-Sight (ROS) Mode;

d) Restricted Manual (RM) Mode; and

e) Cut-off Mode.

Automatic Train Operation (ATO) Mode

In ATO mode, the train operator shall operate without intervention except when starting from a station stop. ATO automatically controls the train braking and traction systems under the supervision of the ATP system. In ATO mode opening of the train doors is automatic at stations. The train shall depart from the station after the train doors are detected 'closed' and the train operator has pressed the Start Button.

Automatic Train Operation (ATP) Mode

In ATP Mode the train will be driven by the train operator, obeying cab signals provided in the operator's HMI. In ATP mode, the on-board signaling system shall provide cab signals and all other indications necessary to operate the train. Door opening and closing operation shall be carried out by the train operator.

Running-on-Sight (ROS) Mode

ROS mode is selected by the train operator if the signaling system (on board or wayside) is not fully operational. In ROS mode of operation, the Mode Selector Switch is in the ATP position and ROS mode is selected by a ROS button/key and the train operator drives the train by sight. Maximum speed in ROS mode is 25km/h. This mode remains in operation until sufficient conditions have been met to allow for a transfer to the ATP mode. However, the train operator will select the ROS signaling mode in certain cases (e.g. following an emergency brake application). The CBTC Signaling System shall permit the train to transfer

from ROS to ATP mode automatically without stopping the train, however the ROS mode can only be selected when the train is stationary.

Restricted Manual (RM) Mode

RM mode is the default mode of operation in the Depot. In Restricted Manual mode the train speed shall be limited to 25 km/h. This mode shall be available only when the on-board signaling equipment is operational. RM mode shall also be utilized on the main line for coupling of trains call-on or push-out train operations.

Cut-off Mode

In Cut-off mode, the train will be operated by the train operator in accordance with procedures and instructions from the Traffic Controller. Cut-off mode is intended for use in the case of complete train-borne signaling-system failure preventing release of the emergency brake. In Cut-off mode the Rolling Stock Contractor will ensure to limit the maximum speed to 15 km/h.

18.6 ETCS EQUIPMENT

18.6.1 ETCS Equipment Cubicles

The ETCS Contractor shall supply the ATP equipment cubicle enclosure(s). All supports, braces, mounting holes, cabling apertures, etc. required for mounting the cubicle and its equipment shall be correctly coordinated between the ETCS and Rolling Stock Contractors to ensure secure mounting, and ease of access.

To achieve the ETCS control functions, the ETCS Contractor shall identify any interfacing circuits specifically required for ETCS operation and liaise with the Rolling Stock Contractor. This shall include acceleration, service braking and emergency brake commands.

For train control circuits, the ETCS Contractors shall identify any voltage-free contacts that are to be provided by the Rolling Stock Contractor, including the number and type of I/O's required between the ATP equipment and the equipment provided by the Rolling Stock Contractor. The two Contractors shall co-ordinate to agree on I/O's and protocols for all such data.

18.6.2 Fixtures and Fittings

The ETCS Contractor shall provide the Rolling Stock Contractor with complete mounting details, apertures, fixing holes, etc.

The ETCS Contractor shall supply the necessary disconnection and terminal blocks, device mounting brackets and plates, flexible conduit assemblies complete with connectors and cables from speed measurement devices to the junction boxes. The ETCS Contractor will supply all the mechanical fixing items and cables for ATP Cubicles, DMI, Monitor, Odometer, Train-borne ATP Antenna, Accelerometer, Doppler Radar etc, in a timely manner.

Also, both contractors shall consider position of on-board antennas to correspond with MCRP, Limited express for MCRP, NSRP-S, NSCR, and MMSP lines.

18.6.3 Power Supply and Earthing Arrangements

Power supply circuits, including positive and negative poles, for the ETCS on-board equipment will be provided by the Rolling Stock Contractor. Both Contractors shall co-ordinate and agree the power supply requirements.

The ETCS Contractor shall provide the Rolling Stock Contractor with full mounting details, apertures, fixing holes, etc.

The ETCS Contractor shall supply the necessary disconnection and terminal blocks, device mounting brackets and plates, flexible conduit assemblies complete with connectors and cables from speed measurement devices to the junction boxes. The ETCS Contractor will supply all the mechanical fixing items such as ETCS Cubicles, Odometer, Train-borne ETCS Antenna, Accelerometer, Doppler Radar etc. Additionally, cables required for the ETCS such as cables for ETCS Cubicles, Odometer, Train-borne ETCS Antenna, Accelerometer, Doppler radar, etc. shall also be supplied in a timely manner.

The Rolling Stock Contractor shall provide dedicated earthing arrangements for the signaling equipment. The ETCS Contractor shall specify their earthing requirements and impedance values.

The power supply cable between the train power supply and the ETCS onboard power equipment shall be as short as possible.

18.6.4 Factory Installation and Testing

All the special equipment associated with the ETCS onboard equipment shall be designed by the ETCS Contractor and forwarded to the Rolling Stock Contractor's assembly premises. Each contractor shall be aware of the locations of manufacturing plants.

The ETCS Contractor shall be responsible for providing all data and training to Rolling Stock Contractor's staff in all aspects of ETCS installation and testing where applicable. The ETCS on-board equipment shall be installed by the Rolling Stock Contractor, under the supervision of the ETCS Contractor's Engineer, including the wiring for the interface of the ETCS equipment with Rolling Stock.

The ETCS Contractor shall coordinate with the Rolling Stock Contractor for design of all appurtenances. The Rolling Stock Contractor shall provide a report and validate the installation of the ETCS Contractor equipment for each train.

The Rolling Stock Contractor shall provide adequate and stress-relieving provisions for the cabling of the ETCS equipment after these are mounted to ensure that cables are not fouling, chaffing or unduly stressed with other equipment.

The Rolling Stock Contractor shall be responsible to provide all supports, brackets braces, mounting holes, etc. to ensure proper mounting and to allow adequate access to the train-borne ETCS equipment.

The ETCS Contractor shall be responsible for the testing of equipment (or initial supervision of Rolling Stock personnel until suitably trained), inclusive of its subsequent functional test.

The testing of each car shall comply with the accepted international standards agreed between the two Contractors and with the Engineer.

The first train shall be fitted with all the required equipment at the Rolling Stock Contractor's facility under the supervision of the ETCS Contractor. Initial Integration tests (static and dynamic) shall be carried out at the Rolling Stock manufacturer's premise's and performed by the test personnel of both Contractors jointly. Further main line integration tests shall be carried out to ensure all train control functions between OCC and Trains, are done jointly by both the Rolling Stock and ETCS Contractors on site in Manila. The test certificate for the on-board equipment shall be issued jointly (and duly signed) by both the Rolling Stock and ETCS Contractors. As a result of the examination of the first train, if modification occurs, then they shall also be carried out for the remaining trains.

The Rolling Stock Contractor shall provide facilities including a test track for comprehensive

static, dynamic, and interface testing between the Rolling Stock and ETCS systems at their premises. If it is difficult to implement it at their premises, then it is acceptable to use the test line or main line. The ETCS Contractor shall be responsible for the provision of special test equipment and instrumentation.

The ETCS Contractor shall provide wiring looms as an intermediate for connection of ETCS cubicle connector and train wiring and externally mounted ETCS equipment (including antenna readers, radar, tachometers, monitor, accelerometers etc.), to be installed by the Rolling Stock Contractor during vehicle manufacture. The Rolling Stock Contractor shall then provide an Installation Report to confirm the completion of the installation works for acceptance by the ETCS Contractor.

Upon delivery of the Rolling Stock's to Manila, the ETCS Contractor shall then install the remaining signaling equipment using the pre-wired loom.

Should the need arise for any alterations in the configuration of the respective equipment or systems as a result of the integration test or otherwise, the scope of work and division of responsibility shall be jointly agreed amongst the two Contractors and a detailed procedure developed prior to the introduction of the modification.

All modifications shall be carried out at the Rolling Stock factory before shipment.

18.7 RUNNING AND STOPPING ASSISTANT SYSTEM

18.7.1 Running and Stopping assistant system Cubicles

The Running and Stopping assistant system Contractor shall supply the Running and Stopping assistant system equipment cubicle enclosure(s). All supports, braces, mounting holes, cabling apertures, etc. required for mounting the cubicle and its equipment shall be correctly coordinated between the Running and Stopping assistant system and Rolling Stock Contractors to ensure secure mounting, and ease of access.

To achieve the Running and Stopping control functions, the Running and Stopping assistant system Contractor shall identify any interfacing circuits specifically required for this operation and liaise with the Rolling Stock Contractor. This shall include acceleration, service braking commands.

For train control circuits, the Running and Stopping assistant system Contractors shall identify any voltage-free contacts that are to be provided by the Rolling Stock Contractor, including the number and type of electrical I/O's required between the Running and Stopping assistant system equipment and the equipment provided by the Rolling Stock Contractor. The two Contractors shall co-ordinate to agree on I/O's and protocols for all such data.

18.7.2 Fixtures and Fittings

The Running and Stopping assistant system Contractor shall provide the Rolling Stock Contractor with complete mounting details, apertures, fixing holes, etc.

The Running and Stopping assistant system Contractor shall supply the necessary disconnection and terminal blocks, device mounting brackets and plates, flexible conduit assemblies complete with connectors and cables from speed measurement devices to the junction boxes. The Running and Stopping assistant system Contractor shall supply all the mechanical fixing items and cables for main Cubicles, On-board Antenna, Speed sensor, Doppler Radar etc, in a timely manner.

Also, both contractors shall consider position of on-board antennas to correspond with MCRP, Limited express for MCRP, NSRP-S, NSCR, and MMSP lines.

18.7.3 Power Supply and Earthing Arrangements

Power supply circuits, including positive and negative poles, for this on-board equipment will be provided by the Rolling Stock Contractor. Both Contractors shall co-ordinate and agree the power supply requirements.

The Running and Stopping assistant system Contractor shall provide the Rolling Stock Contractor with full mounting details, apertures, fixing holes, etc.

The Running and Stopping assistant system Contractor shall supply the necessary disconnection and terminal blocks, device mounting brackets and plates, flexible conduit assemblies complete with connectors and cables from speed measurement devices to the junction boxes. The Running and Stopping assistant system Contractor will supply all the mechanical fixing items such as main Cubicles, On-board Antenna, Doppler Radar etc. Additionally, cables required shall also be supplied in a timely manner.

The Rolling Stock Contractor shall provide dedicated earthing arrangements for this onboard equipment. The Running and Stopping assistant system Contractor shall specify their earthing requirements and impedance values in accordance with the latest provisions on Philippine Electrical Code.

The power supply cable between the train power supply and this onboard equipment power equipment shall be as short as possible.

18.7.4 Factory Installation and Testing

All the special equipment associated with this onboard equipment shall be designed by the Running and Stopping assistant system Contractor and forwarded to the Rolling Stock Contractor's assembly premises. Each contractor shall be aware of the locations of manufacturing plants.

The Running and Stopping assistant system Contractor shall be responsible for providing all data and training to Rolling Stock Contractor's staff in all aspects of Running and Stopping assistant system installation and testing where applicable. This on-board equipment shall be installed by the Rolling Stock Contractor, under the supervision of the Running and Stopping assistant system Contractor's Engineer, including the wiring for the interface of this equipment with Rolling Stock.

The Running and Stopping assistant system Contractor shall coordinate with the Rolling Stock Contractor for design of all appurtenances. The Rolling Stock Contractor shall provide a report and validate the installation of the Running and Stopping assistant system Contractor equipment for each train.

The Rolling Stock Contractor shall provide adequate and stress-relieving provisions for the cabling of this equipment after these are mounted to ensure that cables are not fouling, chaffing or unduly stressed with other equipment.

The Rolling Stock Contractor shall be responsible to provide all supports, brackets braces, mounting holes, etc. to ensure proper mounting and to allow adequate access to this equipment.

The Running and Stopping assistant system Contractor shall be responsible for the testing of equipment (or initial supervision of Rolling Stock personnel until suitably trained), inclusive of its subsequent functional test.

The testing of each car shall comply with the accepted international standards agreed with

between the two contractors and with the Engineer.

The first train shall be fitted with all the required equipment at the Rolling Stock Contractor's facility under the supervision of the Running and Stopping assistant system Contractor. Initial Integration tests (static and dynamic) shall be carried out at the Rolling Stock manufacturer's premise's and performed by the test personnel of both Contractors jointly. Further main line integration tests shall be are carried out to ensure all train control functions, which shall be required to be done jointly by both the Rolling Stock and Running and Stopping assistant system Contractors on site in Manila. The test certificate for the on-board equipment shall be issued jointly (and duly signed) by both the Rolling Stock and Running and Stopping assistant system Contractors. As a result of the examination of the first train, if modification occurs, then they shall also be carried out for the remaining trains.

The Rolling Stock Contractor shall provide facilities including a test track for comprehensive static, dynamic, and interface testing between the Rolling Stock and Running and Stopping assistant system systems at their premises. If it is difficult to implement it at their premises, then it is acceptable to use the test line or main line. The Running and Stopping assistant system Contractor shall be responsible for the provision of special test equipment and instrumentation.

The Running and Stopping assistant system Contractor shall provide wiring looms as an intermediate for connection of this cubicle connector and train wiring and externally mounted Running and Stopping assistant system, to be installed by the Rolling Stock Contractor during vehicle manufacture. The Rolling Stock Contractor shall then provide an Installation Report to confirm the completion of the installation works for acceptance by the Running and Stopping assistant system Contractor.

Upon delivery of the Rolling Stock's to Manila, the Running and Stopping assistant system Contractor shall then install the remaining equipment using the pre-wired loom.

Should the need arise for any alterations in the configuration of the respective equipment or systems as a result of the integration test or otherwise, the scope of work and division of responsibility shall be jointly agreed amongst the two Contractors and a detailed procedure developed prior to the introduction of the modification.

All modifications shall be carried out at the Rolling Stock factory before shipment, wherever possible.

18.8 PSD CONTROLLER

18.8.1 PSD Controller Cubicles

The PSD Controller Contractor shall supply the PSD Controller equipment cubicle enclosure(s). All supports, braces, mounting holes, cabling apertures, etc. required for mounting the cubicle and its equipment shall be correctly coordinated between the PSD Controller and Rolling Stock Contractors to ensure secure mounting, and ease of access.

To achieve the PSD control functions, the PSD Controller Contractor shall identify any interfacing circuits specifically required for PSD operation and liaise with the Rolling Stock Contractor.

For train control circuits, the PSD Controller Contractors shall identify any voltage free contacts that are to be provided by the Rolling Stock Contractor, including the number and type of I/O's required between this equipment and the equipment provided by the Rolling Stock Contractor. The two Contractors shall co-ordinate to agree on I/O's and protocols for all such data.

18.8.2 Fixtures and Fittings

The PSD Controller Contractor shall provide the Rolling Stock Contractor with complete mounting details, apertures, fixing holes, etc.

The PSD Controller Contractor shall supply all the mechanical fixing items and cables. Additionally, cables required shall also be supplied in a timely manner.

Also, both contractors shall consider position of on-board antennas to correspond with MCRP, Limited express for MCRP, NSRP-S, NSCR, and MMSP lines.

18.8.3 Power Supply and Earthing Arrangements

Power supply circuits, including positive and negative poles, for this on-board equipment will be provided by the Rolling Stock Contractor. Both Contractors shall co-ordinate and agree the power supply requirements.

The PSD Controller Contractor shall provide the Rolling Stock Contractor with full mounting details, apertures, fixing holes, etc.

The PSD Controller Contractor shall supply the necessary disconnection and terminal blocks, device mounting brackets and plates, flexible conduit assemblies complete with connectors and cables from speed measurement devices to the junction boxes. The ETCS Contractor will supply all the mechanical fixing items. Additionally, cables required shall also be supplied in a timely manner.

The Rolling Stock Contractor shall provide dedicated earthing arrangements for the PSD controller equipment. The PSD controller Contractor shall specify their earthing requirements and impedance values.

The power supply cable between the train power supply and this onboard power equipment shall be as short as possible.

18.8.4 Factory Installation and Testing

All the special equipment associated with this onboard equipment shall be designed by the PSD Controller Contractor and forwarded to the Rolling Stock Contractor's assembly premises. Each contractor shall be aware of the locations of manufacturing plants.

The PSD Controller Contractor shall be responsible for providing all data and training to Rolling Stock Contractor's staff in all aspects of PSD Controller installation and testing where applicable. This on-board equipment shall be installed by the Rolling Stock Contractor, under the supervision of the PSD Controller Contractor's Engineer, including the wiring for the interface of the PSD Controller equipment with Rolling Stock.

The PSD Controller Contractor shall coordinate with the Rolling Stock Contractor for design of all appurtenances. The Rolling Stock Contractor shall provide a report and validate the installation of the PSD Controller Contractor equipment for each train.

The Rolling Stock Contractor shall provide adequate and stress-relieving provisions for the cabling of this equipment after these are mounted to ensure that cables are not fouling, chaffing or unduly stressed with other equipment.

The Rolling Stock Contractor shall be responsible to provide all supports, brackets braces, mounting holes, etc. to ensure proper mounting and to allow adequate access to this equipment.

The PSD Controller Contractor shall be responsible for the testing of equipment (or initial supervision of Rolling Stock personnel until suitably trained), inclusive of its subsequent functional test.

The testing of each car shall comply with the accepted international standards agreed between the two Contractors and with the Engineer.

The first train shall be fitted with all the required equipment at the Rolling Stock Contractor's facility under the supervision of the PSD Controller Contractor. Initial Integration tests (static and dynamic) shall be done at the Rolling Stock manufacturer's premise's and performed by the test personnel of both Contractors jointly. Further main line integration tests shall be carried out to ensure all train control functions, are done jointly by both the Rolling Stock and PSD Controller Contractors on site in Manila. The test certificate for the on-board equipment shall be issued jointly (and duly signed) by both the Rolling Stock and PSD Controller Contractors. As a result of the examination of the first train, if modification occurs, then they shall also be carried out for the remaining trains.

The Rolling Stock Contractor shall provide facilities including a test track for comprehensive static, dynamic, and interface testing between the Rolling Stock and PSD Controller systems at their premises. If it is difficult to implement it at their premises, then it is acceptable to use the test line or main line. The PSD Controller Contractor shall be responsible for the provision of special test equipment and instrumentation.

The PSD Controller Contractor shall provide wiring looms as an intermediate for connection of PSD Controller cubicle connector and train wiring and externally mounted PSD Controller equipment, which shall be installed by the Rolling Stock Contractor during vehicle manufacture. The Rolling Stock Contractor shall then provide an Installation Report to confirm the completion of the installation works for acceptance by the PSD Controller Contractor.

Upon delivery of the Rolling Stock's to Manila, the PSD Controller Contractor shall then install the remaining signaling equipment using the pre-wired loom.

Should the need arise for any alterations in the configuration of the respective equipment or systems as a result of the integration test or otherwise, the scope of work and division of responsibility shall be jointly agreed amongst the two Contractors and a detailed procedure developed prior to the introduction of the modification.

All modifications shall be carried out at the Rolling Stock factory before shipment, wherever possible.

18.9 ELECTRO-MAGNETIC COMPATIBILITY (EMC) / ELECTRO-MAGNETIC INTERFERENCE (EMI) INTERFACE

The contractors for four devices shall provide a list of frequencies and other electro-magnetic sensitive requirements to the Rolling Stock Contractor, to enable them to avoid such frequency bands in their design, and to provide devices to isolate the source of potential EMI emissions whether they are radiated, conducted, or induced wherever required. Conversely, the four equipment Contractor's shall ensure their equipment does not generate spurious or transient frequencies or harmonics, which may adversely affect Rolling Stock apparatus. It may be permissive to discuss each specification among contractors, if necessary. All equipment shall work safely, reliably under electromagnetic and electrostatic interference conditions which shall have the 1,500 V_{DC} traction voltages and any other high voltage Electrical power cables running along the track. The system shall be designed to operate under worst fault conditions.

The Rolling Stock and the four equipment Contractor shall ensure that emissions and immunity levels of their respective equipment's meet the requirements of IEC62236.

The Rolling Stock Contractor shall ensure that the return current in the track at the specified frequencies, if any, does not exceed the values specified by the four equipment Contractor.

All Contractors shall also jointly develop a test plan detailing how the electromagnetic compatibility of Traction, Signaling, Running and stopping assistant and PSD control systems will be verified. All Contractors shall work together to assure that all electronic and electrical equipment on the rolling stock operate correctly without interfering with the other systems and vice versa.

The cable layout in the cable ducts provided by the Rolling Stock Contractor shall be jointly agreed. The separation between Signaling cables and power cables of 1,500 V_{DC}, 440 V_{AC} three-phase, 220 V_{AC} single phase, 100 V_{DC} or any other higher voltage rating shall be in accordance with Japanese practices.

19 CCTV SYSTEM

19.1 GENERAL

Four (4) cameras in each car interior and one (1) camera in operator cab shall be installed and placed in the most optimum locations to capture the maximum view. Operator cab camera shall monitor at least the operator, operator table and in front of the vehicle.

19.2 MONITORING, MEMORY AND TRANSMISSION

The camera images shall be transmitted by the ethernet network or equivalent in the Rolling Stock. For this transmission, the monitor transmission line shall be used and not the control transmission line, but the monitor transmission line or equivalent shall be used.

When the Passenger Emergency Intercom (PEI) is activated, the driver shall be able to view nearby (several) camera image(s) of the activated PEI on TMS monitor in the driver's cab in real time. In addition, the driver shall be able to select specific camera image(s) they want to view.

The data shall also be recorded onto the memory, meaning it can be viewed historically. As a minimum, high definition video quality and a week-long video memory capacity shall be provided.

These all images shall be interfaced with communication system provided by CP106.

The CCTV system shall be reviewed by the Engineer.

19.3 PLATFORM MONITORING SYSTEM FOR PSD OPERATION THROUGH MILLIMETER WAVE

This system shall display images of platform on monitors in cabs, to be capable of overseeing all aperture of PSD. The images of the platform screen door shall be sent from the ground system to on-board system, and those shall be displayed on the driver's cabinet monitor. This system shall be achieved by coordination between CP-107 contractor and CP-106 contractor, though equipment of monitoring system will be basically provided by CP-106 contractor.

CP-107 contractor shall be responsible for installation of equipment provided by CP-106. Interface between monitoring system and Rolling Stock shall be coordinated by both contractors. Requirements for installation of CP-106 contractor's equipment will be submitted to CP-107 contractor by CP-106 contractor. CP-107 contractor shall design around antenna in consideration with utilization of millimeter-wave for transmission between on-board and grand. At the first train, CP-106 contractor's devices shall be installed under CP-106 contractor's instruction.

Rolling stock contractor shall design the interface with monitoring system to be able to control that monitors are lit and turned off according to predetermined speed.

20 (NOT USED)

21 GENERAL DOCUMENTATION REQUIREMENTS

21.1 GENERAL

All documents shall be written in the English language and all drawing in SI/metric units. Documents shall be made in a well-structured manner relevant to the vehicle system.

All documents and drawings shall be supplied in electronic format, with the correct number of prints. Where special software is required in the use/access of the supplied documents/drawings, the corresponding software, all interface programs and hardware shall also be provided. All software/programs that have been custom- designed for this Project shall have no licensing restrictions.

All drawings furnished by the Contractor shall be in accordance with the guidelines to be provided by the Engineer, including but not limited to the following:

21.1.1 Drawing Submittals

1) All drawings shall conform to current industry standards. All drawings shall be supplied in electronic format, the specific format to be reviewed by the Engineer, and with the required number of prints;
2) The drawings submitted shall be of a quality capable of being reproduced clearly;
3) The drawing number and its revision level shall be clearly marked on the drawing; and
4) When revisions are made to drawings resulting in re-submittal, such drawings shall be accompanied by a covering letter detailing the changes made.

21.1.2 Drawings to be submitted for Acceptance/Approval

1) All top-level assembly drawings of items installed on the vehicle in the form of production drawings (dimensioned outline drawings may be considered acceptable upon review by the Engineer);
2) Wiring and interconnecting diagrams or tables for equipment, panels, assemblies and components, etc. requiring connection on the vehicle;
3) Complete schematic diagrams for equipment and systems (electric, air, hydraulic, etc.);
4) Interface drawings (unless all interface information is contained on other drawings);
5) Assembly or outline drawings which show the details of mechanical attachment and electrical connection interfaces;
6) Switch logic diagrams (where appropriate);
7) Performance curves e.g. traction, braking and/or tabulations of equipment, systems, components, etc., and
8) Drawing tree, delineating all major drawings entering into the construction of the vehicles, and indicating construction and system logic.

The Employer through the Engineer reserves the right to review any/all drawings used in the design and manufacture of the vehicles.

21.1.3 General Format

All drawings shall be produced on standard sheet sizes and format as required in the General Requirements or as reviewed by the Engineer.

All drawings shall contain a title block containing the following minimum information:

1) Supplier company names;
2) Drawing title (which shall not be ambiguous);
3) Revision level of drawing, and date of revision (which must be updated for change and then be resubmitted for the Engineer's review);
4) Scale, where appropriate;
5) Number of sheets as "x" of "y"; and
6) Date of released of drawing.

A table of revisions shall be provided for each drawing, which shall clearly show each revision level, the date, and the revision made.

A list of parts and required quantities shall be provided on each drawing, or as a separate bill of material.

A reference table shall be provided for product acceptance criteria.

The drawing shall comply with accepted drawing standards. The Contractor shall state which standard is used in their proposal and quotation.

Two clear areas shall be made available in the title block of the drawing for the Employer's use.

21.1.4 Drawing Requirements

Drawings submitted shall conform to the following minimum requirements in relation to scope, content and format.

These requirements are not intended to restrict the presentation of information and shall be applied as appropriate to the equipment concerned.

Top Level Assembly/Outline Drawing:

1) Scope - to show equipment as supplied, in sufficient detail to determine basic specification compliance; and
2) Content Information.

As a minimum, the content information shall consist of:

1) Important dimensions;
2) Mounting arrangements and their tolerances;
3) Panel, enclosure, frame, etc. construction, material, and finish;
4) Direction of rotation (where applicable), speed or frequency, and amount of unbalance;
5) Location of center of gravity, mass (in full working order), and mass carried at each mounting point;
6) Location and size of grounding straps or grounding facility;
7) Location of servicing features and clearance requirements for removal of all normal service items;
8) Labeling and location of notices and decals;
9) Special mounting instructions;

10) Equipment arrangements, including fastening hardware; and

11) List of parts, which must include the type number of devices as documented by the original manufacturer.

21.1.5 Electrical Information Requirements

1) Operating voltage, power consumption, power factor, and tolerances thereon;

2) Type of windings (for transformers and machines) and type of insulation;

3) Resistance and tolerances;

4) Contact ratings;

5) Operating parameters relevant to the type of device, type and size of cables and wires used;

6) Wire codes, and marking methods of wires and devices; and

7) Indication of color-coding of wire insulation (if used).

21.1.6 Schematic Diagram

As a minimum, the schematic diagram shall consist of:

1) Scope - to show in diagrammatic form how the subsystem equipment, printed circuit boards, etc. function, without regard to the physical location of the equipment or cable routing.

2) Content Information

   a) All circuits contained within the equipment concerned;

   b) Wire identification code numbers;

   c) Vehicle builder/supplier interface terminal code numbers and connector pin numbers;

   d) Trip/rupture current values of all protective devices;

   e) Settings of all pressure, temperature, vacuum float, limit switches, time delay relays, etc. with tolerances;

   f) Values and tolerance of passive components;

   g) Load power consumption;

   h) Circuit voltages (nominal);

   i) Terminal code numbers on polarity sensitive components and subsystems for which a separate schematic is provided; and

   j) Control logic charts and sequence diagrams.

Electrical symbols on schematics and wiring diagrams shall comply with accepted standards. The Contractor shall state in their proposal which standard is used, subject to the Engineer's review.

21.2 DRAWINGS AND DESIGN DATA CHANGES

Prior to the qualification tests, the Contractor must notify the Engineer of any design changes. After the First Article Configuration Inspection (FACI) is approved, any change to any part must be submitted to the Engineer for review, together with an assessment of its impact on performance, reliability and interchangeability.

21.3 ENGINEERING DOCUMENTATION

The Contractor shall furnish three (3) copies in electronic format and all required prints of the latest revision of all necessary contract drawings and documents. Thereafter, the Contractor shall update all subsequent revisions to these documents and shall submit three (3) copies in electronic format and all required prints of all revisions of these controlled documents to the Engineer for review.

The Contractor shall provide six (6) copies in electronic format and six (6) copies of prints of the as-built drawings.

21.4 AS-BUILT VEHICLE SPECIFICATION

The Contractor shall be required to provide an electronic copy and six (6) hard copies of this ERT, updated and modified to reflect the as-built specifications of the train.

21.5 MAINTENANCE MANUALS

21.5.1 General

A fully integrated maintenance manual shall be provided, which shall provide step- by-step instructions on how to maintain, repair and replace all components on the vehicles, down to the Lowest Line Replaceable Unit (LLRU) and working time required for various maintenance activities. It shall be assumed that the technicians performing this work have familiarity with rail vehicles, but not a detailed working knowledge. The LLRU shall be defined, as any component within an assembly that is identified in the Original Equipment Manufacturers (OEM) illustrated parts catalogue and/or is offered for sale by the original equipment manufacturer.

The maintenance manual shall provide all necessary detail to perform the work required, and shall include the judicious use of diagrams, drawings, colored photographs, illustrations, etc., as appropriate for the tasks at hand, including necessary safety precautions. Detailed maintenance and troubleshooting procedures and test and repair procedures shall be provided for all electronic assemblies and circuit boards. Manuals shall identify all tools (special and standard) needed to perform the work. This listing of tools shall be provided in the appropriate sections describing the discrete tasks being performed.

All manuals shall be provided in electronic format, and six (6) prints of properly bound oil and dirt resistant hard copies. The material for the hard copies shall be reviewed by the Engineer.

The maintenance manuals shall be divided into three parts:

1) Running maintenance manual;
2) Scheduled maintenance manual; and
3) Overhaul manual.

21.5.2 Running Maintenance Manual

The running maintenance manual shall describe all work and inspections to be performed on the trains on a routine basis, including servicing, lubrication, adjustments, problem diagnosis, etc. Recommended cleaning procedures shall be provided, including necessary cleaning solutions. A substantial troubleshooting and repair guide shall be included to streamline the process of finding the root cause of problems and providing resolution.

21.5.3 Scheduled Maintenance Manual

The scheduled maintenance manual shall describe all work and inspections to be performed

on the trains according to pre-set time periods or accumulated Km-run and per sub-system structure (i.e. body, bogie, propulsion, auxiliary, ACU, pneumatics, braking, etc.). An appropriate troubleshooting guide and/or parts repair /replacement shall be provided.

21.5.4 Overhaul Manual

The overhaul manual shall describe all work and inspections to be performed on the trains at designated overhaul periods or accumulating certain number of Km-run. An appropriate troubleshooting guide and/or parts repair/replacement shall be provided.

21.5.5 Illustrated Parts Catalogue

The Illustrated Parts Catalogue (IPC) shall enumerate and describe all assemblies and constituent components down to the LLRU.

The IPCs shall be internally arranged in a logical fashion, by system, and shall identify the Contractor's part number and the OEM part number. Additionally, the Contractor shall provide the pertinent information on at least two different alternative suppliers for non-propriety all components. Suppliers must be approved according to the Engineer's review.

Parts common to different assemblies shall bear the same Contractor number. The next level assembly of all parts shall be clearly identified.

The judicious use of cutaway isometric and exploded drawings, photographs, illustrations, etc., shall be used to clearly identify all components down to the LLRU.

Six (6) copies of the IPCs shall be provided in electronic and interactive format, along with six (6) properly bound oil and dirt resistant hard copies. The Illustrated Parts Catalogue shall be reviewed by the Engineer.

21.5.6 Operator Manual

The Contractor shall provide six (6) sets of properly bound, oil and dirt resistant hard copies of operator manual, which shall contain all information required for the proper operation of the vehicles. This shall include general vehicle familiarization material and the location, function and operation of all controls, switches, indicators, gauges, etc.

The operator manual shall also be provided in electronic format, six (6) sets hard copies. The Operator Manual shall be reviewed by the Engineer.

21.6 TRAINING MATERIAL

Attention is drawn to the requirements of ERG Section 14 - Training. The Contractor shall provide six (6) sets of all material used to train the personnel to operate and maintain the vehicles.

The training material and the entire training program shall be reviewed by the Engineer.

The training materials shall also be provided in electronic format and six (6) sets of hard copies.

21.7 VEHICLE HISTORY BOOKS

The Contractor shall provide a vehicle history book for each vehicle at the time of delivery and acceptance. Each vehicle history book shall contain, but not be limited to, the following car-specific information:

1) Certified weight (vehicle and axle loads), including scale tickets;
2) Results summary of all tests performed on the complete vehicle and its systems and subsystems, including certification performed where required;
3) A set of test results for each component or system where these are required;
4) A description of each configuration change from the base-line in sufficient detail for the Engineer's understanding;
5) Configuration record of each assembly, sub-assemblies and major components, including revision number and dates;
6) List of defects noted, status and disposition;
7) List of serial-numbered equipment;
8) List of "as built" drawings with revision status;
9) Axle assembly (wheels, bearings, gears) mounting records, including pressing charts;
10) Provision for the service to record inspection, servicing, overhaul and repair activities; and
11) Shipping documents.

The Contractor shall supply in electronic format and in six (6) hard copies of properly bound oil and dirt resistant hard copies for each car, the full history and configuration records, arranged by component type, assembly, sub-assembly, major component and other serial-numbered components, including spares, test equipment and special tools. The vehicle history book format shall be reviewed by the Engineer.

21.8 INTERVENTION/MODIFICATIONS HISTORY RECORD (DEFECTS NOTIFICATION PERIOD)

The Contractor shall provide a supplemental history record for each vehicle at the time of final acceptance/after the DNP. Each supplemental history record shall contain the following car-specific information:

1) Intervention and repairs during DNP;
2) All modifications/revisions done during DNP;
3) All tests/validation tests report and records; and
4) All component exchange and new numbers.

The intervention/modification history record shall be provided in electronic format, and six (6) sets of hard copies of properly bound oil and dirt resistant. The intervention/modification history record format shall be reviewed by the Engineer.

22 INSPECTION, TESTING AND COMMISSIONING

22.1 INSPECTION

22.1.1 General

The Engineer shall have free access to the Contractor's premises throughout the Contract, for the purpose of reviewing and inspecting the design and manufacturing processes.

The Contractor shall extend to the Engineer or their nominee, full cooperation and provide facilities at its premises and final assembly site to enable convenient inspection of materials, work and equipment.

To initiate this process the Contractor shall arrange for some orientation meetings, whereby the Engineer and Employer shall attend their premises for discussions leading to greater mutual understanding of the Contract.

The Contractor shall bear the cost of attendance in line with that stated in Section 22.1.2.4.

It is anticipated, that the level of support will in accordance with that shown in Table 22.1, below.

Table 22.1 Orientation Trips

N	Attendance	Quantit	Remarks
1	Employer	2 roundtrips*7 days*2 persons	Orientation
2	Engineer	2 roundtrips*7 days*5 persons	

Copies of all design data shall be provided. Design data shall be sufficient to enable the Engineer to review the design, construction, assembly, installation, workmanship, clearance, tolerances, and functioning of all Works. The Engineer shall have unrestricted rights of inspection of all documents, tools, and test equipment to be delivered to the Engineer as part of the Works.

The Engineer shall be at liberty to inspect the manufacturing process at any stage. Without prejudice to any other provision of the Contract, the Engineer reserves the right to reject all materials and workmanship which do not fully conform to this ERT. Repetitious rejections at either a subcontractors' or Contractor's facilities shall be cause for the Engineer to suspend inspection. In such case, the work in question shall also be suspended until satisfactory corrective action is taken by the Contractor.

The Engineer shall have unrestricted rights of inspection of all documents, tools and test equipment.

22.1.2 Inspection Hold Points

1) The Contractor shall propose a structured set of inspection hold points. The hold points shall be structured so that a formal hold point is allowed for each significant element of the car's manufacturing process. At each hold point the Engineer shall hold a formal inspection, or advise that the inspection has been waived;

2) The construction of each vehicle shall not proceed until the inspection by the Engineer has been completed or waived;

3) The Contractor shall propose the inspection hold points within 180 days of the date for commencement of the Works. The inspection hold points shall be submitted for review by the Engineer;

4) No Rolling Stock shall be considered ready for delivery without the Engineer's endorsement in writing. The Contractor shall bear the cost of attendance at the inspections/tests made outside the Country including travel, flight charge (economy class) from Manila to the place where the inspection/test will be made, lodging, local transportation, safety gears, per diem allowance of $100 US each upon landing until the last day of stay on the country of destination, etc., for the Employer's and Engineer's Personnel (attendance). It is expected that five (5) attendances will attend at each inspection/test at fifty-nine (59) times with seven (7) days including travel time for each inspection/test as shown in Table 20.2. If the inspection/test cannot be completed satisfactorily, the additional inspection/test attended by attendance will be arranged and the cost of attendance for such additional inspection shall be borne by the Contractor;

Table 22.2 Inspection Trips

N	Attendance	Quantity	Remarks
1	Employer	59 roundtrips*7 days*3 persons	Type test, FAT, IFAT and FACI
2	Engineer	59 roundtrips*7 days*2 persons	

5) The Contractor shall submit the inspection/test procedure for Engineer review ninety (90) days prior to the commencement of the respective inspection/test activity;

6) The Contractor shall prepare and submit to the Engineer for review two (2) copies of inspection or test report immediately after the completion of each inspection or test;

7) Once the inspection/test and any required remedial actions are completed to the satisfaction of the Engineer, the Engineer shall give a notice of endorsement for unit shipment; and

8) Any unit delivered without the Engineer's endorsement may be rejected at the Site and all expenses thereby incurred shall be borne by the Contractor.

22.1.3 Inspection Prior to Delivery

1) The Engineer/Employer shall be afforded the opportunity of inspecting all cars to be delivered under the Contract before leaving the Contractor's facility and prior to delivery to the Site;

2) The Contractor shall advise the Engineer no less than 15 days in advance of a vehicle being available for inspection; and

3) Once the inspection and any required remedial actions are completed to the satisfaction of the Engineer, the Engineer shall give consent for vehicle shipment.

22.2 GENERAL TESTING REQUIREMENTS

22.2.1 General

The Contractor, in addition to testing for design verification purposes, shall carry out all testing of cars to ensure and demonstrate that the train consist and all its equipment is safe, functional and suitably reliable for revenue service.

The Contractor shall be responsible for all materials, consumables, test equipment, labor and facilities for the test, unless specified differently in writing by the Engineer.

22.2.2 Test Plan

1) The Contractor shall, within 90 days of the date for commencement of the Works, submit for review and concurrence by the Engineer an Inspection, Testing and Commissioning Plan outlining categories and the general quantity of tests to be carried out and

approximate schedule of testing;

2) The Inspection, Testing and Commissioning Plan shall be submitted in accordance with the requirements of the ERG Sub-Clause 1.7.7. The Inspection, Testing and Commissioning Plan shall be separated into two major categories: the Factory Acceptance Test (FAT) and the on-site testing and commissioning;

3) For the submission of the Inspection, Testing and Commissioning Plan, the Contractor shall combine the requirements of design qualification testing, First Article Configuration Inspection, Factory Acceptance Test, on-site testing and commissioning and Trial Operations into one single plan, if appropriate;

4) The Contractor shall, within 180 days of the date for commencement of the Works, submit for review by the Engineer an updated version of the Inspection, Testing and Commissioning Plan detailing:

   a) All tests to be carried out;

   b) Scheduled test dates;

   c) Location of the test;

   d) Function to be tested and requirement to be demonstrated; and

   e) Party responsible for the testing.

5) Without prejudice to any other provisions of the Contract, the Engineer reserves the right to witness any or all tests, and to require submission of any or all test specifications and reports. The Engineer reserves the right to reasonably call for additional tests if considered necessary;

6) The Contractor shall reissue the Inspection, Testing and Commissioning Plan monthly thereafter, updating all information as test scheduling is confirmed and tests are carried out, annotating which tests the Engineer shall witness and which test reports shall be submitted. No test date shall be changed without the Engineer having a minimum of 15 days' notice; and

7) The Contractor shall within 90 days of the substantial completion of the Works submit for review a Commissioning Plan Compendium, recording all testing carried out, functions and performance demonstrated, reports produced and reviewed by the Engineer. This shall include all System Performance Demonstrations.

22.2.3 Testing Details

1) For any tests where the Engineer has indicated that they wish to witness, no testing shall be carried out against a test specification prior to its review by the Engineer;

2) The test specification shall include sample test certificates, design values and also the tolerances;

3) All materials and/or details represented by samples, which are found to be non-compliant, shall be rejected; and

4) The Contractor shall replace any material or detail destroyed in the process of testing.

22.3 DESIGN QUALIFICATION TESTING

1) As part of the design verification process, type tests shall be carried out to demonstrate that the design of the train consist and its systems are in full compliance with the requirements specified in this ERT. The tests shall be completed at the Contractor's manufacturing facility unless otherwise specified or reviewed by the Engineer;

2) The Contractor shall perform an endurance test in accordance to the requirements of ERT Sub-Clause 8.1 - Passenger Side Entrance Doors on the proposed door design to demonstrate that the requirements specified therein are met;

3) The door system shall be endurance tested on a rig in suitable climatic conditions to demonstrate that the door system shall allow the train consist to meet the requirements of this ERT. The rig shall test opening and closing of the door, obstruction detection and re-opening of the door in a combination to simulate likely service operation and shall be submitted for review by the Engineer;Design qualification testing shall be performed on the complete propulsion, braking and TMS systems configuration, using simulated loads on the traction motors. Combined propulsion system testing shall be in accordance with IEC 61287-1 and IEC 61377 or equivalent;

4) Design qualification testing shall be performed on the complete auxiliary power system configuration, using simulated loads. Combined auxiliary power system testing shall be in accordance with IEC 61287-1 or equivalent;

5) Design qualification testing shall be performed for the TMS system to verify designed capacity of the systems, functional requirement and correct interfacing. The real interface hardware and software shall be used where possible;

6) The braking system shall be tested to demonstrate its ability to satisfactorily interface with the train control and signaling systems, and provide performance as specified herein;

7) The parking brake shall be tested to demonstrate its ability to hold a consist on the specified gradient. The test shall record the actual force required to overcome the parking brake in a failure recovery situation on both level track and a 3.5% gradient. The test shall be undertaken at the time of handing over of the Rolling Stock;

8) Before transporting the Rolling Stock to Manila, the Contractor shall perform a test to demonstrate that the emergency and service braking requirements have been met for each design deceleration;

9) The Contractor shall prepare and conduct qualification tests to demonstrate that all other equipment to be supplied shall operate properly within the limits of the environmental and/or physical parameters listed in this ERT. The test shall be undertaken at the time of handing over of the Rolling Stock at the depot; and

10) Running resistance and an energy consumption test shall be conducted during type test.

Any design changes, adjustments, etc., that are required to meet the performance requirements, shall be fully re-tested and documented. All equipment design changes shall be subject to prior review by the Engineer.

For any unit previously qualified, or with a railroad proven service history, the Contractor may request a waiver from performing the qualification test. However, the request for a waiver must be accompanied by a duplicate test report or certification for review by the Engineer in order to satisfy qualification requirements. The waiver request must include justification of the claim that the equipment and test(s) are substantially the same as those in the current qualification requirements.

Only with the written consent of the Engineer shall qualification testing or certification requirements be waived.

22.4 ACCEPTANCE TESTING

22.4.1 General

All cars, sets and consists shall undergo acceptance testing in accordance with the requirements of IEC 61133 or accepted equivalent as a minimum. Acceptance tests shall be completed on every vehicle supplied under this Contract to prove that manufacturing and assembly of the trains have been carried out appropriately. A type test shall be conducted for the first 8-car train set and a routine test shall be completed on every trainset after that.

The tests shall be completed at the Contractor's manufacturing facility as a Factory Acceptance Test (FAT) and on-Site after delivery of the train as on-Site testing and commissioning.

22.4.2 Factory Acceptance Test (FAT)

The Contractor shall perform a FAT to ensure that the various train systems are functioning correctly before shipment of the trains. The tests shall be conducted in the test track and any other special test facilities of the Contractor.

The following tests shall be carried out as a minimum but not limited to:

1) Dimension inspection;
2) Weighing; and balancing the vehicle weight over all eight (8) wheels;
3) Dielectric test;
4) Brake system test;
5) Auxiliary power supply operation;
6) Door system operation;
7) Air conditioning operation; and
8) Water tightness test.

22.4.3 Integrated Factory Acceptance Test

Integrated Factory Acceptance Test (IFAT) to verify the integration of the Rolling Stock with E&M systems; the minimum IFAT being:

1) Rolling Stock – signaling system (wayside / on board); and
2) Rolling Stock – Communications.

The CP107 and CP106 Contractors shall provide an Integrated Factory Acceptance Test plan, to be submitted to the Engineer for recommendation. This shall be the responsibility of the CP106 Contractor.

The minimum integrated interface tests to be carried out include the following:

1) Integrated Factory Bench Test (IFBT) to verify communication and protocols between the electronic control units of the CP107 Contractor and the CP106 systems. This test is to be carried out in the designated factory of the CP107 Contractor;
2) Static integrated factory interface test (SIFIT) to verify the satisfactory mechanical and electrical integration of the train control on-board and the wayside equipment. This test is to be carried out in the designated factory of the CP107 Contractor and supported by the CP106 Contractor; and

3) Dynamic Integrated Interface Test (DIIT) shall be carried out to verify train characterization, response times, stopping distances, stopping accuracy, train control functions, communications and operating modes. This test is to be carried out at the designated test track of the CP107 Contractor and shall include for the provision of interfacing systems of the CP106 Contractor e.g. Signaling, Communications, Power, OCS, etc.

In case of each test for interoperability section, it shall be applied as the above replacing from CP106 to CP NS-01.

Regarding hand over specification around boundary between MMSP section and NSRP-S section, it shall be applied as the above adding CP NS-01.

22.4.4 On-site Testing and Commissioning

During on-site testing and commissioning of the 8-car consists, the following inspections and tests, as a minimum but not limited to, shall be carried out to demonstrate functions. On-site commissioning shall be considered as the completion tests to be performed by the Contractor under the Contract.

1) Post Delivery inspection;
2) TMS operation;
3) Performance acceleration to set speeds;
4) Air system integrity;
5) Air system protective devices;
6) Parking brake integrity;
7) CCTV integrity;
8) Performance of emergency brake from set speeds;
9) Blended pneumatic and regenerative braking from set speeds;
10) Train radio operation;
11) Public Address system operation;
12) Lighting operation;
13) Air conditioning operation;
14) Passenger information display operation;
15) Cab controls, functions and indications;
16) Door control and functionality, per door and all doors;
17) Signaling system operation;
18) Safety critical functions; and
19) Any other routine test demonstrating fulfillment of the requirements of the interface specifications.

Commissioning shall be carried out on all consists supplied under this Contract. For each consist delivered to the Site, the Contractor shall establish an open actions list. The open actions list shall record all actions to be carried out on the train consist, and shall be supplemented as additional actions become known. These shall include:

1) Type, routine, integration and commissioning tests;
2) Fault correction and equipment repairs; and
3) Fleet modifications and defect rectification.

22.5 TRIAL RUN

The Contractor shall undertake a Trial Run which will take place at the completion of the testing and commissioning process. The Trial Run shall be supported by the Engineer and other interested parties.

It consists of operating the newly procured trains, taking into consideration requirements of operating the trains for Revenue Service, but without passengers.

The objectives of the Trial Run shall include but is not limited to:

1) Validation of all interfaces with ETCS systems;
(Conducted in NSRP-S line)
2) Validation of all interfaces with CBTC system;
3) Validation of all interfaces with Running and Stopping assistant system;
(Conducted in NSRP-S line)
4) Validation of all interfaces with PSD controller system;
(Conducted in NSRP-S line)
5) Validation of all interfaces with Radio systems;
(Conducted in NSRP-S line and MMSP line)
6) Validation of train schedule running;
(Conducted over 80km/h in NSRP-S line)
7) Training of Drivers, OCC Staff and line Managers;
8) Emergency exercises; and
9) Station stop precision (including regenerative braking force fluctuation)
(Conducted in NSRP-S line and MMSP line).

As for station stop precision, improvement and trial operation must be continued until a certain standard is achieved. Regarding this improvement, not only ETCS but also coordination with equipment such as a propulsion system, a brake system, a TMS, a brake shoe, etc. shall be made when necessary.

All trains shall run the entire line taking into consideration Revenue Service, without passengers and in accordance with commercial service pattern.

The Trial Run testing shall be more intensive for the first 8-car consist delivered than for all other trains, in order to obtain an intensive benchmark.

Different Test cases shall be developed in normal operation and degraded modes in such conditions that they do not risk disrupting commercial service (simulating different incidents) as follows:

a) Failure during pre-departure tests;

b) Traction mode failure;

c) Train doors fail to close;

d) On-board signaling defects;

e) Rescue of Failed Train; Etc.

A detailed list of Test cases shall be drafted by all interested parties prior to the commencement of the Trial Run. Some of these tests may be an opportunity to close co-ordination with third parties such as Police and Emergency Services, to check any new features of the procured new trains.

During the Trial Run, trains shall be driven by the Contractor's drivers qualified to Sub-Clause 12.1 of the General Specification, under supervision of the OCC and operations managers. Maintenance staff will also witness and support the process for degraded modes, though the Contractor's staff shall also support these.

After completion of all the tests and trial run Taking-Over Certificate will be issued by the Employer.

The Defects Notification Period shall begin upon issue of Taking-Over Certificate

22.6 TEST DOCUMENTATION

All test documentation, procedures, reports and certifications shall be provided with a unique document number and be subject to formal document control procedures.

22.6.1 Test Procedures

The test procedure must state the purpose of the test, and reference the relevant portion of the ERT or standard with which the procedure aims to comply. The test procedure shall clearly define the condition of the equipment and the test set-up (test conditions), and any tests that the equipment must have previously passed. The test procedure must describe in detail the equipment needed to perform the test.

The test procedure must provide detailed, step-by-step instructions as to how the test is to be carried out. This includes results expected and actions to be taken if the expected results are not achieved.

The test procedure shall define the data to be recorded.

22.6.2 Test Reports

The test report(s) shall identify the test procedures in accordance with which the tests were performed, and the reason for performing the tests.

The test report(s) shall describe the specific test conditions encountered compared to those required by the test procedure. If there are any differences, shall be highlighted.

The test report shall provide a detailed description as to how the test was performed, clearly stating if any steps were different than specified, and describing the differences. The test report must provide a rational explanation for any deviations from the procedure.

The test report shall clearly detail the results obtained, and discuss the results in context with those expected.

The test report must provide a conclusion as to whether the test passed or failed.

22.7 INTEGRATED TESTING AND COMMISSIONING

During Integrated Testing and Commission of the railway, the E&M is the lead Contractor responsible for the tests plans, monitoring and test reports, with all interfacing Contractors supporting these activities accordingly.

The CP107 and the CP106 Contractors shall coordinate and submit the following Integrated Testing and Commissioning (ITC) deliverables:

1) Production of an ITC plan, for inspection and testing of equipment that interfaces with other contracts;
2) Coordination with interfacing parties regarding the requirements relating to interface testing;
3) Production of a test schedule of tests, providing full details of all tests to be carried out under the Contract; and
4) Testing procedures to be presented to the Engineer for review.

22.8 TRIAL OPERATIONS

The objective of Trial Operations, is that operational readiness is verified, meaning that full training of operational staff including drivers, emergency-service personnel and others, has taken place successfully, demonstrating that the required railway operational safety, together with the requisite performance criteria in the employer's requirements, has been achieved.

The Contractor shall support the Employer during the Trial Operations which shall take place at the completion of the Testing and Commissioning.

The Trial Operations consist of operating the newly procured trains, taking into consideration requirements of operating the trains for revenue service, but without passengers.

The objectives of the Trial Operations shall include, but is not limited to:

1) Validation of all interfaces with the on-board signaling system;
2) Validation of train schedule running;
3) Training of drivers, OCC staff and line managers; and
4) Emergency exercises.

Different test cases shall be developed in normal operation (checking that new trains can achieve daily timetable without delays and incidents) and degraded modes (simulating different incidents) as follows:

1) Failure during pre-departure tests;
2) Traction mode failure;
3) Train doors fail to close;
4) On-board signaling defects; and
5) Rescue of Failed Train.

A detailed list of test cases shall be drafted by all interested parties prior to the commencement of the Trial Operations. Some of these tests may be an opportunity for close-coordination with third parties such as the police and emergency services, to check any new features of the procured new trains.

23 MATERIAL AND WORKMANSHIP

23.1 GENERAL

All materials used in the construction of the Project shall be new, of first-class quality, consistent with materials commonly used in rail vehicle manufacture. All workmanship shall be high quality and shall conform to the best manufacturing practices in all respects.

All materials, specialties, equipment component parts, and accessories shall be manufactured in accordance with, and shall comply with, the standard or specification of the appropriate national technical or professional society or trade association or Government Agency, to ensure compliance.

All materials shall be marked or stored to be readily identified and shall be adequately protected during handling and storage.

Environmentally harmful materials shall be avoided in the design and manufacturing of the vehicle. This shall include but not be limited to the following materials and chemicals:

1) Ozone depleting Freons;
2) Polychlorinated Biphenyls;
3) Brominated Flame retardant;
4) Formaldehyde;
5) Halon;
6) Beryllium;
7) Lead;
8) Cadmium (except in recyclable batteries);
9) Isocyanates;
10) Asbestos; and
11) Urethane foam.

23.2 FASTENERS

All screws, bolts, nuts and washers shall be in metric configuration and conform to applicable standards and shall be zinc plated, unless stainless steel.

All fasteners of 4 mm diameter or larger shall have coarse threads, except as specified. Exceptions may be permitted, but require review by the Engineer.

All hardware used shall be of the same grade, and shall be at least one grade higher than the stress limit required. Exceptions may only be permitted after review by the Engineer.

Bolts used with nuts shall be the shortest standard size that shall provide at least two full threads through the nut. All high strength bolts and cap screws shall have the head marked to indicate grade. All high strength nuts shall be marked to indicate grade. All bolts, nuts, cap screws and machine screws shall be locked to prevent loosening in service. The locking method shall be subject to the Engineer's review.

The threads of stainless-steel fasteners shall be suitably treated to prevent galling upon installation. All wire ties used shall be of the weather-resistant (black) variety.

23.3 PARTS

Components, plates, shields, or other parts, which may be removed for repair or maintained, shall be interchangeable with other identical items.

Non-maintained components shall be designed for a useful life of 30 years. If, during the warranty period, it is demonstrated that the extrapolated life of any component is less than 30 years, the component must be redesigned and replaced on every vehicle.

All parts shall be free from sharp edges and burrs that might injure persons or damage clothing.

23.4 ELECTRICAL COMPONENTS

All the Electrical Components must be in accordance with the latest provision of Philippine Electrical Code unless otherwise approved by the Engineer.

23.4.1 Terminals

Solderless terminals shall be submitted for the review of the Engineer approved equivalent and shall have sufficient current carrying capacity, de-rated to the anticipated maximum operating temperature.

The use of quick connect ("FASTON") terminals shall not be allowed, except subject to review by the Engineer. When allowed, quick connect terminals must be of brass or phosphor bronze.

Only ring tongue terminals shall be used, except as specifically reviewed and commented by the Engineer.

23.4.2 Wire Insulation

a) Unless otherwise specified, wire insulation shall be one of the following types, unless specifically reviewed by the Engineer:

b) Ethylene Tetrafluoroethylene (ETFE) fluoropolymer having a continuous temperature rating of 150 ℃; Abrasion resistant, filled Tetrafluoroethylene (TFE) with a temperature rating of 260 ℃;

c) Cross-linked Polyolefin (XLPO);

d) All wire insulation, except vehicle body wiring, shall be rated at 600 V minimum; unless otherwise specified or agreed to by the Engineer. Vehicle body wire insulation shall be rated at 2000 V minimum; and

e) Wires 6 mm^2 and smaller shall have the appropriate insulation material as defined above. Wires larger than 6 mm^2 shall be insulated only with cross-linked Polyolefin (XLPO).

23.4.3 Wire Current Rating (Ampere Capacity)

The selection of wire sizes and insulation shall be based on the current carrying capacity, voltage drop, mechanical strength, expected maximum operating temperature and flexibility requirements in accordance with applicable rail industry approved standards.

Maximum wire current rating shall conform to applicable rail industry approved standards. Where conductors are routed in a raceway or cable, the current rating shall be suitably de-rated.

23.4.4 Wire Stranding

Wires stranding and conductor construction shall be appropriate for the application, taking into account wire size, flexing requirements, etc., and shall comply with appropriate rail industry approved standards.

23.4.5 Wiring Prohibition

Pinch screw terminals and solid conductors are specifically forbidden.

23.4.6 Creepage and Clearance

Electrical creepage and clearance shall be adequate for the voltage levels and environment.

23.4.7 Insulation Resistance

The insulation resistance of all wiring shall be designed and tested in accordance with industry approved insulation resistance test and high potential test procedure.

23.4.8 Voltage Segregation

Wires shall be segregated into separate bundles/harnesses and connectors according to the voltage ratings in the following classes.:

a) Line voltage DC wiring;

b) Low voltage AC wiring (Under 600 V);

c) Battery voltage wiring (Under 125 V);

d) On-board signaling systems, Running and stopping assistant system and PSD controller wiring; and

e) Radio, Intercom, P/A wiring.

23.5 ELECTRONIC EQUIPMENT

As a minimum, all electronic equipment shall comply with Electronic Equipment for Rolling Stock (JIS E 5006) for design manufacture and testing and shall use components purchased against an internationally recognized quality.

Electronic components shall only be purchased from suppliers with a minimum Quality Management System (ISO 9001/2) certification or equivalent.

Electronic equipment shall meet the requirements for radio frequency interference and electro-magnetic compatibility as required in ERT Sub-Clause 1.12.1.

23.6 MECHANICAL PROVISIONS

23.6.1 Metals

Metals shall be supplied in compliance with the following material standards:

1) Stainless Steel (JIS G 4305)

2) Aluminum and Aluminum Alloy Sheets (JIS H 4000); and

3) Painted and Baked Aluminum and Aluminum Alloy Sheets (JIS H 4001).

23.6.2 Welding

All welding procedures shall be documented by the Contractor. Approval of the welding procedures shall be as required by JIS E 4047 – design method for arc welding joints of steel for railway Rolling Stock.

The Engineer reserves the right to require the quality of individual welds, particularly in critically stressed areas, to be verified by an approved Non-Destructive Testing (NDT) procedure.

23.7 PAINTS, COATING AND PROTECTION

All surfaces shall be completely free of rust, scale, grease and other foreign material immediately before painting and shall be painted with at least two coats of primer and one finish coat of paint. Areas exposed to corrosive fluids or cleaning solutions shall be protected with coatings resistant to those fluids. The finish coat shall match that of the equipment in quality and color. There shall be no paint applied to hoses and electrical lines. The interior surfaces of equipment enclosures shall be primed and given one coat of insulating paint. There shall be no exposed, unpainted or untreated surfaces on the equipment supplied unless specifically reviewed by the Engineer.

23.8 FIRE SAFETY

The Contractor shall make every possible effort to ensure that all materials used in the construction of the equipment supplied have properties that are not conducive to the propagation of flame, nor to the generation of smoke and toxic gases, consistent with the properties required to perform the service intended.

The Rolling Stock shall comply with all relevant requirements in the Japanese Ministerial Ordinance, MLIT Chapter 8, Article 83 (Countermeasures for Fire of Rolling Stock) .

The Contractor shall provide data pertaining to all relevant tests having been performed on the materials to be used.

The Employer reserves the right to request the Contractor to prove compliance to this specification.

23.9 EQUIPMENT ENCLOSURES

All equipment enclosures installed in locations exposed to outside ambient conditions shall be designed and manufactured to prevent the entry of foreign substances, such as liquids (including water, spilled drinks, vehicle wash over spray, and wheel splash), dust and dirt, oil, or debris.

Enclosures shall be made to IP 55 rating or better.

Enclosures containing equipment, which may produce gases (such as battery boxes), shall be designed and manufactured to ensure that the gases are safely exhausted to outside the enclosure.

23.10 SECURITY, ANTI-SOCIAL BEHAVIOR AND VANDALISM

The vehicle shall be capable of being made secure when stabled without compromising the need to maintain accessibility for emergencies.

The design of the interior body side windows and glazed surfaces shall optimize passenger safety in all foreseeable circumstances.

The modular interior shall be sufficiently robust to minimize damage from foreseeable vandalism and misuse.

Tamper-proof fixing arrangements shall be fitted where necessary. Fasteners shall not be visible or accessible to passengers as far as is practicable.

All interior body side windows and glazed surfaces shall incorporate a means to minimize the damage from vandalism, by etching or scratching.

Internal and external finishes shall permit the easy removal of graffiti by trained personnel using proprietary graffiti cleaning chemicals, and the surfaces shall not readily degrade as a result of the removal process.

The modular interior shall be free from gaps and crevices where litter, sharp objects or any other items could be concealed or lodged. Any equipment fitted behind seats shall be adequately designed to eliminate gaps or hidden voids.

Soft furnishings shall be resistant to damage by sharp objects and be designed to be economical and easy to replace when deemed necessary.

All modular interior equipment within the passenger areas shall be resistant to vandalism.

24 PROJECT MANAGEMENT REQUIREMENTS

24.1 GENERAL

As required in ERG Sub-Clause 1.7.5, the Contractor shall submit a Project Management Plan for the Engineer's review. In addition, the Contractor shall submit the Detailed Works Programs (Project Implementation Program) as required in ERG Sub-Clause 1.7.8 of General Requirements.

24.2 ENGINEERING SCHEDULE AND REVIEWS

It shall be the responsibility of the Contractor to promptly advise the Engineer of any anticipated delays in drawing or document submittal, with the reason for such delays, so that the impact may be assessed, and appropriate measures taken.

At a minimum, design reviews must be conducted on all of the following major systems:

1) CBTC Equipment interface;
2) ETCS Equipment interface;
3) Running and Stopping assistant system Equipment interface;
4) PSD Controller interface;
5) Auxiliary Power Supply Equipment (APSE);
6) Battery;
7) Bogies;
8) Braking equipment, including air compressor;
9) CCTV system;
10) Vehicle body structure;
11) Air compressor;
12) Vehicle interior arrangement;
13) Vehicle roof layout;
14) Vehicle underfloor layout;
15) Couplers;
16) Destination signs;
17) Diagnostic test equipment;
18) Door actuation and control equipment;
19) Driver's cab layout;
20) Gearbox and coupling;
21) Ventilation and air conditioning equipment;
22) Lighting equipment;
23) Oil injection system;
24) PA system;
25) Power collection equipment;
26) Power conversion equipment;

27) Power electronics control equipment;

28) Propulsion control;

29) Radio and communications equipment interface;

30) Seats;

31) Traction motor;

32) Train Management System (TMS);

33) Wheel sets;

34) Windows and glazing; and

35) High Voltage train line.

Conceptual	:	The system and subsystem requirements are finalized.
Preliminary	:	All interface requirements are identified and finalized, such as envelope dimensions, weights, electrical and pneumatic requirements, and functional interactions.
Final	:	Hardware designs are finalized.

24.3 DESIGN APPROVAL PROCESS

The Contractor shall follow the design submission and review process outlined in ERT Sub-Clauses 24.1 - Project Management Requirement and 24.2 - Engineering Schedule and Reviews, and submit the documentation required by Clause 21 General Documentation Requirements. Upon approval of the manufacturing drawings and documentation, the Contractor shall begin manufacturing.

The Engineer's response to the submission shall be made within 45 days of receipt of the submission; however, the Engineer shall endeavor to respond within 30 days, provided that the submission is made no later than the date shown on the design submissions program. The Engineer may extend the review period depending on the amount of documentation accompanying the submission.

24.4 FIRST ARTICLE CONFIGURATION INSPECTION

Prior to serial production taking place, the Contractor shall conduct a First Article Configuration Inspection (FACI), in accordance with a procedure to be reviewed by the Engineer, during which the first component produced shall be subjected to a rigorous test and inspection to confirm that the hardware fully complies with the Contractor's design and manufacturing process requirements. Hardware inspections may take place prior to this point, initiated either by the Contractor or the Engineer, but they shall be considered hardware reviews, and not FACI's.

At the FACI, the Contractor shall make available all pertinent design and manufacturing process documentation, test records, material certifications, etc. Should all the requirements of the FACI not be met, then the inspection shall be considered a hardware review.

Upon acceptance of the FACI by the Engineer, the Contractor is then free to proceed to manufacture all pertinent hardware. The hardware must meet or exceed the quality standards set at the FACI, and must incorporate any comments made by the Engineer at the FACI.

The Contractor is reminded, however, that the installation of any unproved (changed) component or equipment in the vehicle shall likewise be subject to the FACI process.

All hardware entering into the construction of the vehicles shall be subject to the FACI

process.

At a minimum, the following equipment shall undergo the FACI process:

1) On-board signaling equipment interface;
2) Auxiliary Power Supply Equipment (APSE);
3) Battery;
4) Bogies;
5) Braking equipment, including air compressor;
6) CCTV system;
7) Vehicle body structure;
8) Air compressor;
9) Vehicle interior arrangement;
10) Vehicle roof layout;
11) Vehicle underfloor layout;
12) Couplers;
13) Destination signs;
14) Diagnostic test equipment;
15) Door actuation and control equipment;
16) Driver's cab layout;
17) Gearbox and coupling;
18) Ventilation and air conditioning equipment;
19) Lighting equipment;
20) PA system;
21) Power collection equipment;
22) Power conversion equipment;
23) Power electronics control equipment;
24) Propulsion control;
25) Radio and communications equipment interface;
26) Seats;
27) Traction motor;
28) Train management system;
29) Wheel sets; and
30) Windows and glazing.

24.5 SYSTEMS INTEGRATION

The Contractor shall submit a Systems Integration Plan for review. This plan shall describe in detail the means by which the Contractor shall ensure that all systems and subsystems are compatible with each other, and shall work together to satisfy the requirements of this ERT.

24.6 TECHNICAL SUPPORT

The Contractor shall make available experienced maintenance engineers & maintenance staff to provide assistance throughout the whole Defects Notification Period (DNP). All works carried by the Contractor during the Defects Notification Period shall be carried out within the operating schedule maintenance periods.

Assigned maintenance engineers and staff shall have good command of English language.

Access to the depot and to cars by the Contractor's staff shall be controlled by the Engineer. The Contractor shall adhere to all the Employer's working practices, including safety procedures of the Employer.

The Contractor shall provide operation and maintenance training to the Employer, as defined in Clause 14 - Training of the ERG.

Where defects notification maintenance or additional work is required on the cars, the procedure and documentation for the work shall be strictly applied, regardless of whether the work is carried out by the Contractor and/or the Employer.

The Contractor shall provide an office space at the site, from the Commencement Date until the end of Defects Notification Period (DNP), for ten (10) employers, four (4) engineers, and equipped with complete facilities. As a minimum, the office shall be equipped with the following essential furniture/equipment:

1) Tables and chairs for ten persons;
2) Secured locker cabinet (10 units);
3) Telephone line with international direct dial;
4) Fax machine and photocopy machine (latest model heavy duty);
5) Computer with internet connection (ten (10) sets, current model with printers and all peripherals);
6) Air conditioning; and
7) Meeting room with 1 conference table, 10 chairs, white board and bookshelves

All equipment stated above shall be handed over to the Employer after the completion of the depot.

24.7 VEHICLES FOR THE EMPLOYER

It shall be decided in liaison with the Contractor the best arrangement to ensure the following vehicles are available as a minimum up to the point of issue of the TOC. These vehicles may be purchased in accordance with existing laws, rules and regulations, or leased by the Contractor, or a combination of both arrangements, whichever is best suited for the particular situation subject to the Engineer's review. Leased vehicles will go off-hire but any purchased vehicles shall be transferred to the Employer at this time.

1) For the Employer; 5 units – MPV or SUV, Diesel, automatic transmission.

Authorized drivers only shall be allowed to use the vehicles, which shall be well maintained to the appropriate standard.

24.8 WARRANTIES/GUARANTIES

The Contractor shall warrant that the design, materials and workmanship incorporated and used in the production of each system and vehicle shall be free from defects and that system and its related components and apparatus comply with their corresponding specifications and/or relevant Engineer reviewed data and drawings.

Unless otherwise specified, the guarantee period for the following components shall commence from the date of issue of the Taking Over Certificate (TOC), which shall be done after all action items have been closed out on the vehicle on which they are installed.

1) The vehicle body structure (including the underframe and support brackets) shall be guaranteed for not less than ten (10) years;
2) The following equipment shall be guaranteed for an extended period of five (5) years:
    a) Major components of the bogie (bogie frame, axles, suspensions, traction motors, gearboxes, etc.);
    b) Areas painted for corrosion protection; and
    c) Glass.
3) The vehicle batteries shall be guaranteed for not less than three (3) years; and
4) All other vehicle components and system shall be guaranteed for a period of two (2) years.

24.8.1 Responsibility of the Contractor

Under the Warranties/Guarantees, the Contractor shall be responsible, at their own cost and expense (including cost of removal and installation), for the repair and/or replacement of each component or apparatus which, under normal use and maintenance becomes defective or inadequate in the performance of its function during the warranty/guarantee period, or during such period fails to comply with the ERT.

Should the removal or replacement of a failed component or apparatus cause removal or replacement of any other equipment or parts, such work and related cost shall be borne by the Contractor.

The warranty/guarantee covering any component or apparatus repaired or replaced by the Contractor shall be renewed for a period equal to the period of the original warranty/guarantee effective as of the day when such repaired/replaced part was installed. If the failure is found to affect any other component or apparatus, the renewal of the warranty/guarantee shall also be extended to cover the components or apparatus so affected, and shall start as of the date the interrelated components and apparatus function was restored.

24.9 MAINTENANCE MANAGEMENT SYSTEM

As required in item 6 of Table 1 of Appendix B to the ERG, the Contractor shall support the Maintenance Management System (MMS) development by the CP106 Contractor. The Contractor shall coordinate and agree with the CP106 Contractor and provide the necessary required data for the MMS.

25 QUALITY ASSURANCE REQUIREMENTS

25.1 GENERAL

The Contractor shall submit a Quality Management Plan for the Engineer's review and acceptance as required in Sub-Clause 1.7.1 of the General Requirements. The plan shall delineate the responsibilities of the Quality Assurance organization in the Contractor's company, including personnel reporting arrangements.

This plan shall describe the Contractor's quality assurance organization, including the names of personnel to be assigned to the Project, and shall describe the responsibilities of each separate unit and their contribution to the Project. In particular, the plan shall describe the quality organization's involvement and influence at all stages of the Project.

In the plan, the Contractor shall describe the means by which the Contractor shall utilize the quality assurance organization to adequately control all in-house work, and that of major suppliers and sub-suppliers, including ensuring their adherence to the requirements of this ERT.

The Contractor's Quality Management Plan shall also describe the procedure to be used to ensure that the First Article Configuration Inspection (FACI) process is controlled, and that series production does not take place until the product has been accepted by the Engineer. Also, to be included is a thorough description of the means used to control engineering changes and field changes.

25.2 CONFIGURATION CONTROL

In order to control the vehicle configuration, the following requirements shall be adhered to for all changes to all equipment following First Article Configuration Inspection (FACI).

25.2.1 Design Changes

The Contractor shall submit design details of the change proposed to the Engineer for review and determination. In some cases, at the discretion of the Engineer, a simple verbal explanation shall be sufficient for preliminary review and acceptance. In all cases however, a written explanation shall be required for final acceptance.

The written explanation shall take the form of a Field Modification Instruction (FMI) or service bulletin, together with updated engineering drawings.

Before any modifications are made to vehicles, the FMI and design details must be reviewed and accepted by the Engineer.

The format and content of the design change notice is the responsibility of the Contractor to determine, based on the Contractor's normal method of operation.

Only with the express approval of the Engineer shall the above procedure be waived. The Contractor shall submit to the Employer for review a monthly listing of all active design change requests and their implementation status.

As a minimum, the design change request shall contain the following information:

1) Description of subject;
2) Reason for change;
3) List of related documents;
4) The supplier & manufacturer part numbers, serial numbers, quantities and location of

affected parts or assemblies;

5) The parts required to make the change;
6) The effect of the change on interchangeability;
7) Special tool requirements;
8) Material disposition (rework, scrap, etc.);
9) A detailed procedure for making the change;
10) Test equipment required; and
11) Test procedure.

25.3 PART NUMBERS AND SERIAL NUMBERS

The Contractor shall permanently identify all hardware components to the lowest level of repair and replacement. The hardware identification marking shall at all times coincide with the officially released engineering data.

Major assemblies and subassemblies shall be assigned individual serial numbers. Duplicate serial numbers shall not be used within a type or model series. The serial number shall be marked on the equipment nameplate.

26 SPARE PARTS AND SPECIAL TOOLS

26.1 GENERAL

The Contractor shall provide spare parts, special tools as specified in both the General Requirements as well as this clause.

Prior to the issuance of the Taking Over Certificate (TOC), the Contractor shall deliver the spares and consumables, special tools and diagnose test equipment to the Site.

26.2 SPARE PARTS

The Contractor shall provide a list of capital spares, unit exchange spares and consumables (spares and consumables) and supply for the Defects Notification Period (DNP).

The Employer may order additional spares required for the following 15 years from the recommended spare parts and consumables list as provided by the Contractor.

The Contractor shall provide a complete listing of spares and consumables to be supplied, including the following information:

1) Contractor part number;
2) Original equipment manufacturer part number; and
3) Part description.

An indicative list of spares and consumables which may be required is given in the list below.

List of Capital Spares for Rolling Stock to be Supplied by the Contractor

The Contractor shall provide the required number of each unit equivalent to two vehicles set of the below listed major parts, assemblies/sub-assemblies.

1) Motor Bogie Assembly;
2) Trailer Bogie Assembly;
3) Wheel and Axle Assembly for Motor;
4) Wheel and Axle Assembly for Trailer Bogie;
5) Wheel Assembly;
6) Bogie Frame for Motor Bogie;
7) Bogie Frame for Trailer Bogie;
8) Primary Suspension;
9) Secondary Suspension;
10) Brake Disk Assemblies;
11) Gearbox Assembly;
12) Flexible Coupling Assembly (link for Gear box and Traction Motor);
13) Traction Motor Assembly;
14) Current Return Assembly;
15) Air Compressor Assembly;
16) Air Drier for Compressed Air;

17) Pantograph Assembly;
18) Arrestor Assembly
19) Air Conditioning Unit Assembly;
20) ACU Compressor Assembly;
21) Roll Filter of ACU (24cars);
22) Ventilation system Assembly;
23) Filter of ventilation (if needed, 24cars)
24) Unit Brake Assemblies;
25) Evaporator Blower Assembly;
26) Air Conditioning Unit (ACU) Control;
27) Battery Set;
28) Battery Contactor
29) Auxiliary Power Supply Equipment;
30) Replaceable Circuit Boards for (APSE);
31) Main Control Device (PCE);
32) Replaceable Circuit Boards for (PCE);
33) Major sub-assemblies of Main Control Devices;
34) Master Controller (Rate Controller);
35) Master Controller (for intermediate car);
36) Cab Console Assembly;
37) Cab Switch Panel;
38) Cab Relay Board;
39) Jumper and Cable Assemblies;
40) Main Circuit Breaker;
41) CCTV Assemblies;
42) Semi-permanent Coupler and Draft Gear;
43) Slewing Ring;
44) Destination Sign Assembly;
45) Door Actuator;
46) Door Controller;
47) Interior Panel;
48) Windows;
49) Windscreen;
50) Passenger Door;
51) Cab Side Door;
52) Cab Saloon Door;

53) Passenger Seats;
54) Drivers Chair;
55) Panels of Cab;
56) Interior Lights;
57) Exterior Lights (head light, brake light, etc.);
58) Wiper Assembly;
59) Washer Tank;
60) Horn Assembly;
61) Train Management System;
62) Glass of Windows and Doors;
63) Flooring Material;
64) High voltage train line Assembly;
65) Oil injection system Assembly;
66) Power Electronic Control Equipment (PECE);
67) Brake Control Unit (BCU); and
68) Any other items.

The final list however, shall be determined after the design review has been concluded.

26.2.1 Spares Parts and Consumables Required During the Defects Notification Period

The Contractor shall supply the spares and consumables to service the trains during the DNP.

In case any of these spares and consumables are used during the DNP, they shall be replenished immediately at no extra cost to the Employer.

Immediately after the DNP, the Contractor shall handover to the Employer additional spares and consumables required, if any, to complete the total of these items, as per the list.

If any additional spares and consumables including parts replacement, which has not being listed, become necessary during the DNP, the same shall be added to the list and shall be provided by the Contractor, along with two additional sets for any further requirement at no additional cost. The cost for the same shall be deemed to have been included in the Schedule of Prices.

26.2.2 Spares Parts and Consumables Required After the Defects Notification Period

The Contractor shall submit a list of recommended spare parts and consumables deemed to be required in the course of normal train operation after the DNP.

The list shall quote the unit rates with guaranteed prices valid up to one year after the completion of the DNP, but after this, all price escalation shall be considered but the Contractor shall give an escalation formula to be applied to the quoted price, in case spares are ordered later than one year after the completion of the DNP.

The recommended spare parts list shall be reviewed and finalized based on the experience of operation of the train service in the first year of DNP.

26.2.3 Guaranteed Period of Spare Parts

The Contractor shall guarantee the availability of Capital Spares, Unit Exchange Spare Parts and Consumables for a period of not less than 15 years from the date of completion of the DNP. Where parts/items were sourced from a subcontractor and/or other manufacturer; the Contractor shall secure and submit to the Employer a similar guarantee, equally binding to the Employer, for spare parts availability from the respective Subcontractor/Manufacturer, for all the Works.

Should the manufacturing of the listed parts, spares and consumables be discontinued due to unavoidable circumstances, before the end of the 15 years guarantee period, the Contractor shall give sufficient notice to the Employer of such intention. The Employer shall be given sufficient opportunity of ordering such quantities of spare parts the Employer may require prior to close-down of production.

Should circumstances beyond the Contractor's control prohibit the Contractor complying with the above obligations, the Employer shall by default be entitled to the following, but not limited to:

1) Manufacturing drawings;
2) Specifications;
3) Patterns; and
4) All other relevant information in respect of each spares item affected.

This is to enable the Employer to make or have made such spare parts.

Under the aforesaid circumstances, the Contractor shall also grant to the Employer, without payment of any royalty or charge, full right and liberty to make and have made such spare parts and make copies of such drawings, patterns, specifications and other information, provided it is for exclusive use of the Employer and only for the Project covered under this Contract.

26.3 SPECIAL TOOLS

The Contractor shall provide a sufficient number of special tools required, to enable the Employer to properly maintain the trains. These tools shall include, but not be limited to special assembly/disassembly jigs, test benches, simulators (as applicable) handling tools, equipment mounting/dismounting tools, diagnostic test equipment for all electronic assemblies, test stands and simulators as may apply, interface hardware & software, hook-up lines/cables to test all train line systems, and other tools considered particular to the vehicle and its equipment. The number of tools required to be supplied shall be as reviewed by the Engineer.

26.4 DIAGNOSTIC TEST EQUIPMENT

The Contractor shall provide diagnostic test equipment to ascertain the functionality of all discrete pieces of specialized equipment. This equipment shall consist of embedded fault monitoring and diagnostic systems, portable test equipment and shop test equipment.

The portable test equipment shall consist of a suitable number of pre-programmed laptop computers and standard cable connectors, as reviewed by the Engineer. The Portable Test Units (PTU) shall be connectable to the equipment to be tested, allowing faults to be quickly and easily diagnosed and allow data download and analysis.

Connection points shall be provided both on the inside and exterior of the cars, as required, in order to be able to quickly diagnose faults with associated systems. The location of these

points shall be reviewed by the Engineer.

Portable test equipment shall be provided for each major vehicle system including all interface software and hardware. Test capability shall include, but not limited to, measurement of major vehicle parameters, such as line current, line voltage, traction current, tractive effort, speed and others, both in static and dynamic conditions.

The shop test equipment shall consist of at least one set of test benches for each major vehicle system, or simulator, as may be applicable, whereby the equipment to be tested is removed from the vehicle and loaded onto the test bench. The test equipment shall allow all faults to be easily and quickly diagnosed. Each test unit shall be completely wired and shall use 220 V ac, 60 Hz single phase power and compressed air, as may be needed.

The Contractor shall provide sufficient number of items of this test equipment to allow the Employer to properly maintain and repair the trains. The number of test equipment items shall be reviewed by the Engineer, based on an operational analysis to be performed by the Contractor.

The Contractor shall be required to maintain the equipment software throughout the DNP and handover the same at the end of the DNP. As part of the diagnostic test equipment, the Contractor shall provide the following:

1) Complete operational manual, schematic diagrams, maintenance and calibration instructions for the equipment, including printed circuit boards and microprocessors;
2) Complete schematic diagrams and maintenance and calibration instructions for the vehicle-borne system and its printed circuit boards directly associated with the diagnostic test equipment;
3) Spare parts and consumables;
4) Five (5) sets of replacement cable and connector assemblies and a suitable amount of interface hardware for each piece of test equipment;
5) Any other parts/item necessary or required to complete the diagnostic tests; and
6) An external re-loadable software (in CD or USB) as back-up installer shall be made available in case the PTU/laptop software for diagnostics become corrupted.

There shall be no restriction (license) in the usage of the re-loadable software.

The cost for any licensed software renewal for the diagnostic test equipment and the portable test units will be under the Contractor's cost for a period of not less than 15 years from the date of completion of the DNP.

26.5 MAIN SPECIAL TOOLS AND DIAGNOSTIC TEST EQUIPMENT

The main Special Tools and Diagnostic Test Equipment is listed, but not limited, as follows. The below Tools and Equipment shall be introduced to MMSP Depot.

Table 26.1 Main Special Tools and Diagnostic Test Equipment

ID	Name
Light repair	Safety device tester
	Event recorder reader
	VVVF log reader
	Brake control unit log reader

ID	Name
	Rewriting device for internal display system
	Rewriting device for external display system
	Rewriting device for public address system
	Brake-pad replacement tool
	Recovery of derailment equipment
PTU	VVVF
	BCU
	ACU
	Doors
	TMS
	APSE
Bogie removal	Radius arm gauge
Traction Motor	Motor disassembling/reassembling tools
	Coupling extractor
	Non-disassembling bearing exchange special tool
Bogie	Bogie disassembling/reassembling special tools
	Lock bolt for axle spring
Tight lock coupler and draft gear	Special tool for draft gear
Air Conditioner	Special tool for air conditioner overhaul
	Refrigerant extractor
	Refrigerant filler
	Gas leak tester
	Cleaner for special parts
Electric Shop	HB tester
	High voltage device tester
	Contactor tester
	Solenoid valve tester
Electric Shop	Electronic relay tester
	Door operating device tester
	Safety device tester
	Event recorder reader and analyzer
	Failure data reading device
	Train radio tester
	Speed sensor tester
	VVVF inverter tester
	VVVF log reader
	Cleaner for special parts
Bearings	Special tool for bearing overhaul
Spring, Air Spring & Iron work	Special tool for air-spring overhaul
	Special tool for damper overhaul
Air Brake valve	Brake test equipment
	Brake control unit log reader
	Special tool for air valve overhaul
	Special tool for compressor overhaul
Final adjustment	Safety device tester
	Event recorder reader

The final special tools and diagnostic test equipment list shall be determined after the Operation and Maintenance (O&M) Manuals have been concluded.

If any additional special tools and diagnostic test equipment are identified during the development of the (O&M) Manuals, those items shall be added to the list proposed during the Bid and shall be provided by the Contractor. The cost for the additional special tools and diagnostic test equipment shall be deemed to have been included in the Schedule of Prices.

27 TRAIN OPERATION SIMULATOR

27.1 GENERAL

A train operator shall be provided in order to establish a high-quality approach for driver training and route familiarization. It is essential to get the required number of train drivers ready prior to the taking-over of MMSP. They may be newly trained and/or converted from the existing lines. MMSP differs from the other existing lines not only geographically but also in the sense of the signaling system which shall be applied in the Project. Accordingly, these drivers have to be familiar with the new line profile and the newly applied signaling system before the inauguration.

In addition, drivers shall be trained in countermeasures for emergency case such as Rolling Stock faults, signaling faults and railway bogie faults, etc.

27.2 REQUIRED MAIN FUNCTIONS AND PERFORMANCE

27.2.1 Environment Simulation

A virtual reality environment shall be provided, such as running sound generation. Wayside visual systems with wide LCD monitor shall be provided. Artificial wayside landscape data (approximately 36 km, approximately 16 stations and Depot) shall be provided; after taking-over of the main line, wayside visual data shall be modified to be real. In addition, cab side views shall be provided using "Picture in Picture technology" for driver's confirmation regarding train stop position.

5 kinds of weather shall be simulated and be available to be chosen for use: Sunny, Cloudy, Rainy, Misty and typhoon. 3 kinds of time range shall be simulated and can be chosen: Daytime, Night-time and Twilight. Sounds shall be simulated and can be chosen: rail friction sound, rail gap sound, emergency brake sound, inverter sound, turnout passing sound, crash sound, wind/rain/thunder sound and horn sound, operation control command voice according script, and etc.

The simulator shall have the capacity for adding any Phase 2 alignment and station details.

27.2.2 Driver Console and On-board Equipment Simulation

Instruments, displays, lamps, switches, handles and on-board equipment in the driver's console shall be the same hardware as the actual ones, as much as possible. The reaction of moving the handles shall simulate the same effect using the visual image generator, sound generator, signal monitor, meters and lamps compared to the real driving environment.

Door opening/closing shall be simulated with the same hardware equipment as actually used on the train.

27.2.3 Driver Training

The Train Operation Simulator shall allow the drivers to be trained under the simulated situation not only for regular operation but also abnormal situations such as Rolling Stock failures, signaling failures and railway bogie failures, etc. Hereinafter, training scenario shall mean a combination of route settings, environment settings, and events. The simulator shall be capable of providing the following training with its scenarios.

a. Routine works at the stabling yard before running on the main line

Step1 Understanding cab layout, alignment, and role of cab equipment

Step2 Prior check before operation

* This sequence shown below are just a case. It shall follow the real train designs.

1) Driver's key

2) Miscellaneous switches ON/OFF

3) 1. 100 V dc initial power ON

   2. Initial indication, meter, gauge check

   3. Train Management System display check including Time and date check

4) Initial setting TMS and on-board signaling system

   1. Train number

   2. Destination

5) Communication function checks

   1. Radio model and Cab/OCC model

   2. Public Address, inter-communication,

6) Wiper and horn

7) Door opening/closing

   1. Passenger door (PD)

   2. PD re-opening/re-closing

8) Passenger Information Display

9) Lighting switches ON/OFF

10) Air conditioning control

   1. Mode selection

   2. Temperature setting

   3. Cab air conditioning control

11) Brake function check

12) Propulsion function check

b. Routine operation under various operation modes

Step 3 Daily routine work

1) ATO Operation

2) Manual Operation

   1. ATP Operations (ATP, ROS and RM)

   2. Shunting to mainline (Depot ATP and manual)

   3. Main line shunting and turn-back at the terminal station

3) Washing mode operation inside the depot

4) Shut down and store Rolling Stock

c. Artificial incident response and recovery action such as cutout and report

27.3 SUBSYSTEMS OF TRAIN OPERATION SIMULATOR

Subsystems of the train operation simulator shall be typically categorized as seen below and the functions and performance shall be defined and specified on each subsystem.

1) Simulated driver's cab;

2) Display system;

3) Computer unit;

4) Instructor's console;

5) Train door

6) PSD

Step 4 Response to artificial incident

1) Failure and cutout

1. Traction, braking
2. Air compressor and low pressure
3. Air conditioning unit
4. Passenger door
5. Low voltage
6. TMS
7. ETCS
8. CCTV
9. PSD

All items shall have situations regarding no work, no response, failure indication, power down (breaker off) and black out

2) Traction unit cutout

3) On-board signaling system, telecom failure or error, manual braking

4) Brake not released and cutout, parking brake not released and cutout

5) Station or OCC request emergency stop, departure stop signal from OCC

6) Passenger emergency call response and CCTV check, OCC call

7) Wayside facilities down

1. 1500 V dc power supply (include power wire catch object or power wire cut down)
2. Wayside signal system (mainline and depot)
3. Object against train in track

8) No CBTC clearance,

1. Running on site mode (no radio locally)
2. OCC manual clearance.

9) Passenger door issue

1. opened manually
2. emergency button pushed

3. passenger injured

4. door opened when train runs

5. emergency buzzer work soon after train started

10) Passenger evacuation

1. Passenger door opening with fire alert*)

* Fire detected when train running, train stopped in station, PSD not work

11) Rescue operation, back operation (water flood in track)

12) Terrorism (fire, smoke, no power, and panic), station own train or other train vandalism.

13) hand stop sign (from station staff, track worker, and passenger in platform)

14) PSD trouble (no communication with train, all PSD doors error, one PSD door error, PSD keep detecting jammed object, train door pinched object without PSD detection,)

15) destination indicator signal shows wrong direction

16) worker go into train front from invisible place in depot

17) derailment

27.4 REQUIRED SUBSYSTEM FUNCTIONS AND PERFORMANCE

27.4.1 Rolling Stock Cab (Driver Console subsystem)

Cab equipment, driver's console desk, layout, and operation-related provision shall be the same as the actual ones as much as possible. Equipment is provided by the CP107 Contractor and CP106 Contractor on this Project. In addition, speakers for simulated sounds, and cameras to monitor trainees shall be installed. One set of doors shall be installed near around of the driver's cab and will be controlled with a door switch.

27.4.2 Visual Image Display subsystem

A visual image display subsystem shall be installed in the front of the driver's console and to show the simulated view of the driver. Monitor shall be mounted upon the cab. 3 views for checking passengers getting on and off (cab CCTV monitors) shall be simulated as pictures in picture on the main monitor. The Specification is shown below.

a) Monitors 1 set of around 45-inch monitor; and

b) Resolution more than 1920×1080.

27.4.3 Computer Unit

A computer unit shall be provided which connects each subsystem, and generates visual image/sound in accordance with training scenario or driver/instructor's command. The computer unit consists of visual image generators, TMS control unit, amplifier and central processing unit, and UPS. The Specification is as follows:

a) UPS capacity: Only for shutdown/reboot of the Central Processing Unit.

27.4.4 Control and Monitoring Subsystem

This subsystem enables the instructor to monitor each subsystem and control sequences such as start/stop, initial condition set, reposition, temporary pause, visual control, malfunction set, and emergency set. This subsystem also has the function of mirroring the TMS monitor and on-board signaling system monitor, communication system (which is wired to the instructor's telephone handset), speaker system generating the same sound as when train is in use, and monitoring cameras installed in the driver's cab. Facilities available:

a) Record and playback function

The instructor's console has a record and playback function. This function records the front image of the driver along with video image of driver's operations, and displays it later on the same monitor. Maximum recording time is assumed to be less than 30 min.

27.4.5 Train Door

One set of doors shall be installed near around of the driver's cab and will be controlled by a door switch. The doors shall have pinching sensor, emergency door open handle and door closed indicator.

27.4.6 Platform and Displays Simulating Platform Image Subsystem

One set of full height PSD doors shall be installed near around of the driver's cab and front of train doors. The doors shall be controlled by a train door switch and/or its control panel. The doors shall have pinching sensors, emergency door open switch, and evacuation mini door.

27.5 MAJOR EQUIPMENT OF THE SIMULATOR

The related parts and equipment shall be basically the same as in the real cab. The detailed equipment list is shown below.

Table 27.1 Major Equipment of the Simulator

System	Description	Qty.	Remarks
Simulated Driver's Cab	Body	1 set	Approx. 3 msq Cab
	Cab seat	1 set	
	Train doors (Passenger side door system)	1 set	Passenger door manual release mechanism (inside and outside) is included
	PSD doors	1 set	Passenger door emergency open switch, control panel and mini evacuation door is included
	Passenger emergency call system	1 set	
	Driver's console	1 set	Master controller; buttons; switch panels; TMS unit; signal monitor are included
	Handy talks (PA, PEC, and Driver/Trainee)	1 set	Connect to Instructor's Console
	Sound system	1 set	Simulated PA system and radio system; speaker (inside and outside) are included
	CBTC equipment	1 set	Information from the CP106 (signaling) Contractor
	ETCS equipment	1 set	Information from the CP NS-01 (signaling) Contractor
	Running and Stopping assistant system	1 set	Information from the CP NS-01 (signaling) Contractor
	PSD controller	1 set	Information from the CP NS-01

System	Description	Qty.	Remarks
			(signaling) Contractor
	Camera	1 set	For instructors to monitor
Display System	LCD monitor	1 set	Or additional 3 sets as CCTV monitors, if necessary
Computer Unit	Visual Image generator	1 set	For display system
	Visual Image generator	3 sets	For CCTV monitors, if necessary
Computer Unit	TMS control unit	1 set	
	Central Processing Unit	1 set	
	Amplifier	1 set	
	Instructor's computer	1 set	
	Rack, flame	1 set	
	Hub	2 sets	
	UPS	1 set	
Instructor's Console	Front Image monitor	1 set	For monitoring Driver
	Monitoring camera monitor	1 set	Mirroring the driver cabin monitor
	Communication device	1 set	Wiring to Handy talks in cabin
	Signal control system	1 set	
	Control device for instructor	1 set	Including monitor, printer and switches
	Instructor's console desk and chair	1 set	
Recorder		1 set	If necessary
Others	Transformer	1 set	Necessary amount
	Cable, Server rack	1 set	Necessary amount

Spare and expendable parts shall be provided according to the following table;

Table 27.2 Spare and Expandable Parts

Description
Monitor
Processing Unit
Other electrical parts
UPS
Cab parts (master controller, handle, switch)
Door parts (drive units for each doors
Other mechanical parts

27.6 LANGUAGE

All subsystems and manuals of the Train Operation Simulator shall be produced in English.

27.7 SOFTWARE INSTALLATION AND UPGRADE

1st stage: Artificial landscape visual data 6 months before main line first taking-over 2nd stage; Real wayside visual data shall be installed by the Contractor, it is preferable after taking-over of the all main line

27.8 DESIGN LIFE

The design life is eight (8) years after completion, visual devices and central processing unit shall be replaced to maintain its performance. 15 years after completion, all systems shall be replaced. The Contractor shall use parts which match the above design life.

27.9 PERIOD OF DEFECTS NOTIFICATION

The Contractor shall have the Defects Notification Period for 2 years upon issuance of TOC. Regardless of the above mentioned, the Defects Notification Period shall be not less than 1 year after hand over. Whichever comes later shall be applied.

27.10 INSTALLATION REQUIREMENTS

27.10.1 Locations

The train operation simulator shall be installed in the designated place.

27.10.2 Condition

Train Operation Simulator must be designed for the condition shown below.

- Temperature 16 – 36 °C (operation), 0 – 40 °C (reservation)
- Humidity 40- 70%
- Dust same level ISO6 in ISO 14644-1d

27.10.3 Power supply

Single phase 230 V ac electricity shall be provided for the train operation simulator in the PRI. The electric consumption of the train operation simulator is assumed to be less than 13.8 kW. A transformer shall be provided by the Contractor, if necessary.

27.11 TEST OF TRAIN OPERATION SIMULATOR

The Contractor shall submit a plan for testing and commissioning the Train Operation Simulator, as well as the test specification for the Engineer's review. Training of operation staff shall be completed two months prior to the commencement of the first train's running test. The number of staff and schedule shall be specified in due course. Major testing items after installing the equipment and software are as follows:

1) Visual check and safety inspection;
2) Grounding circuit, insulation resistance check, and dielectric test;
3) Visibility and brightness of the screen;
4) Equipment allocation;
5) Power ON, indication, electric meter, gauge check;
6) Equipment operability;
7) Function check;

8) Electro-Magnetic Interference check; and

9) Vibration, sound level check.

27.12 STAFF TRAINING

The Contractor shall supply the train operation simulator. The simulator is a tool for operation staff to study the operation procedures in a virtual reality environment. After handing over the simulator, the Contractor shall have its commissioning engineers on stand-by during the experimental train running period and to train the Employer's instructors about the way to operate and maintain the simulator as well as how to install and modify the software. Its time length of training period for instructors of the railway operator to be able to use simulator shall be not less than 1 month.

27.13 SUBMITTING DOCUMENT

The Contractor shall provide the operation and maintenance manual of the simulator written in English. The simulator maintenance manual shall include the following but not be limited to: schematic/electrical diagram, illustrated parts catalogue, and spare parts (complete with description and part nos.).

28 TRAIN PART MODELS FOR EDUCATION

28.1 GENERAL

A train part models shall be provided in order to establish a high quality approach for understanding maintenance of trains.

There are two training organizations in MMSP depot. One is the Training Center of this project as a department of this subway operator, the other one is the Philippine Railway Institute as the governmental training school to get railway staff license. All employees in railway operators shall get license first in PRI, then they will learn in training center of each railway operator.

In PRI, the students have to know "What is train" to get license, then they have to be familiar with the technologies and structures of the train parts using parts models in TC before starting their maintenance work.

28.2 REQUIRED GENERAL FUNCTIONS AND PERFORMANCE

28.2.1 Part models appearance

Self-standing train part models shall be installed in PRI and TC.

These models shall be the same hardware as the actual ones, as much as possible.

For these models shall be held by its display base to be fixed well even if there is an earthquake.

28.3 PART MODELS FUNCTIONS AND PERFORMANCE

The part models shown below shall be installed in PRI by the Contractor,

1) Pantograph and its fuse;
2) High speed breaker for main circuit;
3) Induction motor;
4) Brake and pneumatic system; and
5) Bogie.

Also, the part models shown below shall be installed in TC by the Contractor,

1) Induction motor;
2) High speed breaker for main circuit; and
3) Brake and pneumatic system.

For fuse, High speed breaker, Induction motor, brake and pneumatic system, these models shall be displayed in state that the structure inside can be seen.

For Pantograph, high speed breaker, brake and pneumatic system, bogie shall be worked an elementary function when user input a signal such as "push a button".

28.3.1 Brake and Pneumatic System

The model shall have compressor, air resolver, brake unit, master pressure valve, brake pressure valve, brake cylinder, brake pad and small cut wheel. And also have a step switches, a cutoff switch. The system has two functions which simulate "service brake" and "emergency brake". When user changes a step switch, service brake shall be worked. Also set cutoff switch as off, emergency brake shall be worked. At the same time that students understand the basic

functions of brake system, also will understand the dangerousness regarding pinching finger between wheel and brake pad. For keeping this demonstration safety, the gap shall be covered clear panel. One system shall be installed in TC, the other shall be installed PRI. In PRI, the system shall be embedded as a part of bogie model.

28.3.2 Bogie

The model shall have one bogie frame, four springs, four wheels, two axles, four bearings, two gears, two air suspensions, one motor and 4 m rail track. The bogie-set shall be installed upon the rail track. Rail track shall have rail sleeper and rail bed. The bogie set shall have all parts same as main line trains, however 1 motor shall be lacked to support student's understanding the structure of coupling gear.

28.3.3 Major Equipment of the Train Part Model

The related parts and equipment shall be basically the same as in the real train. The detailed equipment list is shown below.

Table 28.1 Major Equipment of the Train Part Model

System	Description	Qty.	Remarks
Pantograph and its fuse	Base	1 set	
	Pantograph	1 set	
	Arrester	1 set	
	Fuse	1 set	
	Air valve	1 set	
	Triger switch	1 set	For pantograph up
	Mini air compressor	1 set	
	Mini air resolver	1 set	
High speed breaker for main circuit	Base	1 set	
	High speed breaker	1 set	Breaker for VVVF
	Switch	1 set	Make contact in breaker
	Power supply	1 set	DC power for make contact
Induction motor	Base	1 set	
	Induction motor	1 set	To devise an display method so that students understand more about how to replace bearings
brake and pneumatic system	Base	1 set	
	Cut wheel	1 set	Exception for PRI
	Brake pad	1 set	
	Brake cylinder	1 set	compressor, air resolver,
	valve	2 sets	
	Brake unit	1 set	Electro-Pneumatic control
	Mini air resolver,	1 set	

System	Description	Qty.	Remarks
	Mini compressor	1 set	
bogie	4 m rail track.	1 set	Rail, sleeper, rail bed. Concrete base will be prepared by CP101
	Bogie frame	1 set	Four wheels, two axles, four bearings, two gears, two air suspensions, one motor and 4m rail track.
	Axle spring	4 sets	
	Wheels and axle	2 sets	Total 4 wheels
	bearing	4 sets	With axle box
	gear	2 sets	With coupling gear
	Air suspension	2 sets	
	Induction motor	1 set	Imitation will be accepted

28.4 LANGUAGE

All manuals including teaching sample descriptions shall be produced in English.

28.5 INSTALLATION

PRI / TC opening or 12 months before main line opening, whichever come earlier is the limit of hand over.

28.6 DESIGN LIFE

The design life is 15 years after completion.

28.7 PERIOD OF DEFECTS NOTIFICATION

The Contractor shall have the Defects Notification Period for 2 years upon issuance of TOC. Regardless of the above mentioned, the Defects Notification Period shall be not less than 1 year after hand over. Whichever comes later shall be applied.

28.8 INSTALLATION REQUIREMENTS

The part models shall be installed in 3rd floor or higher, and also size are bigger than elevator or stairs. Regarding the installation of this part model, the Contractor shall coordinate with the Civil Contractor in CP101.

28.8.1 Locations

The models shall be installed in the designated place.

28.8.2 Condition

Train Part Models must be designed for the condition shown below.

- Temperature 16 – 36 °C (operation), 0 – 40 °C (reservation)
- Humidity 40- 70%
- Dust same level ISO6 in ISO14644-1d

28.8.3 Power supply

The single phase 230 V ac will be prepared in nearest switch board. The electric consumption of the Train Part Models are assumed to be less than 3 kW / each system. A transformer shall be provided by the Contractor, if necessary.

28.9 TEST OF THE TRAIN PART MODELS

The Contractor shall submit a plan for testing and commissioning the system / model, as well as the test specification for the Engineer's review. Training of operation staff shall be completed one week prior to the commencement of the first train's running test. The number of staff and schedule shall be specified in due course. Major testing items after installing the equipment and software are as follows:

1) Visual check and safety inspection;
2) Grounding circuit, insulation resistance check, and dielectric test;
3) Visibility and brightness of the Indicator, if it has;
4) Equipment allocation;
5) Power ON, indication, electric meter, gauge check, if it has;
6) Equipment operability;
7) Function check, if it has; and
8) Electro-Magnetic Interference check, if it has;

28.10 STAFF TRAINING

After handing over it, the Contractor shall have its commissioning engineers during the experimental train running period and to train the Employer's instructors about the way to operate and maintain the system / model. Its time length of training period for instructors of the railway operator to be able to use system / model shall be not less than one week.

28.11 SUBMITTING DOCUMENT

The Contractor shall provide the operation and maintenance manual of the train part models written in English. The train part models maintenance manual shall include the following but not be limited to: schematic/electrical diagram, illustrated parts catalogue, and spare parts (complete with description and part nos.).

29 SHIPPING AND DELIVERY

29.1 SHIPPING

At no time shall cars or other parts be exposed to salt water or spray when unprotected, loading on deck shall not be allowed.

The Contractor shall prepare a shipping manual to cover the shipping of all items covered under the Contract, including cars, spare parts and simulator. The shipping manual shall detail the method, packaging and other details required to ensure the safe shipment to the delivery point. The shipping manual shall be submitted for review by the Engineer prior to the shipment of any equipment.

The Contractor shall notify the Engineer ten days in advance of any expected shipment date and give further notification of the actual shipment date and routing when established. This shall complement the inspection requirements prior to delivery as specified herein.

Unless otherwise reviewed by the Engineer, no loose or boxed equipment shall be permitted to be shipped in the cars.

The Contractor shall be responsible for the insurance for shipping.

29.2 DELIVERY

The Contractor shall be responsible for delivery of all items to be supplied under this Contract to the Site, as designated by the Engineer.

The Contractor shall be responsible for the loading, transport and unloading of cars and spare parts from the factory site to the designated delivery point and locating them as instructed by the Engineer.

Cars, parts or items damaged in transit shall not be considered as delivered until all repairs or replacements have been completed and all necessary spare parts or items have been delivered to the Site.

All documents, manuals, drawings and other deliverables shall be delivered to MMSP operator, Philippines.

The Contractor shall be responsible for all storage and security of cars, spare parts and other items until the items have been inspected and are considered delivered at the point designated by the Engineer.

Removal of all temporary fittings required for shipment and re-assembly of equipment shall be the responsibility of the Contractor, and shall be completed prior to the car parts being inspected and considered delivered.

Prior to delivery, the Contractor is recommended to plan the route to ensure they are aware of actual road conditions, underpasses, bridges and potentially other construction work which may hinder his delivery from port to the Site.

The Contractor shall comply with the requirements of the Employer or any relevant section of local government and/or any other relevant authority regarding any traffic arrangements that may be necessary for delivery of the car plus other equipment from port to the Site. The Contractor shall make all arrangements and assume full responsibility for transportation to the Site.

APPENDICES TO TECHNICAL SPECIFICATION

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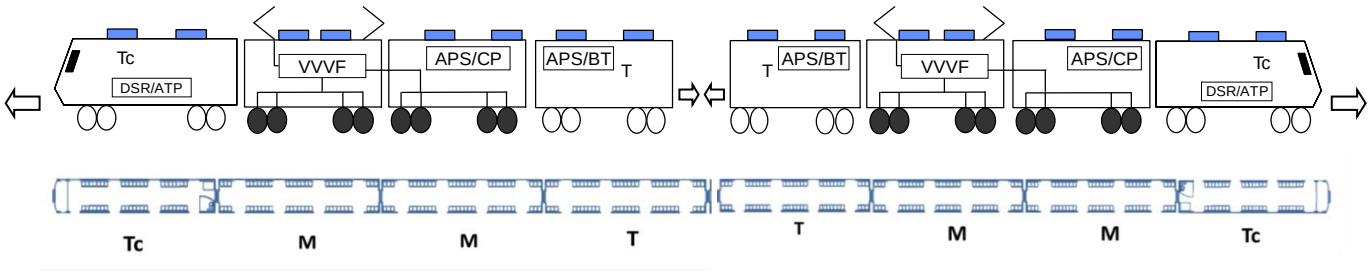
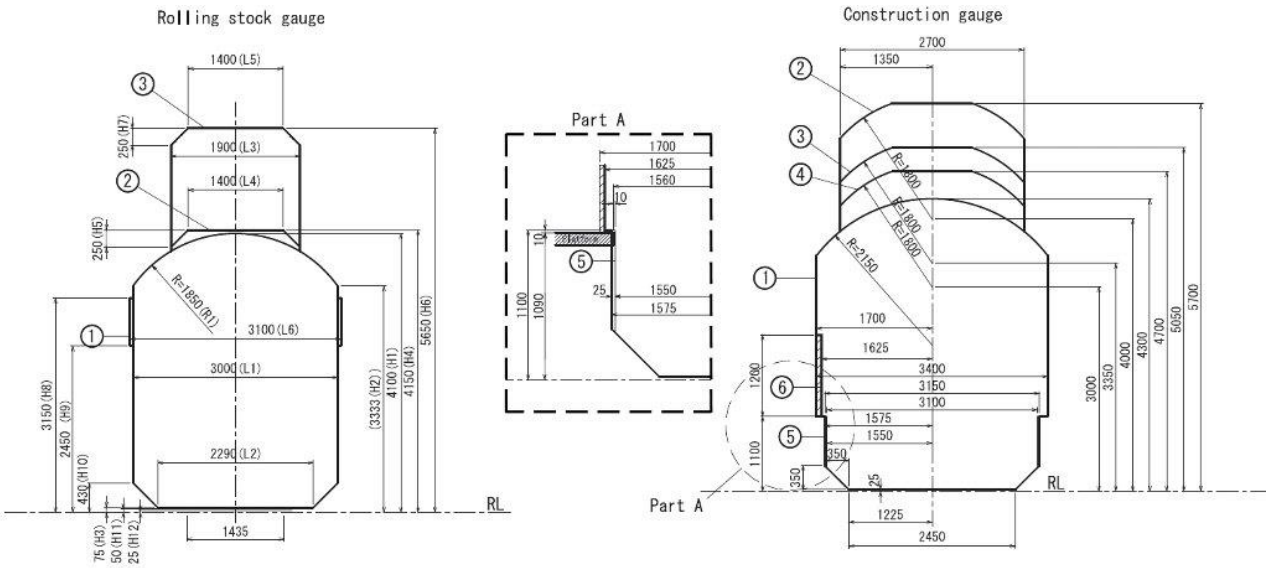
Appendix. A Schematic diagram of basic vehicle configuration (for reference)



Legend ● : Motor Axle ○ : Trailer Axle ⇦ : Tight lock coupler
ATP : Automatic Train Protection, R : Radio,
VVVF : VVVF inverter, CP : Compressor,
APS : Auxiliary power Supply, PT : Pantograph,
BT : Battery, : Air Conditioner ▭

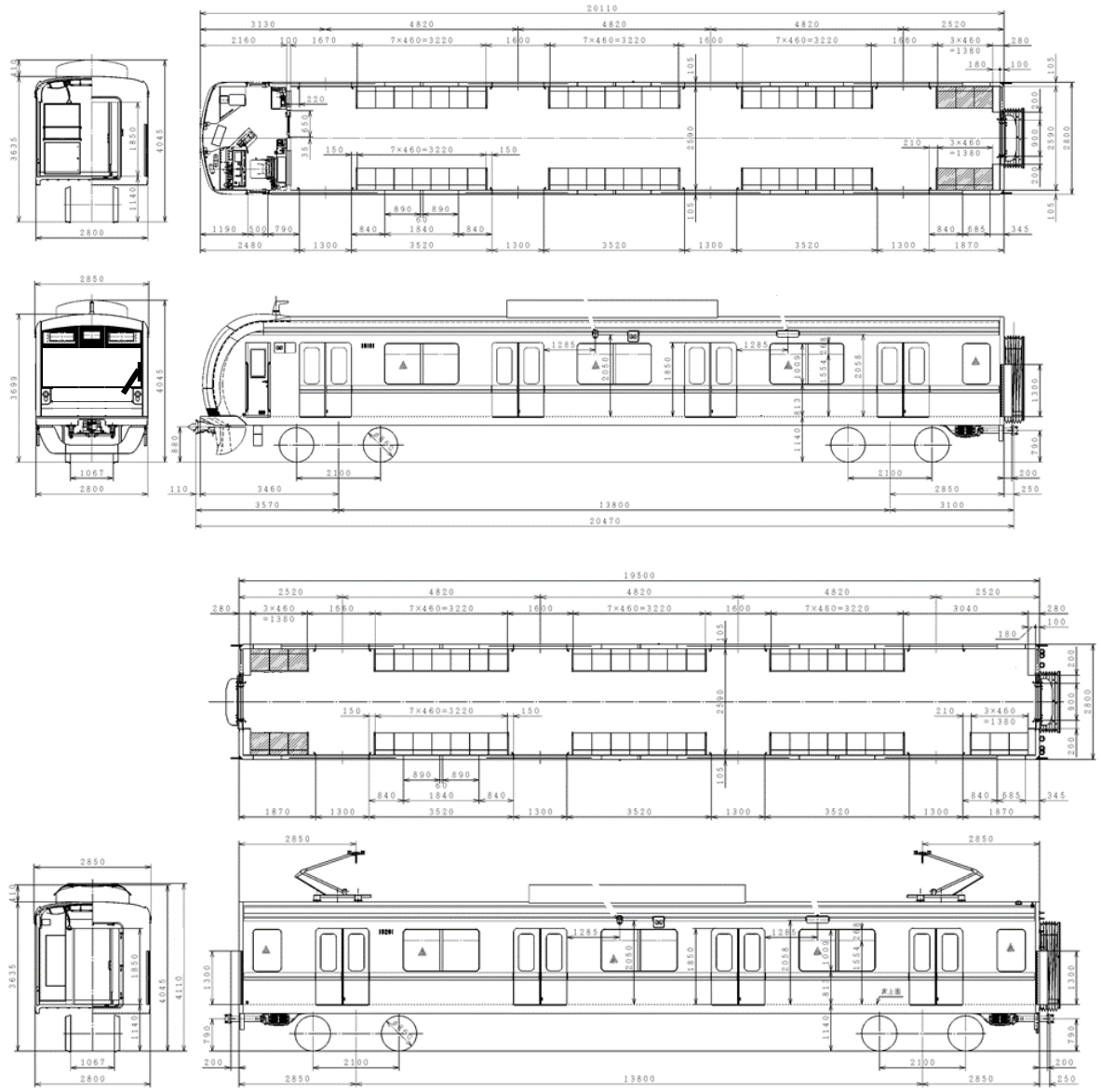
Appendix. B Schematic diagram of Rolling Stock Gauge and Construction Gauge



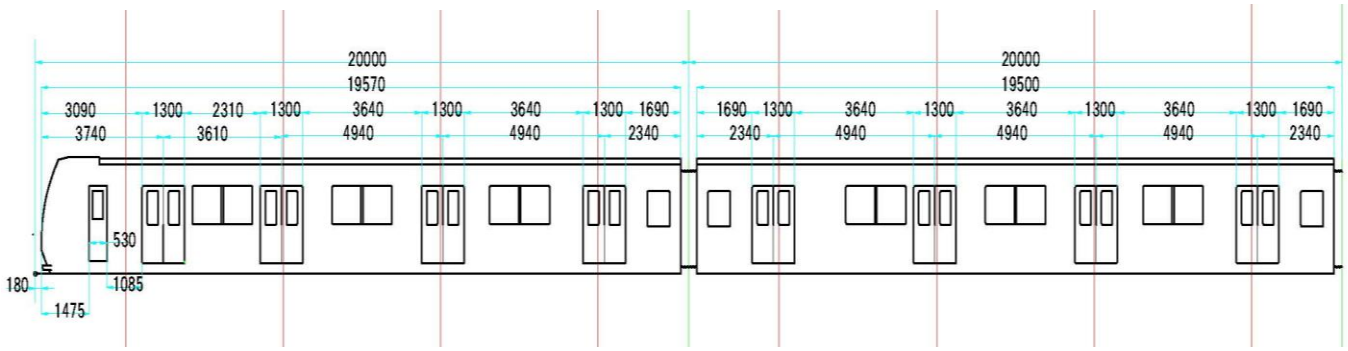
		Gauge	
	———	Basic	H1, H2, H3, H10, L1, L2, R1
②	———	Gauge when current collector is folded.	H4, H5, L3, L4
③	———	Gauge in relation to top of roof when current collector is operated.	H6, H7, L3, L5
①	———	Gauge in relation to signs, marker lamps, car side lamps.	H8, H9, L6
	- - - - -	Gauge in relation to parts that do not move vertically due to action of bogie spring.	H11, L2
	———	gauge in relation to sanding pipe, obstacle deflector, brake shoe and other parts that do not exceed the wheel rim width.	H12

		Gauge
①	———	Basic gauge for subway tunnel section
②	———	Gauge for track on which trains run receiving supply of direct current.
③	———	Gauge for tunnels, bridge, overpass, along track on which trains run receiving supply of direct current.
④	———	Gauge for tunnel section in case of using rigid overhead wire or safe supporting system.
⑤	———	Gauge for platform edge.
⑥	———	Gauge for platform screen door sensors.

Appendix. C Schematic diagram of Vehicle (for reference)



Door positions in the car and door pitches shall be complied with the below configuration.



Appendix. D Tractive Effort Curve and Regenerative Effort Curve

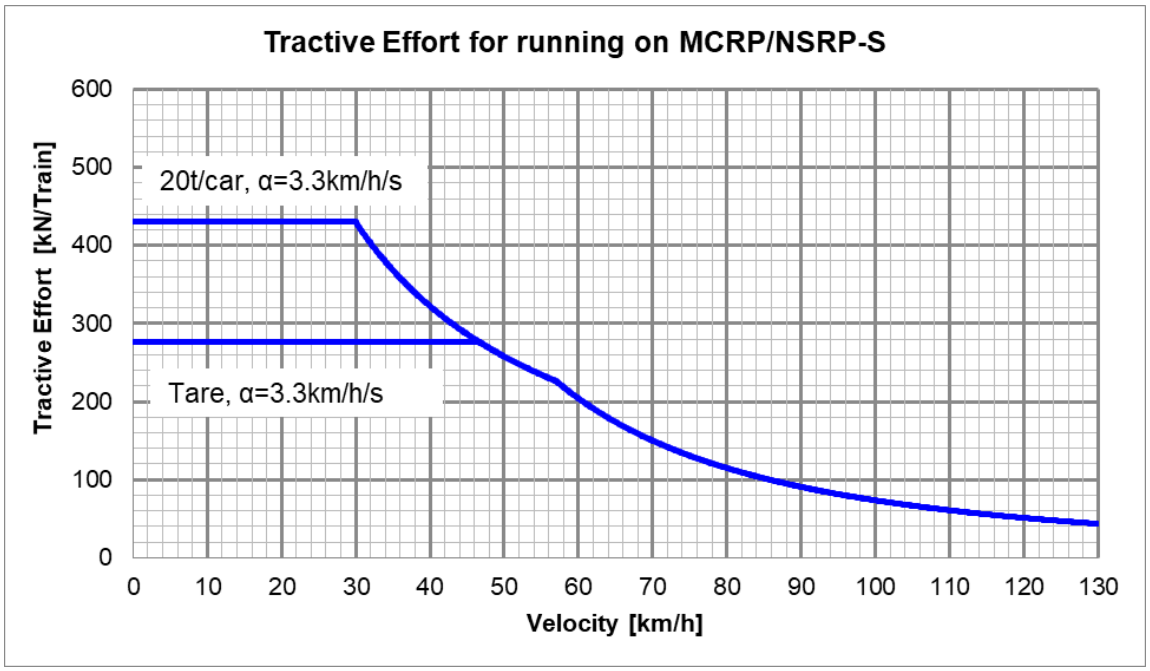


Fig.1 Tractive Effort for running on MCRP/NSRP-S at 820mm (for reference)

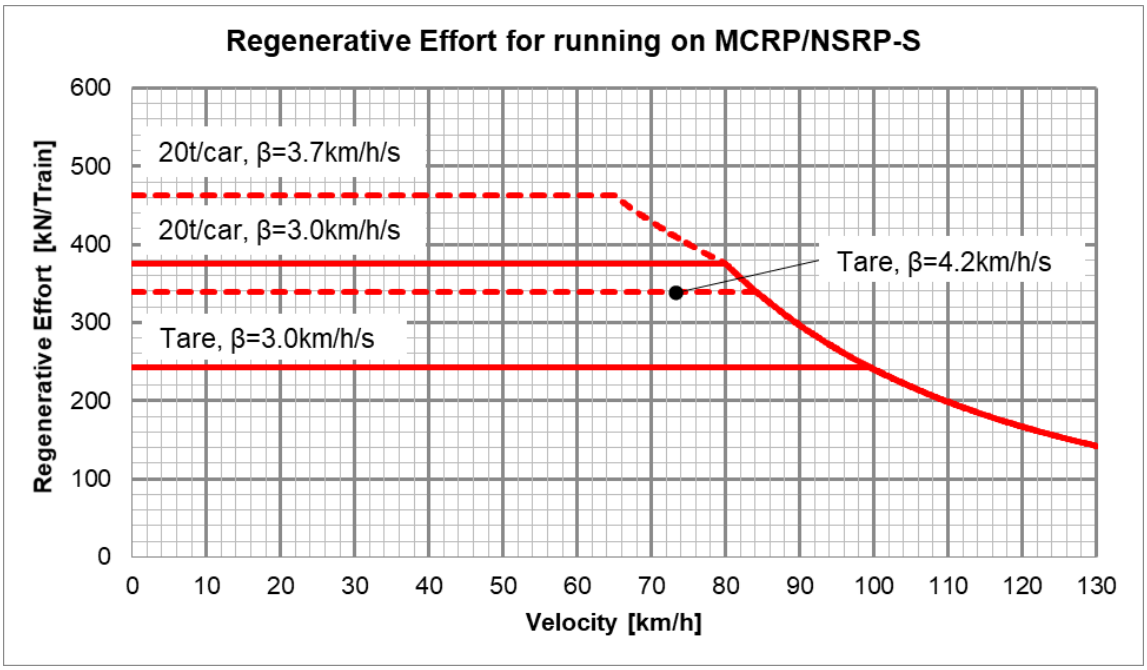


Fig.2 Regenerative Effort for running on MCRP/NSRP-S at 820mm (for reference)

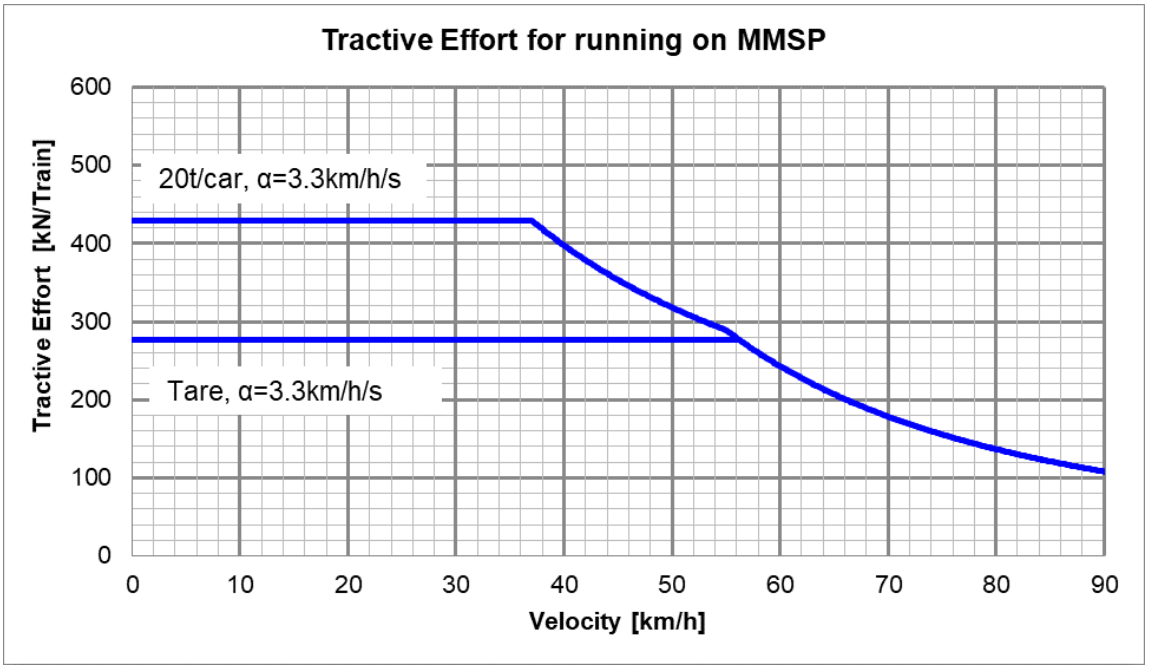


Fig.3 Tractive Effort for running on MMSP at 820mm (for reference)

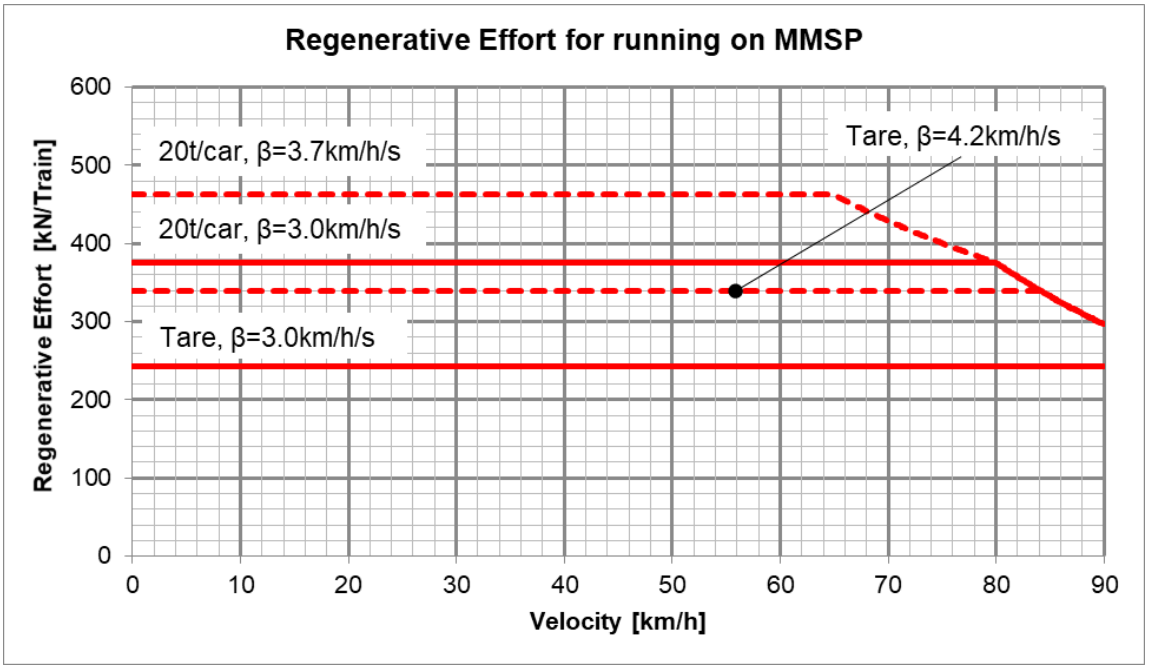
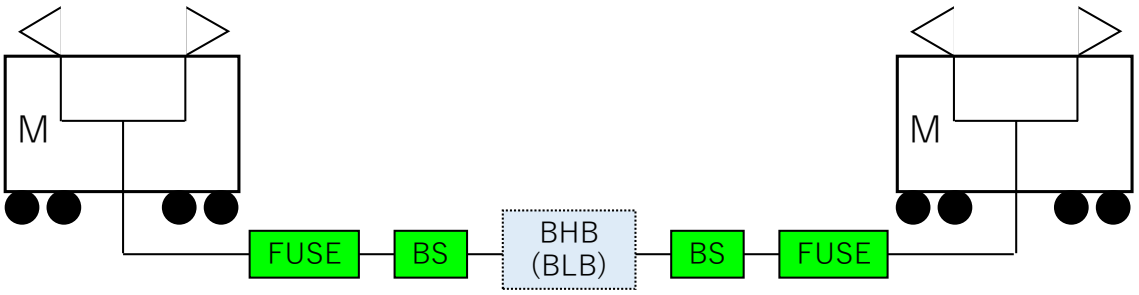
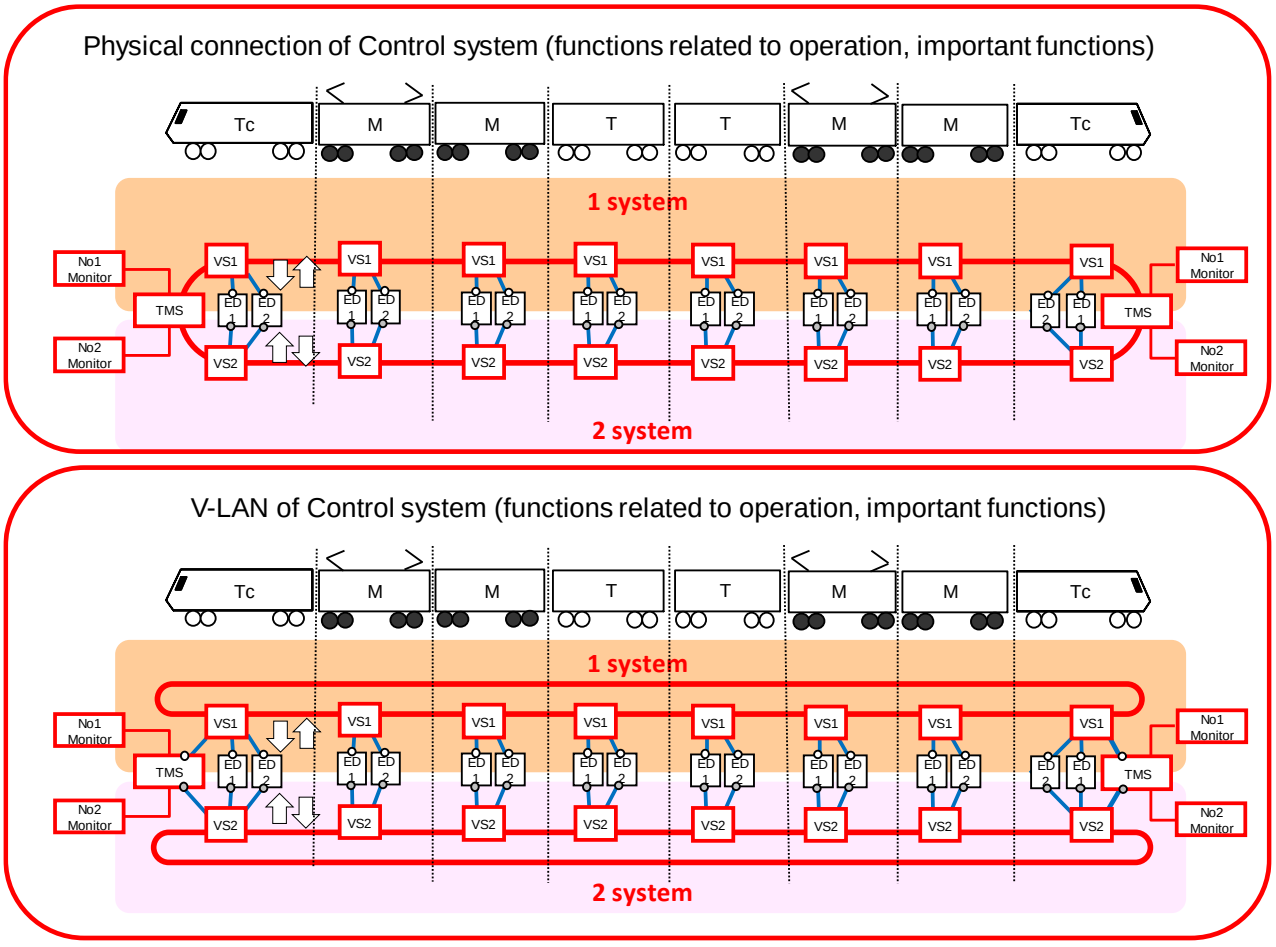


Fig.4 Regenerative Effort for running on MMSP at 820mm (for reference)

Appendix. E Schematic diagram of High Voltage Train line (for reference)

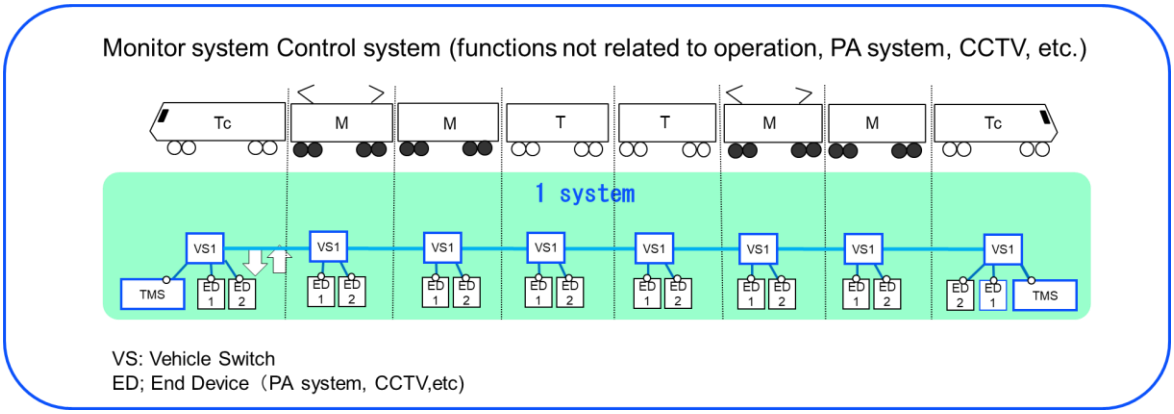


Appendix. F Schematic diagram of model of control transmission system (for reference)



VS: Vehicle Switch
ED; End Device（VVVF,APS,BCU,etc)

Appendix. G Schematic diagram of model of monitor transmission system (for reference)



Appendix. H Sample data of run-curve simulation for considering the capacity of Propulsion system (Station data for MMSP)

Quirino Highway - Bicutan

Forward			Return		
Station	Distance [m]	Stop time [sec]	Station	Distance [m]	Stop time [sec]
Quirino Highway	0	*	Bicutan	0	*
Tandang Sora	1699	30.0	FTI	1694	30.0
North Ave.	3886	30.0	Lawton West	5581	30.0
Quezon Ave.	5177	30.0	Lawton East	7457	30.0
East Ave.	6930	30.0	Bonifacio Global City	9645	30.0
Anonas	9006	30.0	Kalayaan Ave.	10710	30.0
Katipunan	10655	30.0	Ortigas South	12818	30.0
Ortigas North	13763	30.0	Ortigas North	14078	30.0
Ortigas South	15023	30.0	Katipunan	17186	30.0
Kalayaan Ave.	17131	30.0	Anonas	18835	30.0
Bonifacio Global City	18196	30.0	East Ave.	20911	30.0
Lawton East	20384	30.0	Quezon Ave.	22664	30.0
Lawton West	22260	30.0	North Ave.	23955	30.0
FTI	26147	30.0	Tandang Sora	26142	30.0
Bicutan	27841	*	Quirino Highway	27841	*

Quirino Highway - Terminal 3

Forward			Return		
Station	Distance [m]	Stop time [sec]	Station	Distance [m]	Stop time [sec]
Quirino Highway	0	*	Terminal 3	0	*
Tandang Sora	1699	30.0	Lawton West	1362	30.0
North Ave.	3886	30.0	Lawton East	3238	30.0
Quezon Ave.	5177	30.0	Bonifacio Global City	5426	30.0
East Ave.	6930	30.0	Kalayaan Ave.	6491	30.0
Anonas	9006	30.0	Ortigas South	8599	30.0
Katipunan	10655	30.0	Ortigas North	9859	30.0
Ortigas North	13763	30.0	Katipunan	12967	30.0
Ortigas South	15023	30.0	Anonas	14616	30.0
Kalayaan Ave.	17131	30.0	East Ave.	16692	30.0
Bonifacio Global City	18196	30.0	Quezon Ave.	18445	30.0
Lawton East	20384	30.0	North Ave.	19736	30.0
Lawton West	22260	30.0	Tandang Sora	21923	30.0
Terminal 3	23622	*	Quirino Highway	23622	*

(*) The dwell time is 180 sec.

Appendix. I Sample data of run-curve simulation for considering the capacity of Propulsion system (Speed Limit for MMSP, Quirino Highway - Bicutan)

Quirino Highway - Bicutan

Forward			Return		
Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]	Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]
134	265	80	963	1111	80
336	692	80	1122	1271	80
2073	2527	80	1803	1873	80
2691	2868	80	2197	2269	80
2985	3239	80	2388	2473	80
3489	3599	80	2803	2945	80
3741	3856	80	3055	3157	80
3935	4068	70	4616	5407	80
4208	4348	80	6136	6210	80
4602	4842	60	6235	6309	80
5324	5432	80	6781	6878	80
5911	6085	80	6903	7001	80
6203	6544	80	7161	7230	80
7525	7909	80	7829	8491	80
9243	9482	80	8524	8987	80
11060	11267	80	9124	9382	60
11471	11644	80	9436	9590	55
11757	12064	80	9921	10162	60
12166	12648	80	10200	10438	60
12648	12984	80	10847	10936	80
13328	13634	80	10966	11055	80
14000	14149	80	12116	12330	80
14174	14326	80	12365	12679	70
14597	14881	70	12960	13244	70
15165	15481	70	13517	13666	80
15481	15511	80	13691	13843	80
15511	15725	80	14206	14504	80
15725	16385	80	15193	15675	80
17394	17635	60	15777	16084	80
17671	17911	60	16197	16370	80
18251	18405	55	16568	16775	80
18459	18717	60	18359	18598	80
18827	19311	80	19932	20316	80
19348	20021	80	21296	21629	80
20611	20680	80	21755	21927	80
20840	20905	80	22281	22488	80
20929	20993	80	22853	22953	60
21532	21606	80	22999	23239	60
21631	21705	80	23501	23633	80
22434	23225	80	23773	23906	70
24490	24592	80	23985	24100	80
24977	25122	80	24321	24430	80
25320	25450	80	24599	24849	80
25660	25784	80	24994	25168	80
25962	26023	80	25312	25769	80
26453	26564	80	27165	27551	80
26766	26838	80			

Quirino Highway - Terminal 3

Forward			Return		
Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]	Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]
134	265	80	516	711	80
336	692	80	743	1083	80
2073	2527	80	1956	2010	80
2691	2868	80	2035	2090	80
2985	3239	80	2437	2502	45
3489	3599	80	2562	2659	80
3741	3856	80	2684	2782	80
3935	4068	70	2942	3011	80
4208	4348	80	3610	4272	80
4602	4842	60	4305	4768	80
5324	5432	80	4905	5163	60
5911	6085	80	5217	5371	55
6203	6544	80	5702	5943	60
7525	7909	80	5981	6219	60
9243	9482	80	6628	6717	80
11060	11267	80	6747	6836	80
11471	11644	80	7897	8111	80
11757	12064	80	8146	8460	70
12166	12648	80	8741	9025	70
12648	12984	80	9298	9447	80
13328	13634	80	9472	9624	80
14000	14149	80	9987	10285	80
14174	14326	80	10974	11456	80
14597	14881	70	11558	11865	80
15165	15481	70	11978	12151	80
15481	15511	80	12349	12556	80
15511	15725	80	14140	14379	80
15725	16385	80	15713	16097	80
17394	17635	60	17077	17410	80
17671	17911	60	17536	17708	80
18251	18405	55	18062	18269	80
18459	18717	60	18634	18734	60
18827	19311	80	18780	19020	60
19348	20021	80	19282	19414	80
20611	20680	80	19554	19687	70
20840	20905	80	19766	19881	80
20929	20993	80	20102	20211	80
20993	21022	80	20380	20630	80
21120	21185	45	20775	20949	80
21532	21587	80	21093	21550	80
21612	21666	80	22946	23332	80
22539	22879	80			
22911	23106	80			

Appendix. J Sample data of run-curve simulation for considering the capacity of Propulsion system (Gradient for MMSP)

Quirino Highway - Bicutan

Forward			Return		
Start Dist. [m]	End Dist. [m]	Gradient [‰]	Start Dist. [m]	End Dist. [m]	Gradient [‰]
0	128	0	0	157.271	0
128	923	2	157.271	1516.678	-33
923	1119.1	22	1516.678	1844.591	0
1119.1	1557	2	1844.591	5415.436	-3
1557	1873	0	5415.436	5717.053	0
1873	2296	-8	5717.053	6819.101	5
2296	2926.5	-5	6819.101	7299.785	25
2926.5	3053	5	7299.785	7602.508	0
3053	3605	2	7602.508	9346.078	-5
3605	4142	0	9346.078	10031	0
4142	5042	-5	10031	10557	-10
5042	5319	0	10557	10845	0
5319	5600	2	10845	10959	-3
5600	6205.9	20	10959	11186.492	13
6205.9	6788	10	11186.492	11456.05	-25
6788	7062	0	11456.05	12546	25
7062	8170.25	2	12546	13004.6	0
8170.25	8864	-2	13004.6	13351	5
8864	9150	0	13351	13892	-2
9150	9858	5	13892	14276	0
9858	10510	2	14276	14857.07	2
10510	10796.5	0	14857.07	15391	30
10796.5	11487.5	2	15391	16353.5	2
11487.5	12450	-2	16353.5	17044.5	-2
12450	12983.93	-30	17044.5	17331	0
12983.93	13565	-2	17331	17983	-2
13565	13949	0	17983	18691	-5
13949	14490	2	18691	18977	0
14490	14836.4	-5	18977	19670.75	2
14836.4	15295	0	19670.75	20779	-2
15295	16384.95	-25	20779	21053	0
16384.95	16882	35	21053	22035.875	-10
16882	16994	3	22035.875	22522	-2
16994	17284	0	22522	22811	0
17284	17880.8	10	22811	23334.833	10
17880.8	18494.922	0	23334.833	23704	-2
18494.922	19191.557	5	23704	24241	0
19191.557	20238.492	-2	24241	24496	-2
20238.492	20384	0	24496	24740.054	-33
20384	20541.215	0	24740.054	24914.5	-5
20541.215	21021.899	-25	24914.5	25545	5
21021.899	22123.947	-5	25545	25968	8
22123.947	22425.564	0	25968	26284	0
22425.564	25996.409	3	26284	26721.9	-2
25996.409	26324.322	0	26721.9	26918	-22
26324.322	27683.729	33	26918	27713	-2
27683.729	27841	0	27713	27841	0

Quirino Highway – Terminal 3

Forward			Return		
Start Dist. [m]	End Dist. [m]	Gradient [‰]	Start Dist. [m]	End Dist. [m]	Gradient [‰]
0	128	0	0	222	2
128	923	2	222	1196.436	-3
923	1119.1	22	1196.436	1498.053	0
1119.1	1557	2	1498.053	2600.101	12
1557	1873	0	2600.101	3080.785	25
1873	2296	-8	3080.785	3383.508	0
2296	2926.5	-5	3383.508	5127.078	-5
2926.5	3053	5	5127.078	5812	0
3053	3605	2	5812	6338	-10
3605	4142	0	6338	6626	0
4142	5042	-5	6626	6740	-3
5042	5319	0	6740	6967.492	13
5319	5600	2	6967.492	7237.05	-25
5600	6205.9	20	7237.05	8327	25
6205.9	6788	10	8327	8785.6	0
6788	7062	0	8785.6	9132	5
7062	8170.25	2	9132	9673	-2
8170.25	8864	-2	9673	10057	0
8864	9150	0	10057	10638.07	2
9150	9858	5	10638.07	11172	30
9858	10510	2	11172	12134.5	2
10510	10796.5	0	12134.5	12825.5	-2
10796.5	11487.5	2	12825.5	13112	0
11487.5	12450	-2	13112	13764	-2
12450	12983.93	-30	13764	14472	-5
12983.93	13565	-2	14472	14758	0
13565	13949	0	14758	15451.75	2
13949	14490	2	15451.75	16560	-2
14490	14836.4	-5	16560	16834	0
14836.4	15295	0	16834	17816.875	-10
15295	16384.95	-25	17816.875	18303	-2
16384.95	16882	35	18303	18592	0
16882	16994	3	18592	19115.833	10
16994	17284	0	19115.833	19485	-2
17284	17880.8	10	19485	20022	0
17880.8	18494.922	0	20022	20277	-2
18494.922	19191.557	5	20277	20521.054	-33
19191.557	20238.492	-2	20521.054	20695.5	-5
20238.492	20541.215	0	20695.5	21326	5
20541.215	21021.899	-25	21326	21749	8
21021.899	22123.947	-12	21749	22065	0
22123.947	22425.564	0	22065	22502.9	-2
22425.564	23400	3	22502.9	22699	-22
23400	23622	-2	22699	23494	-2
			23494	23622	0

Appendix. K Sample data of run-curve simulation for considering the capacity of Propulsion system (Curvature Radius for MMSP)

Quirino Highway – Bicutan (1/2)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
0	134	0	0	963	0
134	265	800	963	1111	600
265	336	0	1111	1122	0
336	692	400	1122	1271	600
692	2073	0	1271	1803	0
2073	2527	560.2	1803	1873	1200
2527	2691	0	1873	2197	0
2691	2868	400	2197	2269	2000
2868	2985	0	2269	2388	0
2985	3239	450	2388	2473	1000
3239	3489	0	2473	2803	0
3489	3599	550	2803	2945	400
3599	3741	0	2945	3055	0
3741	3856	700	3055	3157	800
3856	3935	0	3157	4616	0
3935	4068	500	4616	5407	400
4068	4208	0	5407	6136	0
4208	4348	400	6136	6210	1100
4348	4602	0	6210	6235	0
4602	4842	250	6235	6309	1100
4842	5324	0	6309	6781	0
5324	5432	400	6781	6878	700
5432	5911	0	6878	6903	0
5911	6085	400	6903	7001	700
6085	6203	0	7001	7161	0
6203	6544	400	7161	7230	1000
6544	7525	0	7230	7829	0
7525	7909	500	7829	8491	700
7909	9243	0	8491	8524	0
9243	9482	400	8524	8987	400
9482	11060	0	8987	9124	0
11060	11267	400	9124	9382	250
11267	11471	0	9382	9436	0
11471	11644	400	9436	9590	700
11644	11757	0	9590	9921	0
11757	12064	400	9921	10162	250
12064	12166	0	10162	10200	0
12166	12648	500	10200	10438	250
12648	13328	0	10438	10847	0
13328	13634	400	10847	10936	700
13634	14000	0	10936	10966	0
14000	14149	500	10966	11055	700
14149	14174	0	11055	12116	0
14174	14326	500	12116	12330	400
14326	14597	0	12330	12365	0
14597	14881	300	12365	12679	300
14881	15165	0	12679	12960	0

Quirino Highway – Bicutan (2/2)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
15165	15481	300	12960	13244	300
15481	15511	0	13244	13517	0
15511	15725	400	13517	13666	500
15725	17394	0	13666	13691	0
17394	17635	250	13691	13843	500
17635	17671	0	13843	14206	0
17671	17911	250	14206	14504	400
17911	18251	0	14504	15193	0
18251	18405	700	15193	15675	500
18405	18459	0	15675	15777	0
18459	18717	250	15777	16084	400
18717	18827	0	16084	16197	0
18827	19311	400	16197	16370	400
19311	19348	0	16370	16568	0
19348	20021	700	16568	16775	400
20021	20611	0	16775	18359	0
20611	20680	1000	18359	18598	400
20680	20840	0	18598	19932	0
20840	20905	1300	19932	20316	500
20905	20929	0	20316	21296	0
20929	20993	1300	21296	21629	400
20993	21532	0	21629	21755	0
21532	21606	1100	21755	21927	400
21606	21631	0	21927	22281	0
21631	21705	1100	22281	22488	400
21705	22434	0	22488	22853	0
22434	23225	400	22853	22953	400
23225	24490	0	22953	22999	0
24490	24592	800	22999	23239	250
24592	24977	0	23239	23501	0
24977	25122	400	23501	23633	400
25122	25320	0	23633	23773	0
25320	25450	1000	23773	23906	500
25450	25660	0	23906	23985	0
25660	25784	450	23985	24100	700
25784	25962	0	24100	24321	0
25962	26023	1400	24321	24430	550
26023	26453	0	24430	24599	0
26453	26564	1500	24599	24849	450
26564	26766	0	24849	24994	0
26766	26838	1000	24994	25168	400
26838	27841	0	25168	25312	0
			25312	25769	550
			25769	27165	0
			27165	27551	400
			27551	27841	0

Quirino Highway – Terminal 3(1/2)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
0	134	0	0	516	0
134	265	800	516	711	400
265	336	0	711	743	0
336	692	400	743	1083	400
692	2073	0	1083	1956	0
2073	2527	560.2	1956	2010	2000
2527	2691	0	2010	2035	0
2691	2868	400	2035	2090	2000
2868	2985	0	2090	2437	0
2985	3239	450	2437	2502	500
3239	3489	0	2502	2562	0
3489	3599	550	2562	2659	700
3599	3741	0	2659	2684	0
3741	3856	700	2684	2782	700
3856	3935	0	2782	2942	0
3935	4068	500	2942	3011	1000
4068	4208	0	3011	3610	0
4208	4348	400	3610	4272	700
4348	4602	0	4272	4305	0
4602	4842	250	4305	4768	400
4842	5324	0	4768	4905	0
5324	5432	400	4905	5163	250
5432	5911	0	5163	5217	0
5911	6085	400	5217	5371	700
6085	6203	0	5371	5702	0
6203	6544	400	5702	5943	250
6544	7525	0	5943	5981	0
7525	7909	500	5981	6219	250
7909	9243	0	6219	6628	0
9243	9482	400	6628	6717	700
9482	11060	0	6717	6747	0
11060	11267	400	6747	6836	700
11267	11471	0	6836	7897	0
11471	11644	400	7897	8111	400
11644	11757	0	8111	8146	0
11757	12064	400	8146	8460	300
12064	12166	0	8460	8741	0
12166	12648	500	8741	9025	300
12648	13328	0	9025	9298	0
13328	13634	400	9298	9447	500
13634	14000	0	9447	9472	0
14000	14149	500	9472	9624	500
14149	14174	0	9624	9987	0

Quirino Highway – Terminal 3 (2/2)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
14174	14326	500	9987	10285	400
14326	14597	0	10285	10974	0
14597	14881	300	10974	11456	500
14881	15165	0	11456	11558	0
15165	15481	300	11558	11865	400
15481	15511	0	11865	11978	0
15511	15725	400	11978	12151	400
15725	17394	0	12151	12349	0
17394	17635	250	12349	12556	400
17635	17671	0	12556	14140	0
17671	17911	250	14140	14379	400
17911	18251	0	14379	15713	0
18251	18405	700	15713	16097	500
18405	18459	0	16097	17077	0
18459	18717	250	17077	17410	400
18717	18827	0	17410	17536	0
18827	19311	400	17536	17708	400
19311	19348	0	17708	18062	0
19348	20021	700	18062	18269	400
20021	20611	0	18269	18634	0
20611	20680	1000	18634	18734	400
20680	20840	0	18734	18780	0
20840	20905	1300	18780	19020	250
20905	20929	0	19020	19282	0
20929	20993	1300	19282	19414	400
20993	21120	0	19414	19554	0
21120	21185	500	19554	19687	500
21185	21532	0	19687	19766	0
21532	21587	2000	19766	19881	700
21587	21612	0	19881	20102	0
21612	21666	2000	20102	20211	550
21666	22539	0	20211	20380	0
22539	22879	400	20380	20630	450
22879	22911	0	20630	20775	0
22911	23106	400	20775	20949	400
23106	23622	0	20949	21093	0
			21093	21550	550
			21550	22946	0
			22946	23332	400
			23332	23622	0

Appendix. L Sample data of run-curve simulation for considering the capacity of Propulsion system (Station data for Interoperability)

Forward				Return			
Line	Station	Distance [m]	Stop time [sec]	Line	Station	Distance [m]	Stop time [sec]
NSRP-S	Calamba	0	*	MCRP	CIA	0	*
	Banlic	3321	30.0		Clark	7448	30.0
	Cabuyao	8725	30.0		Angeles	12399	30.0
	Santa Rosa	14788	30.0		San Fernando	27439	30.0
	Binan	17840	30.0		Apalit	39594	30.0
	Pacita	20403	30.0		Calumpit	44990	30.0
	San Pedro	21477	30.0	NSCR	Malolos	51892	30.0
	Muntinlupa	25383	30.0		Malolos south	55331	30.0
	Alabang	28298	30.0		Guiguinto	58177	30.0
	Sucat	31989	30.0		Tuktukan	60526	30.0
	Bicutan	36478	30.0		Balagtas	62826	30.0
	FTI	38172	30.0		Bocaue	66791	30.0
	Nichols	41530	30.0		TabingIlog	69681	30.0
	EDSA	42755	30.0		Marilao	72263	30.0
	Buendia	44693	30.0		Meycauayan	74031	30.0
	Paco	48106	30.0		Valenzuela	76849	30.0
	Santa Mesa	50881	30.0		Valenzuela Polo	79241	30.0
	Espana	53052	30.0		Malabon	82366	30.0
	Blumentritt	54627	30.0		Caloocan	83903	30.0
NSCR	Solis St	56837	30.0		Solis	86029	30.0
	Caloocan	58963	30.0	NSRP-S	Blumentritt	88239	30.0
	Malabon	60500	30.0		Espana	89814	30.0
	Valenzuela Polo	63625	30.0		Santa Mesa	91985	30.0
	Valenzuela	66017	30.0		Paco	94760	30.0
	Meycauayan	68835	30.0		Buendia	98173	30.0
	Marilao	70603	30.0		EDSA	100111	30.0
	TabingIlog	73185	30.0		Nichols	101336	30.0
	Bocaue	76075	30.0		FTI	104694	30.0
	Balagtas	80040	30.0		Bicutan	106388	30.0
	Tuktukan	82340	30.0		Sucat	110877	30.0
	Guiguinto	84689	30.0		Alabang	114568	30.0
	Malolos south	87535	30.0		Muntinlupa	117483	30.0
	Malolos	90974	30.0		San Pedro	121389	30.0
MCRP	Calumpit	97876	30.0		Pacita	122463	30.0
	Apalit	103272	30.0		Binan	125026	30.0
	San Fernando	115427	30.0		Santa Rosa	128078	30.0
	Angeles	130467	30.0		Cabuyao	134141	30.0
	Clark	135418	30.0		Banlic	139545	30.0
	CIA	142866	*		Calamba	142866	*

(*) The dwell time is 180 sec.

Appendix. M Sample data of run-curve simulation for considering the capacity of Propulsion system (Speed Limit for Interoperability_1/7)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]	Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]
135.8	315.3	55	457.6	504.8	80
505.1	591.5	75	530.3	577.4	80
612.1	853.1	75	1499.8	3200.8	80
891.7	1083.7	110	3910.9	4292.0	120
2181.1	2244.8	120	4371.2	4720.0	120
2366.6	2514.5	120	4972.7	5434.0	115
2547.9	2682.9	120	5434.0	5894.0	110
2848.8	2979.1	100	6219.6	6522.9	70
3009.6	3206.4	100	6611.8	6855.4	70
3448.1	3571.7	120	7435.8	7660.6	120
3593.6	3724.6	120	8031.4	8134.0	120
3757.0	3919.9	115	8134.0	9927.8	115
3959.8	4115.0	120	10182.0	10314.4	160
4558.1	4639.4	120	10448.9	10589.9	160
5241.1	5322.4	120	10705.8	10934.0	160
6377.2	6480.8	120	10965.3	11829.0	115
6557.2	6713.1	120	11829.0	11982.1	115
6861.9	6972.3	120	12614.0	12876.5	115
7226.2	7287.0	120	13334.0	14819.0	115
7287.0	8080.2	120	16084.0	16444.0	115
8181.4	8342.6	120	19394.0	19994.0	115
8455.5	8614.9	120	21388.8	21506.5	160
8835.0	8998.8	120	21595.1	21712.9	160
9109.3	9270.7	120	22993.5	23370.4	160
9457.5	9719.0	115	23866.0	24259.0	160
11823.2	11905.6	120	25194.0	25664.0	115
11927.9	12312.0	100	25762.8	26048.6	160
12332.2	12430.4	120	26264.0	26827.0	110
14327.6	14391.3	120	28272.1	28539.1	160
14417.0	14506.1	120	28768.8	28912.4	160
14595.0	14660.0	120	29092.6	29209.9	160
15065.9	15127.9	120	29330.6	29506.7	160
15150.7	15215.1	120	29888.9	30047.6	160
15265.9	15502.0	115	30244.3	30339.3	160
15669.3	15735.2	120	30662.8	30827.2	160
16095.2	16177.9	120	31062.1	31179.4	160
16582.5	16646.1	120	31299.2	31416.5	160
17992.0	18304.0	115	31553.2	33266.9	160
19953.9	20036.3	100	35222.5	36971.0	160
20067.6	20281.4	80	38067.8	38200.1	160

Appendix. M Sample data of run-curve simulation for considering the capacity of Propulsion system (Speed Limit for Interoperability_2/7)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]	Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]
20512.6	20585.6	100	38481.1	39272.3	160
20609.0	20682.2	100	39985.8	40135.6	160
21026.6	21145.4	120	40667.9	40865.2	160
21247.9	21366.9	120	41034.0	41534.0	115
21587.1	21712.4	120	41663.4	42442.3	120
21803.8	21942.3	120	43000.2	43206.4	160
22295.8	22397.0	120	43274.0	43840.3	115
22428.1	22516.0	120	43898.5	44599.4	110
22562.0	23146.0	110	45016.4	45154.5	160
23586.5	24029.4	105	45456.8	45685.3	160
24152.0	24352.0	115	45958.5	46090.8	160
24552.7	24616.4	120	47065.2	47194.2	160
25052.9	25116.6	120	47340.5	47559.1	160
25503.8	25595.5	120	50768.9	50904.8	120
25620.5	25715.4	120	50935.4	51061.6	120
25752.0	26121.5	115	51649.7	51680.5	120
26858.8	26927.1	120	51733.5	51764.3	120
27783.6	27930.2	110	52034.0	52703.0	115
28030.4	28167.9	120	55558.0	55781.0	120
28388.0	28493.3	120	56215.0	56300.0	120
28755.7	28853.8	120	56755.0	57050.0	120
28912.0	29232.0	115	57485.0	57575.0	120
29232.0	29423.7	120	57709.0	57786.0	120
30276.9	30337.7	120	58334.0	58771.0	105
31419.1	31642.3	70	58995.0	59093.0	120
31662.4	31867.8	70	59514.0	59968.0	100
32114.2	32479.2	105	61151.0	62077.0	110
32479.2	32530.4	120	64472.0	64547.0	120
32530.4	32854.2	105	64854.0	65122.0	115
33609.6	33972.8	100	65359.0	65432.0	120
34179.7	34497.8	100	66092.0	66567.0	115
34863.8	35230.5	100	67044.0	67117.0	120
35763.4	35867.3	100	67314.0	67402.0	120
35890.0	36017.0	100	70820.0	70913.0	120
36121.5	36194.1	100	70938.0	71063.0	120
36272.1	36368.2	100	71113.0	71215.0	120
36588.3	36720.3	120	71819.0	71928.0	115
36744.0	36787.0	120	71984.0	72093.0	115
36787.0	37552.0	105	72431.0	72540.0	115
37552.0	37592.6	120	72596.0	72705.0	115

Appendix. M Sample data of run-curve simulation for considering the capacity of Propulsion system (Speed Limit for Interoperability_3/7)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]	Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]
37772.0	38017.0	105	72905.0	73193.0	120
38017.0	38062.4	120	74495.0	74707.0	110
38282.6	38395.2	100	75166.0	75706.0	105
38422.6	38535.3	100	76233.0	76311.0	120
38602.0	38792.0	115	76453.0	76577.7	120
38792.0	38892.1	120	76603.0	76743.0	120
38915.0	39003.0	120	76939.8	77076.9	115
39099.3	39170.6	120	77076.9	77214.0	115
39195.7	39326.8	120	77235.1	77632.1	75
39347.3	39452.9	120	77836.3	77909.3	120
39494.1	39585.9	120	78874.2	78947.2	120
39693.5	40236.0	115	79441.1	79774.4	120
40384.6	40448.3	120	79833.6	80360.0	100
40458.0	40708.7	110	80403.0	80465.0	120
40708.7	40772.5	80	80542.8	80605.2	120
40772.5	40839.1	110	80818.6	81220.1	105
40839.1	40901.0	80	81220.2	81246.0	115
41196.0	41286.7	80	81246.1	81505.3	100
41332.9	41420.4	80	81505.4	81546.1	110
41640.5	41735.6	80	81546.2	81598.7	115
41758.7	41852.7	80	81623.4	81714.2	120
42426.0	42503.5	120	81740.9	81833.2	120
42503.5	42564.1	80	82077.2	82147.9	120
42564.1	42585.1	120	82170.6	82231.7	120
42585.1	42645.4	80	83391.2	83543.2	120
42851.7	42911.0	50	83845.2	84056.2	120
42932.2	42989.9	50	84171.7	84258.5	115
43108.2	43183.2	120	84294.6	84527.1	115
43204.7	43265.5	120	84527.2	84642.9	110
43861.7	43958.4	120	84670.5	84786.4	110
44485.6	44582.3	120	85104.0	85294.0	100
44803.2	44922.1	120	85357.5	85718.6	110
45197.0	45657.0	105	85783.8	85851.9	75
45657.0	45962.6	105	85876.8	85944.9	75
46196.0	46259.7	120	86124.6	86192.5	75
46353.6	46435.4	120	86217.9	86285.8	75
47264.0	47324.0	115	87056.5	87500.0	55
47324.0	47735.2	65	87845.4	87939.8	90
47781.5	47833.2	70	88025.1	88126.0	90
48432.0	48791.5	115	88397.5	88676.4	70

Appendix. M Sample data of run-curve simulation for considering the capacity of Propulsion system (Speed Limit for Interoperability_4/7)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]	Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]
48791.5	49099.0	110	88753.6	88818.0	70
49099.0	49155.6	120	88924.0	89313.3	115
49559.6	49651.6	120	91224.1	91483.8	80
49797.9	49896.5	120	91541.4	91760.9	80
50044.3	50626.2	75	92130.6	92218.6	80
50647.4	50735.4	80	92239.8	92821.7	75
51105.1	51324.6	80	92821.7	93172.0	110
51324.6	51352.0	110	93172.0	93767.0	100
51382.2	51641.9	80	95032.8	95084.5	70
51641.9	51983.2	105	95130.8	95542.0	65
52672.1	52794.0	120	95602.0	95824.0	120
52820.2	52941.4	120	98830.6	99574.0	100
53161.9	53212.0	120	99574.0	99779.0	110
53212.0	53552.7	120	99894.0	99947.7	50
53604.5	53665.2	120	99968.2	100019.5	50
54205.5	54483.8	70	100220.7	100305.5	80
54739.2	54782.7	55	100329.3	100414.0	80
54802.9	54847.3	55	101089.0	101139.2	80
55361.5	55824.2	55	101162.6	101214.4	80
56132.0	56418.4	110	101467.9	101513.9	80
56560.7	56638.3	80	101536.3	101587.0	80
56663.3	56740.9	80	101965.0	102026.9	80
56921.0	56999.0	80	102093.4	102157.3	80
57024.0	57102.0	80	102408.0	102630.0	120
57147.0	57509.0	110	103404.0	104074.0	120
58080.0	58195.0	110	106539.6	106580.2	100
58223.0	58339.0	110	107246.5	107619.0	110
58367.0	58501.0	115	107619.0	107635.5	115
58608.0	58694.0	115	107635.5	108002.2	100
58810.0	59021.0	120	108002.2	108368.2	115
59400.0	59510.0	110	108368.2	108686.3	100
59511.0	59738.0	105	108686.3	108727.0	115
60634.0	60695.0	120	108893.2	109256.4	100
60718.0	60789.0	120	109449.0	110011.8	115
60897.0	61136.0	105	110011.8	110335.6	105
61137.0	61195.0	110	110386.8	110751.8	105
61196.0	61266.0	115	110998.2	111203.6	70
61292.0	61348.0	120	111223.7	111446.9	70
61374.0	61437.0	120	111774.0	112067.0	115
61646.0	62174.0	105	114935.8	115082.4	110

Appendix. M Sample data of run-curve simulation for considering the capacity of Propulsion system (Speed Limit for Interoperability_5/7)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]	Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]
62175.0	62351.0	115	115114.0	115319.0	115
62401.0	62463.0	120	116094.0	116354.0	115
63092.0	63425.0	120	117654.0	117979.0	115
63811.0	64190.0	105	118836.6	119279.5	105
64191.0	64648.0	115	120604.0	120884.0	115
64957.0	65030.0	120	121874.0	122074.0	120
65234.0	65631.0	75	122183.8	122257.0	100
65690.0	65776.0	120	122280.4	122353.4	100
65797.0	65883.0	120	122584.6	122798.4	80
66158.0	66227.0	115	122798.4	122829.7	120
66278.0	66372.0	120	122829.7	122912.1	100
66453.0	66738.0	115	122912.1	123174.0	120
67160.0	67700.0	105	128284.0	129689.0	115
69011.0	69209.0	105	130554.0	130938.1	100
69673.0	69961.0	120	138946.2	139109.0	115
70161.0	70270.0	115	139659.6	139856.3	100
70326.0	70435.0	115	139886.7	140017.2	100
70773.0	70882.0	115	140599.0	140899.0	120
70938.0	71047.0	115	141782.3	141974.4	110
71651.0	71753.0	120	142012.9	142253.8	75
71803.0	71928.0	120	142282.3	142369.0	75
71953.0	72046.0	120	142550.0	142728.5	55
75464.0	75552.0	120			
75749.0	75822.0	120			
76299.0	76774.0	115			
77434.0	77507.0	120			
77604.0	77743.0	100			
77810.0	77912.0	120			
78319.0	78394.0	120			
80789.0	81715.0	110			
82898.0	83352.0	100			
83773.0	83871.0	120			
84309.0	84385.0	120			
85080.0	85157.0	120			
85291.0	85381.0	120			
85816.0	86111.0	120			
86566.0	86651.0	120			
87085.0	87308.0	120			
90149.0	90779.0	115			
91801.7	91850.3	120			

Appendix. M Sample data of run-curve simulation for considering the capacity of Propulsion system (Speed Limit for Interoperability_6/7)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]	Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]
95306.9	95525.5	160			
95671.8	95800.8	160			
96775.2	96907.5	160			
97180.7	97409.2	160			
97711.5	97849.6	160			
98266.6	98967.5	110			
99094.2	99317.6	160			
99659.6	99865.8	160			
99897.0	100542.0	115			
100542.0	101202.6	120			
102000.8	102198.1	160			
102252.0	102662.7	115			
102730.4	102880.2	160			
103593.7	104384.9	160			
104665.9	104798.2	160			
105895.0	107643.5	160			
109599.1	111312.8	160			
111449.5	111566.8	160			
111686.6	111803.9	160			
112038.8	112203.2	160			
112526.7	112621.7	160			
112818.4	112977.1	160			
113359.3	113535.4	160			
113656.1	113773.4	160			
113953.6	114097.2	160			
114326.9	114593.9	160			
116817.4	117103.2	160			
118607.0	119000.0	160			
119495.6	119872.5	160			
121153.1	121270.9	160			
121359.5	121477.2	160			
128258.2	129116.3	160			
130883.9	131704.0	115			
131931.9	132160.3	160			
132276.1	132417.0	160			
132551.7	132683.9	160			
133069.0	133201.3	160			
134192.0	134519.4	120			
134631.1	134834.6	120			
135205.4	135430.2	120			

Appendix. M Sample data of run-curve simulation for considering the capacity of Propulsion system (Speed Limit for Interoperability_7/7)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]	Start Dist. [m]	End Dist. [m]	Speed Limit [km/h]
136010.6	136254.2	70			
136312.0	136343.1	115			
136343.1	136646.4	70			
136646.4	136972.0	115			
137201.9	137729.4	120			
138146.0	138352.0	120			
138352.0	138532.0	115			
138532.0	138827.0	105			
138827.0	139607.0	115			
139670.5	141360.9	80			

Appendix. N Sample data of run-curve simulation for considering the capacity of Propulsion system (Gradient for Interoperability_1/7)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Gradient [‰]	Start Dist. [m]	End Dist. [m]	Gradient [‰]
0	232	0	0	2602	-2
232	712	-5	2602	2840	20
712	1052	0	2840	3035.16	0
1052	1332	-5	3035.16	3259	5
1332	1967	0	3259	4039	10
1967	2267	8	4039	4334	34
2267	3510	0	4334	4514	10
3510	3840	5	4514	4972.68	-3
3840	4032	0	4972.68	5434	-10
4032	4162	5	5434	5894	-20
4162	4702	0	5894	6554	10
4702	6159.5	-5	6554	6951.5	4
6159.5	6917	5	6951.5	8134	0
6917	7287	0	8134	9927.75	-8
7287	8080.182	-6	9927.75	10334	0
8080.182	8532	5	10334	10965.25	-2
8532	8917	0	10965.25	11829	-10
8917	9457.5	-5	11829	12614	-5
9457.5	9719	-25	12614	12876.5	-9
9719	10514	-2	12876.5	13334	-5
10514	11112	5	13334	14819	-10
11112	11692	-2	14819	15734	-5
11692	13177	2	15734	16084	0
13177	14582	6	16084	16444	-10
14582	15097	0	16444	19394	-5
15097	15265.85	-5	19394	19994	-10
15265.85	15502	-25	19994	23434	-5
15502	15957	-4	23434	23834	0
15957	17291	2	23834	24084	-5
17291	17527	0	24084	25194	0
17527	17707	5	25194	25664	-10
17707	17992	0	25664	25914	5
17992	18304	-25	25914	26264	14
18304	18897	0	26264	26827	-15
18897	19397	-2	26827	27228	-5
19397	19692	0	27228	28734	0
19692	20172	10	28734	28994	-10
20172	20792	0	28994	29234	-5
20792	20992	10	29234	31274	0
20992	21982	0	31274	31674	5

Appendix. N Sample data of run-curve simulation for considering the capacity of Propulsion system (Gradient for Interoperability_2/7)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Gradient [‰]	Start Dist. [m]	End Dist. [m]	Gradient [‰]
21982	22262	25	31674	32144	-5
22262	22562	5	32144	32634	5
22562	23146	-25	32634	32984	0
23146	24152	0	32984	33134	5
24152	24352	-6	33134	33674	-5
24352	24887	0	33674	33884	5
24887	25212	24	33884	34034	0
25212	25498	0	34034	34474	-5
25498	25752	-3	34474	35134	5
25752	26121.52	-25	35134	35734	0
26121.52	26512	0	35734	36074	-5
26512	26772	10	36074	37334	0
26772	27547	0	37334	37474	-10
27547	27752	20	37474	38840	0
27752	28012	5	38840	39094	10
28012	28912	0	39094	39414	-5
28912	29232	-24	39414	40203.3	0
29232	30799	0	40203.3	40614	15
30799	31092	10	40614	41034	0
31092	31762	5	41034	41534	-10
31762	32252	0	41534	41774	-5
32252	32672	-15	41774	42324	0
32672	33417	10	42324	42969	10
33417	34139	5	42969	43274	0
34139	35247	10	43274	43654	-12
35247	35619.5	16	43654	43840.25	-8
35619.5	36787	0	43840.25	44099	0
36787	37552	-20	44099	44434	10
37552	37772	-5	44434	45404	0
37772	38017	-20	45404	45799	-10
38017	38337	0	45799	49745	0
38337	38602	-5	49745	50134	10
38602	38792	-8	50134	52034	0
38792	39462	6	52034	52427	-10
39462	39693.5	2	52427	52969	3
39693.5	40236	-10	52969	53372	-3
40236	40458	30	53372	54114	1
40458	40859	-34	54114	54371	-1
40859	41146.25	-4	54371	55034	2
41146.25	42182.4	0	55034	55814	0

Appendix. N Sample data of run-curve simulation for considering the capacity of Propulsion system (Gradient for Interoperability_3/7)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Gradient [‰]	Start Dist. [m]	End Dist. [m]	Gradient [‰]
42182.4	42426	5	55814	57101	2
42426	42610	-12	57101	57614	5
42610	43087	0	57614	57994	1
43087	43292	14	57994	58334	0
43292	44035.42	24	58334	58771	-20
44035.421	44467	5	58771	58974	-1
44467	44937	0	58974	59984	2
44937	45197	-5	59984	60374	-2
45197	45657	-24	60374	60834	0
45657	45962.63	-16	60834	61374	-1
45962.625	47042	0	61374	61674	-2
47042	47264	20	61674	61854	1
47264	47432	-10	61854	62174	-1
47432	48432	0	62174	62534	2
48432	48791.5	-8	62534	62994	0
48791.5	49099	-34	62994	63634	1
49099	49694	29	63634	64005	-1
49694	50337.6	15	64005	64371	1
50337.6	50752	5	64371	64854	-1
50752	51212	0	64854	65122	-10
51212	51352	-12	65122	65261	25
51352	51983.2	-23	65261	65814	3
51983.2	52882.4	3	65814	66634	-1
52882.4	53212	0	66634	67242	0
53212	53552.667	-6	67242	67934	1
53552.667	53942	24	67934	69238	-1
53942	55550	0	69238	69534	1
55550	55732	-10	69534	69814	0
55732	56132	-5	69814	70035	-2
56132	56418.4	-25	70035	70274	1
56418.4	57056	0	70274	70674	-1
57056	57259	-4	70674	72039	2
57259	57572	1	72039	72485	0
57572	57762	25	72485	73320	-4
57762	58052	0	73320	73656	1
58052	58281	-1	73656	73854	20
58281	58571	8	73854	74215	0
58571	58790	-5	74215	74495	-1
58790	59401	0	74495	74707	-15
59401	59512	-15	74707	75430	2

Appendix. N Sample data of run-curve simulation for considering the capacity of Propulsion system (Gradient for Interoperability_4/7)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Gradient [‰]	Start Dist. [m]	End Dist. [m]	Gradient [‰]
59512	59739	-20	75430	76127	-5
59739	60206	0	76127	76412	10
60206	60619	4	76412	76674	3
60619	60898	-2	76674	77322.2	0
60898	61138	-19	77322.2	77469.5	-15
61138	61197	-12	77469.5	78217	-1
61197	61267	-7	78217	78674	10
61267	61320	8	78674	79054	20
61320	61361	15	79054	79833.6	0
61361	61503	22	79833.6	80360	-25
61503	61620	25	80360	80514	0
61620	61833	10	80514	80689.8	8
61833	62176	-18	80689.8	81033.3	18
62176	62352	-8	81033.3	81246.1	-10
62352	62506	0	81246.1	81363.3	-25
62506	63032	25	81363.3	81505.4	-22
63032	63812	0	81505.4	81546.2	-15
63812	64192	-20	81546.2	81598.7	-8
64192	64649	-10	81598.7	81669	7
64649	65397	1	81669	81727.6	12
65397	65544	15	81727.6	81967.9	19
65544	66192	0	81967.9	82246.7	2
66192	66454	-3	82246.7	82659.6	-4
66454	66739	-10	82659.6	83127.3	0
66739	67436	5	83127.3	83354	20
67436	68159	-2	83354	83465.1	15
68159	68371	15	83465.1	84075.8	0
68371	68651	1	84075.8	84294.6	5
68651	69012	0	84294.6	84585	-8
69012	69210	-20	84585	84814	1
69210	69546	-1	84814	85104	0
69546	70381	4	85104	85294	-25
70381	70827	0	85294	85606.8	-1
70827	72192	-2	85606.8	85810	4
72192	72592	1	85810	86447.6	0
72592	72831	-1	86447.6	86734	25
72831	73052	2	86734	87134	5
73052	73332	0	87134	87316	10
73332	73628	-1	87316	88924	0
73628	74932	1	88924	89313.3	-24

Appendix. N Sample data of run-curve simulation for considering the capacity of Propulsion system (Gradient for Interoperability_5/7)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Gradient [‰]	Start Dist. [m]	End Dist. [m]	Gradient [‰]
74932	75624	-1	89313.3	89654	6
75624	76232	0	89654	89983.6	0
76232	77052	1	89983.6	90882.8	-3
77052	77605	-3	90882.8	91514	23
77605	77744	-25	91514	91654	12
77744	78012	10	91654	92114	0
78012	78495	1	92114	92528.4	-5
78495	78861	-1	92528.4	93172	-15
78861	79232	1	93172	93767	-29
79232	79872	-1	93767	94074.5	34
79872	80332	0	94074.5	94434	8
80332	80692	-2	94434	95434	0
80692	81012	1	95434	95602	10
81012	81192	-1	95602	95824	-20
81192	81492	2	95824	96903.4	0
81492	82032	1	96903.4	97209	16
82032	82492	0	97209	97669	24
82492	82882	2	97669	97929	5
82882	83892	-2	97929	98399	0
83892	84095	1	98399	98830.6	-5
84095	84532	20	98830.6	99574	-24
84532	84872	0	99574	99779	-14
84872	85252	-1	99779	100256	0
85252	85765	-5	100256	100440	12
85765	87052	-2	100440	100683.6	-5
87052	87832	0	100683.6	101719.8	0
87832	88495	-2	101719.8	102007	4
88495	88752	1	102007	102408	34
88752	89494	-1	102408	102630	-30
89494	89897	3	102630	103172.5	10
89897	90439	-3	103172.5	103404	-2
90439	90832	10	103404	104074	-6
90832	92732	0	104074	104264	8
92732	93121	-10	104264	104529	5
93121	97067	0	104529	104849	0
97067	97462	10	104849	105094	20
97462	98432	0	105094	105314	5
98432	98767	-10	105314	106079	20
98767	99025.75	0	106079	107246.5	0
99025.75	99212	8	107246.5	107619	-16

Appendix. N Sample data of run-curve simulation for considering the capacity of Propulsion system (Gradient for Interoperability_6/7)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Gradient [‰]	Start Dist. [m]	End Dist. [m]	Gradient [‰]
99212	99592	12	107619	108727	-10
99592	99897	0	108727	109449	-5
99897	100542	-10	109449	110194	-10
100542	101092	0	110194	110614	15
101092	101332	5	110614	111104	0
101332	101832	10	111104	111774	-5
101832	102252	0	111774	112067	-10
102252	102662.7	-15	112067	113634	0
102662.7	103452	0	113634	113954	24
103452	103772	5	113954	114854	0
103772	104026	-10	114854	115114	-5
104026	105392	0	115114	115319	-20
105392	105532	10	115319	116094	0
105532	106792	0	116094	116354	-10
106792	107132	5	116354	116744.5	0
107132	107732	0	116744.5	117114	25
107732	108392	-5	117114	117368	3
108392	108832	5	117368	117654	0
108832	108982	0	117654	117979	-24
108982	109192	-5	117979	118514	0
109192	109732	5	118514	118714	6
109732	109882	-5	118714	119720	0
109882	110232	0	119720	120304	25
110232	110722	-5	120304	120604	-5
110722	111192	5	120604	120884	-25
111192	111592	-5	120884	121874	0
111592	113632	0	121874	122074	-10
113632	113872	5	122074	122694	0
113872	114132	10	122694	123174	-10
114132	115638	0	123174	123469	0
115638	116039	5	123469	123969	2
116039	116602	15	123969	124562	0
116602	116952	-14	124562	124874	25
116952	117202	-5	124874	125159	0
117202	117672	10	125159	125339	-5
117672	118782	0	125339	125575	0
118782	119032	5	125575	126909	-2
119032	119432	0	126909	127364	4
119432	122872	5	127364	127600.2	25
122872	123472	10	127600.2	127769	5

Appendix. N Sample data of run-curve simulation for considering the capacity of Propulsion system (Gradient for Interoperability_7/7)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Gradient [‰]	Start Dist. [m]	End Dist. [m]	Gradient [‰]
123472	126422	5	127769	128284	0
126422	126782	10	128284	129689	-6
126782	127132	0	129689	131174	-2
127132	128047	5	131174	131754	2
128047	129532	10	131754	132352	-5
129532	129989.5	5	132352	133147	2
129989.5	130252	9	133147	133408.5	25
130252	131037	5	133408.5	133949	5
131037	131900.75	10	133949	134334	0
131900.75	132532	2	134334	134785.8	-5
132532	132938.25	0	134785.8	135579	6
132938.25	134732	8	135579	135949	0
134732	135914.5	0	135949	136706.5	-5
135914.5	136312	-4	136706.5	138164	5
136312	136972	-10	138164	138704	0
136972	137432	20	138704	138834	-5
137432	137893.32	10	138834	139026	0
137893.32	138352	3	139026	139356	-5
138352	138532	-10	139356	140599	0
138532	138827	-34	140599	140899	-8
138827	139607	-10	140899	141534	0
139607	139830.84	-5	141534	141814	5
139830.84	140026	0	141814	142154	0
140026	140264	-20	142154	142634	5
140264	142866	2	142634	142866	0

Appendix. O Sample data of run-curve simulation for considering the capacity of Propulsion system (Curvature Radius for Interoperability_1/12)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
0	135.8273	0	0	457.62313	0
135.8273	315.3181	-261	457.62313	504.77596	4500
315.3181	505.1298	0	504.77596	530.29392	0
505.1298	591.4698	-800	530.29392	577.44676	-4500
591.4698	612.1436	0	577.44676	1499.78454	0
612.1436	853.1046	304	1499.78454	3200.82249	-640
853.1046	891.6747	0	3200.82249	3910.88548	0
891.6747	1083.715	804	3910.88548	4291.99383	1204
1083.715	2181.1298	0	4291.99383	4371.18013	0
2181.1298	2244.7971	5004	4371.18013	4719.99339	-1200
2244.7971	2366.609	0	4719.99339	5136.61876	0
2366.609	2514.4688	-1400	5136.61876	5664.10437	-1500
2514.4688	2547.9003	0	5664.10437	6219.60976	0
2547.9003	2682.8934	1404	6219.60976	6522.9259	354
2682.8934	2848.7628	0	6522.9259	6611.76349	0
2848.7628	2979.143	1004	6611.76349	6855.41726	-350
2979.143	3009.5783	0	6855.41726	7435.75242	0
3009.5783	3206.4132	-600	7435.75242	7660.57508	1704
3206.4132	3448.0708	0	7660.57508	8031.36182	0
3448.0708	3571.6789	1804	8031.36182	8234.9113	-1200
3571.6789	3593.6366	0	8234.9113	8346.60953	0
3593.6366	3724.6036	-1800	8346.60953	8674.03727	1204
3724.6036	3756.9937	0	8674.03727	9664.74226	0
3756.9937	3919.9175	1104	9664.74226	9796.97421	5000
3919.9175	3959.7782	0	9796.97421	10182.00708	0
3959.7782	4115.0388	-1300	10182.00708	10314.37866	-5004
4115.0388	4558.1187	0	10314.37866	10448.89583	0
4558.1187	4639.3807	-4000	10448.89583	10589.92727	-5004
4639.3807	5241.0972	0	10589.92727	10705.81239	0
5241.0972	5322.3592	4004	10705.81239	10933.96955	5000
5322.3592	6377.2252	0	10933.96955	11162.00692	0
6377.2252	6480.8041	-2500	11162.00692	11982.10209	1104
6480.8041	6557.1733	0	11982.10209	13749.71787	0
6557.1733	6713.1384	1504	13749.71787	14607.83935	-1800
6713.1384	6861.9189	0	14607.83935	21388.76535	0
6861.9189	6972.2537	-2000	21388.76535	21506.51688	-5000
6972.2537	7226.2202	0	21506.51688	21595.12388	0
7226.2202	7336.555	-2000	21595.12388	21712.87542	5004
7336.555	7491.0521	0	21712.87542	22993.49921	0
7491.0521	7597.5869	2004	22993.49921	23370.39257	-1800

Appendix. O Sample data of run-curve simulation for considering the capacity of Propulsion system (Curvature Radius for Interoperability_2/12)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
7597.5869	8181.4232	0	23370.39257	23866.01268	0
8181.4232	8342.598	1304	23866.01268	24258.96782	2204
8342.598	8455.531	0	24258.96782	25762.82709	0
8455.531	8614.854	-1300	25762.82709	26048.55916	2504
8614.854	8835.023	0	26048.55916	28272.11875	0
8835.023	8998.7767	-1200	28272.11875	28539.14903	2504
8998.7767	9109.2742	0	28539.14903	28768.75933	0
9109.2742	9270.7239	1204	28768.75933	28912.35783	5004
9270.7239	11823.1749	0	28912.35783	29092.64161	0
11823.1749	11905.57	-3000	29092.64161	29209.93724	-6000
11905.57	11927.9212	0	29209.93724	29330.5821	0
11927.9212	12312.0219	604	29330.5821	29506.67174	6004
12312.0219	12332.2452	0	29506.67174	29888.9161	0
12332.2452	12430.3587	-3000	29888.9161	30047.64258	-6000
12430.3587	14327.5952	0	30047.64258	30244.25321	0
14327.5952	14391.2625	-5000	30244.25321	30339.28004	-6000
14391.2625	14416.9775	0	30339.28004	30662.79074	0
14416.9775	14506.1176	3304	30662.79074	30827.20836	5004
14506.1176	14594.9823	0	30827.20836	31062.14446	0
14594.9823	14659.9814	-5000	31062.14446	31179.4401	-6000
14659.9814	15065.8926	0	31179.4401	31299.24035	0
15065.8926	15127.892	-5000	31299.24035	31416.53598	6004
15127.892	15150.7149	0	31416.53598	31553.22952	0
15150.7149	15215.0662	5004	31553.22952	33266.89223	-2500
15215.0662	15669.2789	0	33266.89223	35222.49968	0
15669.2789	15735.2461	-5000	35222.49968	36971.02152	1804
15735.2461	16095.1959	0	36971.02152	38067.81744	0
16095.1959	16177.8778	3004	38067.81744	38200.11921	5004
16177.8778	16582.4801	0	38200.11921	38481.08061	0
16582.4801	16646.1309	-5000	38481.08061	39272.27647	-1800
16646.1309	16646.1309	0	39272.27647	39985.83698	0
16646.1309	19953.8713	0	39985.83698	40135.58139	-4000
19953.8713	20036.3023	1504	40135.58139	40667.91487	0
20036.3023	20067.6121	0	40667.91487	40865.16297	2804
20067.6121	20281.3707	-350	40865.16297	41663.43073	0
20281.3707	20512.5738	0	41663.43073	42442.30138	-1200
20512.5738	20585.6143	-2200	42442.30138	43000.18505	0
20585.6143	20609.0084	0	43000.18505	43206.36767	-2600
20609.0084	20682.1911	2204	43206.36767	43548.35597	0
20682.1911	21026.6445	0	43548.35597	43771.78421	-2500

Appendix. O Sample data of run-curve simulation for considering the capacity of Propulsion system (Curvature Radius for Interoperability_3/12)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
21026.6445	21145.4407	1804	43771.78421	43898.49014	0
21145.4407	21247.9414	0	43898.49014	44599.37113	804
21247.9414	21366.8539	-1800	44599.37113	45016.40705	0
21366.8539	21587.142	0	45016.40705	45154.53843	4004
21587.142	21712.4068	-1600	45154.53843	45456.81664	0
21712.4068	21803.768	0	45456.81664	45685.26562	-3000
21803.768	21942.3188	1500	45685.26562	45958.50728	0
21942.3188	22295.7653	0	45958.50728	46090.80904	5004
22295.7653	22397.0368	-2004	46090.80904	47065.18175	0
22397.0368	22428.1472	0	47065.18175	47194.16706	4004
22428.1472	22515.9805	3000	47194.16706	47340.52036	0
22515.9805	23586.5221	0	47340.52036	47559.05428	-3500
23586.5221	24029.4302	-750	47559.05428	50768.86642	0
24029.4302	24552.7376	0	50768.86642	50904.83805	-2000
24552.7376	24616.3883	5004	50904.83805	50935.42232	0
24616.3883	25052.929	0	50935.42232	51061.64791	2000
25052.929	25116.5797	-5000	51061.64791	51649.69048	0
25116.5797	25503.759	0	51649.69048	51680.5242	-18000
25503.759	25595.5283	2504	51680.5242	51733.53809	0
25595.5283	25620.5156	0	51733.53809	51764.29656	18000
25620.5156	25715.3861	-2500	51764.29656	52074	0
25715.3861	26858.796	0	52074	52703	1004
26858.796	26927.098	4504	52703	55558	0
26927.098	27783.6114	0	55558	55781	1204
27783.6114	27930.1608	-1400	55781	56215	0
27930.1608	28030.3787	0	56215	56300	5000
28030.3787	28167.8682	1604	56300	56755	0
28167.8682	28387.9706	0	56755	57050	1200
28387.9706	28493.3067	2204	57050	57485	0
28493.3067	28755.6832	0	57485	57575	4000
28755.6832	28853.8404	-2500	57575	57709	0
28853.8404	29100.9111	0	57709	57786	5004
29100.9111	29423.6645	-2500	57786	58481	0
29423.6645	30276.9169	0	58481	58557	5000
30276.9169	30337.6575	5004	58557	58995	0
30337.6575	31419.0857	0	58995	59093	3204
31419.0857	31642.346	-280	59093	59514	0
31642.346	31662.3794	0	59514	59968	654
31662.3794	31867.8262	284	59968	61151	0
31867.8262	32114.1675	0	61151	62077	900

Appendix. O Sample data of run-curve simulation for considering the capacity of Propulsion system (Curvature Radius for Interoperability_4/12)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
32114.1675	32479.172	704	62077	64472	0
32479.172	32530.375	0	64472	64547	5000
32530.375	32854.1521	-700	64547	64954	0
32854.1521	33609.5727	0	64954	65056	3504
33609.5727	33972.7775	604	65056	65359	0
33972.7775	34179.6774	0	65359	65432	5000
34179.6774	34497.7949	-600	65432	66092	0
34497.7949	34863.7939	0	66092	66567	1100
34863.7939	35230.4612	604	66567	67044	0
35230.4612	35763.4274	0	67044	67117	5004
35763.4274	35867.309	-1200	67117	67314	0
35867.309	35890.0377	0	67314	67402	5000
35890.0377	36016.9504	950	67402	70820	0
36016.9504	36121.4666	0	70820	70913	3204
36121.4666	36194.0681	-2000	70913	70938	0
36194.0681	36272.1417	0	70938	71063	2100
36272.1417	36368.196	1400	71063	71113	0
36368.196	36588.3162	0	71113	71215	4004
36588.3162	36720.3321	1500	71215	71819	0
36720.3321	36744.0151	0	71819	71928	1804
36744.0151	36867.6672	-1700	71928	71984	0
36867.6672	37226.8803	0	71984	72093	1800
37226.8803	37398.8551	1200	72093	72431	0
37398.8551	37419.9526	0	72431	72540	1800
37419.9526	37592.5597	-1200	72540	72596	0
37592.5597	37836.8585	0	72596	72705	1804
37836.8585	37940.8782	-2000	72705	72905	0
37940.8782	37961.8583	0	72905	73193	2000
37961.8583	38062.3887	2000	73193	75166	0
38062.3887	38282.5585	0	75166	75706	750
38282.5585	38395.2261	1000	75706	76233	0
38395.2261	38422.63	0	76233	76311	5000
38422.63	38535.3337	-1000	76311	76453	0
38535.3337	38648.44	0	76453	76577.72707	1500
38648.44	38709.2006	5004	76577.72707	76603	0
38709.2006	38790.0233	0	76603	76743.02841	1500
38790.0233	38892.0596	-2000	76743.02841	76939.83239	0
38892.0596	38914.9597	0	76939.83239	77076.92549	1300
38914.9597	39003.0295	3004	77076.92549	77076.92549	0
39003.0295	39099.2644	0	77076.92549	77214.01859	1300

Appendix. O Sample data of run-curve simulation for considering the capacity of Propulsion system (Curvature Radius for Interoperability_5/12)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
39099.2644	39170.5574	-4000	77214.01859	77235.09463	0
39170.5574	39195.6985	0	77235.09463	77632.10393	654
39195.6985	39326.7822	1504	77632.10393	77836.30285	0
39326.7822	39347.2655	0	77836.30285	77909.31691	5000
39347.2655	39452.9088	-2000	77909.31691	78874.22443	0
39452.9088	39494.0659	0	78874.22443	78947.23719	5004
39494.0659	39585.8787	2504	78947.23719	79441.09556	0
39585.8787	39766.8764	0	79441.09556	79774.42474	1204
39766.8764	39871.4393	-1900	79774.42474	80402.9635	0
39871.4393	40158.8487	0	80402.9635	80465.03433	5004
40158.8487	40219.6049	5004	80465.03433	80542.76095	0
40219.6049	40384.6362	0	80542.76095	80605.24813	5000
40384.6362	40448.3247	5004	80605.24813	80818.62267	0
40448.3247	40708.7063	0	80818.62267	81220.10734	700
40708.7063	40772.5261	-1200	81220.10734	81428.745	0
40772.5261	40839.1014	0	81428.745	81492.39572	5000
40839.1014	40900.96	1504	81492.39572	81518.43651	0
40900.96	41195.9552	0	81518.43651	81573.9308	5304
41195.9552	41286.6878	-750	81573.9308	81623.40566	0
41286.6878	41332.8936	0	81623.40566	81714.21577	2304
41332.8936	41420.3664	800	81714.21577	81740.85133	0
41420.3664	41640.5298	0	81740.85133	81833.23013	2300
41640.5298	41735.6433	700	81833.23013	82077.1629	0
41735.6433	41758.7459	0	82077.1629	82147.90978	5004
41758.7459	41852.7021	-700	82147.90978	82170.57378	0
41852.7021	42503.5092	0	82170.57378	82231.68806	5000
42503.5092	42564.0675	-1500	82231.68806	83391.23085	0
42564.0675	42585.0942	0	83391.23085	83543.15038	2004
42585.0942	42645.3569	1500	83543.15038	83845.23884	0
42645.3569	42851.6821	0	83845.23884	84056.15869	1504
42851.6821	42911.0378	600	84056.15869	84171.6954	0
42911.0378	42932.157	0	84171.6954	84258.48965	6004
42932.157	42989.9315	-600	84258.48965	84365.1497	0
42989.9315	43108.185	0	84365.1497	84498.4447	1600
43108.185	43183.2041	-4000	84498.4447	84527.20208	0
43183.2041	43204.7176	0	84527.20208	84642.87649	1500
43204.7176	43265.4654	5004	84642.87649	84670.45066	0
43265.4654	43861.7016	0	84670.45066	84786.3964	1504
43861.7016	43958.3536	-2500	84786.3964	85357.46009	0
43958.3536	44485.6115	0	85357.46009	85718.56291	800

Appendix. O Sample data of run-curve simulation for considering the capacity of Propulsion system (Curvature Radius for Interoperability_6/12)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
44485.6115	44582.2661	2504	85718.56291	85783.7892	0
44582.2661	44803.1705	0	85783.7892	85851.86861	1100
44803.1705	44922.0872	1804	85851.86861	85876.8336	0
44922.0872	45315.652	0	85876.8336	85944.91301	1100
45315.652	45420.8405	-2200	85944.91301	86124.5606	0
45420.8405	45734.4496	0	86124.5606	86192.4815	-1100
45734.4496	45812.9565	-4000	86192.4815	86217.9132	0
45812.9565	46196.0364	0	86217.9132	86285.834	1100
46196.0364	46259.6663	-5000	86285.834	87056.4963	0
46259.6663	46353.5976	0	87056.4963	87500.0126	-261
46353.5976	46435.3531	4004	87500.0126	87845.3597	0
46435.3531	47324.012	0	87845.3597	87939.8446	1000
47324.012	47735.2196	-300	87939.8446	88025.0933	0
47735.2196	47781.4507	0	88025.0933	88125.9524	-900
47781.4507	47833.164	-1200	88125.9524	88397.4515	0
47833.164	48692.4171	0	88397.4515	88676.4069	300
48692.4171	48870.358	1254	88676.4069	88753.5535	0
48870.358	48992.0863	0	88753.5535	88818.0363	1000
48992.0863	49155.6148	-1350	88818.0363	89200.7503	0
49155.6148	49559.6493	0	89200.7503	89261.491	5000
49559.6493	49651.6192	-2500	89261.491	89487.4024	0
49651.6192	49797.9416	0	89487.4024	89577.9459	2500
49797.9416	49896.4627	2504	89577.9459	89600.0717	0
49896.4627	50044.2978	0	89600.0717	89704.1492	-2004
50044.2978	50626.2202	314	89704.1492	89924.5799	0
50626.2202	50647.397	0	89924.5799	90045.8297	-1604
50647.397	50735.4477	-900	90045.8297	90072.1128	0
50735.4477	51105.1095	0	90072.1128	90193.9482	1650
51105.1095	51324.6045	354	90193.9482	91224.1052	0
51324.6045	51382.1507	0	91224.1052	91483.8423	-354
51382.1507	51641.9018	-350	91483.8423	91541.3891	0
51641.9018	52672.0518	0	91541.3891	91760.8969	350
52672.0518	52793.9637	1654	91760.8969	92130.5523	0
52793.9637	52820.2367	0	92130.5523	92218.603	-904
52820.2367	52941.4201	-1600	92218.603	92239.7634	0
52941.4201	53161.8508	0	92239.7634	92821.7186	310
53161.8508	53265.832	-2000	92821.7186	92969.5373	0
53265.832	53287.9652	0	92969.5373	93068.0584	2500
53287.9652	53378.5976	2504	93068.0584	93214.38	0
53378.5976	53604.509	0	93214.38	93306.3259	-2504

Appendix. O Sample data of run-curve simulation for considering the capacity of Propulsion system (Curvature Radius for Interoperability_7/12)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
53604.509	53665.2497	5004	93306.3259	93710.3779	0
53665.2497	54205.5165	0	93710.3779	93874.1836	-1354
54205.5165	54483.7723	300	93874.1836	93995.9118	0
54483.7723	54739.1703	0	93995.9118	94173.5244	1250
54739.1703	54782.7051	1700	94173.5244	95032.836	0
54782.7051	54802.8669	0	95032.836	95084.5493	-1204
54802.8669	54847.2818	-1200	95084.5493	95130.788	0
54847.2818	55361.5367	0	95130.788	95541.9804	-304
55361.5367	55824.2282	-261	95541.9804	96430.6469	0
55824.2282	56560.6905	0	96430.6469	96512.3457	4000
56560.6905	56638.2734	-1000	96512.3457	96606.277	0
56638.2734	56663.2692	0	96606.277	96669.9418	-5004
56663.2692	56740.8521	1000	96669.9418	97053.1567	0
56740.8521	56921	0	97053.1567	97131.6241	-4004
56921	56999	1000	97131.6241	97445.1595	0
56999	57024	0	97445.1595	97550.4095	-2204
57024	57102	1000	97550.4095	97943.9128	0
57102	57147	0	97943.9128	98062.8295	1800
57147	57509	804	98062.8295	98283.7339	0
57509	58080	0	98283.7339	98380.3885	2500
58080	58195	1500	98380.3885	98907.5712	0
58195	58223	0	98907.5712	99004.2984	-2504
58223	58339	1504	99004.2984	99600.5346	0
58339	58367	0	99600.5346	99661.2824	5000
58367	58501	1604	99661.2824	99682.7959	0
58501	58608	0	99682.7959	99757.815	-4004
58608	58694	6000	99757.815	99893.9992	0
58694	58810	0	99893.9992	99947.6655	900
58810	59021	1500	99947.6655	99968.2447	0
59021	59323	0	99968.2447	100019.4601	-900
59323	59475	2000	100019.4601	100220.6593	0
59475	60634	0	100220.6593	100305.4713	-900
60634	60695	5004	100305.4713	100329.2682	0
60695	60718	0	100329.2682	100413.9924	900
60718	60789	5000	100413.9924	101088.9724	0
60789	61033	0	101088.9724	101139.2372	-2500
61033	61125	2304	101139.2372	101162.6276	0
61125	61152	0	101162.6276	101214.4452	2200
61152	61243	2300	101214.4452	101467.8612	0
61243	61292	0	101467.8612	101513.8564	2300

Appendix. O Sample data of run-curve simulation for considering the capacity of Propulsion system (Curvature Radius for Interoperability_8/12)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
61292	61348	5300	101513.8564	101536.3277	0
61348	61374	0	101536.3277	101586.9531	-2300
61374	61437	5004	101586.9531	101965.0406	0
61437	61646	0	101965.0406	102026.9275	1500
61646	62047	704	102026.9275	102093.3885	0
62047	62261	0	102093.3885	102157.2937	-1204
62261	62323	5004	102157.2937	102417.6753	0
62323	62401	0	102417.6753	102481.3288	5000
62401	62463	5000	102481.3288	102646.3961	0
62463	63092	0	102646.3961	102707.1198	5000
63092	63425	1200	102707.1198	102994.5291	0
63425	63919	0	102994.5291	103099.228	-1904
63919	63992	5000	103099.228	103280.1568	0
63992	64957	0	103280.1568	103371.874	2500
64957	65030	5004	103371.874	103413.0311	0
65030	65234	0	103413.0311	103518.8139	-2004
65234	65631	650	103518.8139	103539.322	0
65631	65690	0	103539.322	103670.2553	1500
65690	65776	3000	103670.2553	103695.3963	0
65776	65797	0	103695.3963	103766.7356	-4004
65797	65883	3000	103766.7356	103862.9705	0
65883	66158	0	103862.9705	103950.9612	3000
66158	66227	5000	103950.9612	103973.8407	0
66227	66278	0	103973.8407	104075.9537	-2004
66278	66372	3000	104075.9537	104156.8138	0
66372	66555	0	104156.8138	104217.5519	5000
66555	66633	5004	104217.5519	104804.1061	0
66633	67160	0	104804.1061	104924.254	-1700
67160	67700	754	104924.254	104946.995	0
67700	69673	0	104946.995	105063.1391	1800
69673	69961	2004	105063.1391	105307.6873	0
69961	70161	0	105307.6873	105411.5445	2000
70161	70270	1800	105411.5445	105437.5881	0
70270	70326	0	105437.5881	105542.4649	-2000
70326	70435	1804	105542.4649	106140.8822	0
70435	70773	0	106140.8822	106201.6044	5000
70773	70882	1804	106201.6044	106539.6106	0
70882	70938	0	106539.6106	106580.1536	-5000
70938	71047	1800	106580.1536	106973.9466	0
71047	71651	0	106973.9466	107109.4205	1500

Appendix. O Sample data of run-curve simulation for considering the capacity of Propulsion system (Curvature Radius for Interoperability_9/12)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
71651	71753	4000	107109.4205	107635.5369	0
71753	71803	0	107635.5369	108002.208	600
71803	71928	2104	108002.208	108368.2068	0
71928	71953	0	108368.2068	108686.3208	-604
71953	72046	3200	108686.3208	108893.2206	0
72046	75464	0	108893.2206	109256.4292	600
75464	75552	5004	109256.4292	110011.8489	0
75552	75749	0	110011.8489	110335.6241	-704
75749	75822	5000	110335.6241	110386.827	0
75822	76299	0	110386.827	110751.8335	700
76299	76774	1104	110751.8335	110998.1635	0
76774	77434	0	110998.1635	111203.6309	280
77434	77507	5004	111203.6309	111223.6647	0
77507	77810	0	111223.6647	111446.9036	-284
77810	77912	3500	111446.9036	112528.3425	0
77912	78319	0	112528.3425	112589.0831	5000
78319	78394	5004	112589.0831	113442.3355	0
78394	80789	0	113442.3355	113765.0889	-2504
80789	81715	904	113765.0889	114012.1596	0
81715	82898	0	114012.1596	114110.3168	-2504
82898	83352	650	114110.3168	114372.6933	0
83352	83773	0	114372.6933	114478.0294	2200
83773	83871	3200	114478.0294	114698.1318	0
83871	84309	0	114698.1318	114835.6213	1600
84309	84385	5004	114835.6213	114935.8393	0
84385	85080	0	114935.8393	115082.3885	-1404
85080	85157	5000	115082.3885	115938.902	0
85157	85291	0	115938.902	116007.204	4500
85291	85381	4004	116007.204	117150.6139	0
85381	85816	0	117150.6139	117245.4844	-2504
85816	86111	1204	117245.4844	117270.4717	0
86111	86566	0	117270.4717	117362.241	2500
86566	86651	5004	117362.241	117749.4203	0
86651	87085	0	117749.4203	117813.071	-5004
87085	87308	1200	117813.071	118249.6117	0
87308	90149	0	118249.6117	118313.2624	5000
90149	90779	1000	118313.2624	118836.5705	0
90779	91801.6727	0	118836.5705	119279.4772	-754
91801.6727	91850.31611	-8000	119279.4772	120349.9423	0
91850.31611	95306.94573	0	120349.9423	120437.93	3004

Appendix. O Sample data of run-curve simulation for considering the capacity of Propulsion system (Curvature Radius for Interoperability_10/12)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
95306.94573	95525.47963	-3504	120437.93	120469.0853	0
95525.47963	95671.83294	0	120469.0853	120570.1125	-2000
95671.83294	95800.81825	4000	120570.1125	120923.458	0
95800.81825	96775.19096	0	120923.458	121062.4551	1504
96775.19096	96907.49272	5000	121062.4551	121153.5932	0
96907.49272	97180.73439	0	121153.5932	121278.8579	-1604
97180.73439	97409.18335	-3004	121278.8579	121499.1461	0
97409.18335	97711.46157	0	121499.1461	121618.0586	-1804
97711.46157	97849.59295	4000	121618.0586	121720.5593	0
97849.59295	98266.62658	0	121720.5593	121839.3555	1800
98266.62658	98967.51215	800	121839.3555	122183.8089	0
98967.51215	99094.21581	0	122183.8089	122256.9916	2200
99094.21581	99317.64401	-2504	122256.9916	122280.3857	0
99317.64401	99659.63235	0	122280.3857	122353.4262	-2204
99659.63235	99865.81494	-2604	122353.4262	122584.6357	0
99865.81494	100423.699	0	122584.6357	122798.3816	-354
100423.699	101202.5689	-1204	122798.3816	122829.6977	0
101202.5689	102000.837	0	122829.6977	122912.1287	1500
102000.837	102198.0851	2800	122912.1287	126219.8691	0
102198.0851	102730.4186	0	126219.8691	126283.5199	-5004
102730.4186	102880.163	-4004	126283.5199	126688.1222	0
102880.163	103593.7238	0	126688.1222	126770.8041	3000
103593.7238	104384.9191	-1804	126770.8041	127130.7538	0
104384.9191	104665.8808	0	127130.7538	127196.7229	-5004
104665.8808	104798.1826	5000	127196.7229	127650.9356	0
104798.1826	105894.978	0	127650.9356	127715.2515	5000
105894.978	107643.5008	1800	127715.2515	127738.0744	0
107643.5008	109599.1078	0	127738.0744	127800.1074	-5004
109599.1078	111312.7704	-2504	127800.1074	128206.0187	0
111312.7704	111449.464	0	128206.0187	128271.0538	-5004
111449.464	111566.7597	6000	128271.0538	128359.9184	0
111566.7597	111686.5599	0	128359.9184	128448.9663	3300
111686.5599	111803.8555	-6004	128448.9663	128474.6469	0
111803.8555	112038.7916	0	128474.6469	128538.3262	-5004
112038.7916	112203.2093	5000	128538.3262	130435.6413	0
112203.2093	112526.72	0	130435.6413	130533.7548	-3004
112526.72	112621.7468	-6004	130533.7548	130553.9761	0
112621.7468	112818.3574	0	130553.9761	130938.0807	600
112818.3574	112977.0839	-6004	130938.0807	130960.43	0
112977.0839	113359.3283	0	130960.43	131042.8251	-3004

Appendix. O Sample data of run-curve simulation for considering the capacity of Propulsion system (Curvature Radius for Interoperability_11/12)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
113359.3283	113535.4179	6000	131042.8251	133595.276	0
113535.4179	113656.0628	0	133595.276	133756.7259	1200
113656.0628	113773.3584	-6004	133756.7259	133867.2234	0
113773.3584	113953.6422	0	133867.2234	134030.9769	-1204
113953.6422	114097.2407	5000	134030.9769	134251.1461	0
114097.2407	114326.851	0	134251.1461	134410.469	-1304
114326.851	114593.8813	2500	134410.469	134523.4019	0
114593.8813	116817.4408	0	134523.4019	134684.5769	1300
116817.4408	117103.1729	2500	134684.5769	135268.4131	0
117103.1729	118607.0321	0	135268.4131	135374.9479	2000
118607.0321	118999.9874	2200	135374.9479	135529.445	0
118999.9874	119495.6076	0	135529.445	135639.7798	-2004
119495.6076	119872.5006	-1804	135639.7798	135893.7463	0
119872.5006	121153.1246	0	135893.7463	136004.0811	-2004
121153.1246	121270.8761	5000	136004.0811	136152.8615	0
121270.8761	121359.4831	0	136152.8615	136308.8267	1500
121359.4831	121477.2347	-5004	136308.8267	136385.1959	0
121477.2347	128258.1609	0	136385.1959	136488.7748	-2504
128258.1609	129116.2819	-1804	136488.7748	137543.6408	0
129116.2819	130883.8973	0	137543.6408	137624.9028	4000
130883.8973	131703.9937	1100	137624.9028	138226.6193	0
131703.9937	131931.8839	0	138226.6193	138307.8813	-4004
131931.8839	132160.3342	5004	138307.8813	138750.9541	0
132160.3342	132276.1495	0	138750.9541	138906.3366	-1304
132276.1495	132417.0274	-5000	138906.3366	138946.1972	0
132417.0274	132551.6912	0	138946.1972	139108.9898	1100
132551.6912	132683.9231	-5000	139108.9898	139141.3797	0
132683.9231	133068.956	0	139141.3797	139272.5266	-1804
133068.956	133201.3276	5004	139272.5266	139294.4844	0
133201.3276	134191.9625	0	139294.4844	139417.9292	1800
134191.9625	134519.3907	1200	139417.9292	139659.5511	0
134519.3907	134631.0889	0	139659.5511	139856.2829	-604
134631.0889	134834.638	-1204	139856.2829	139886.7389	0
134834.638	135205.4249	0	139886.7389	140017.2372	1000
135205.4249	135430.2476	1700	140017.2372	140183.1154	0
135430.2476	136010.5948	0	140183.1154	140318.2237	1400
136010.5948	136254.2244	-354	140318.2237	140351.6726	0
136254.2244	136343.0607	0	140351.6726	140499.4737	-1404
136343.0607	136646.4037	350	140499.4737	140621.2029	0
136646.4037	137201.8958	0	140621.2029	140684.8353	5000

Appendix. O Sample data of run-curve simulation for considering the capacity of Propulsion system (Curvature Radius for Interoperability_12/12)

Forward			Return		
Start Dist. [m]	End Dist. [m]	Curvature Radius [m]	Start Dist. [m]	End Dist. [m]	Curvature Radius [m]
137201.8958	137729.3811	-1504	140684.8353	141782.2845	0
137729.3811	138146.0068	0	141782.2845	141974.3669	800
138146.0068	138494.8196	-1204	141974.3669	142012.9265	0
138494.8196	138570.7255	0	142012.9265	142253.845	300
138570.7255	138951.9333	1200	142253.845	142282.3067	0
138951.9333	139670.4948	0	142282.3067	142368.9996	-805
139670.4948	141360.8982	-644.8	142368.9996	142550.0013	0
141360.8982	142866	0	142550.0013	142728.5496	-261
			142728.5496	142866	0