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GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS



RDSO SPECIFICATION
FOR
BROADBAND INTERNET ON RUNNING TRAINS THROUGH TWO-WAY
SATELLITE COMMUNICATION

SPECIFICATION NO. RDSO/SPN/TC/96/2010
Version 3.0

TELECOM DIRECTORATE
RESEARCH DESIGNS & STANDARDS ORGANISATION
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Title of Document RDSO Specification for Broadband Internet on Running Trains through Two-Way Satellite Communication		
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Abstract This document defines technical specification of Broadband Internet on Running Trains through Two-Way Satellite Communication.		

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RDSO SPECIFICATION
FOR
BROADBAND INTERNET ON RUNNING TRAINS THROUGH
TWO-WAY SATELLITE COMMUNICATION

1. FOREWORD:

- 1.1. Broadband Internet on Running Train can be provided using Two-Way Satellite Communication, as was demonstrated during 2009/2010 in Mumbai-Ahmadabad Shatabdi Express.
- 1.2. Subsequently, a Pilot Project for provision of “Internet facility in New Delhi-Howrah Rajdhani Express Train (3 Rakes)” was undertaken on Indian Railways. This Specification has been prepared based on the experience of Pilot Project.
- 1.3. This specification requires references to the following standards specifications:

SN	Specification No.	Description
1	IS-9000 (Series)	Basic Environment Testing Procedure for Electronic and Electrical items.
2	TEC/IR/SCB- 08/02. September 2009	Communication and Broadcast Networks for FSS /BSS. Mandatory Technical Interface Requirement.

Wherever reference to any of the above specification appears in this document, it shall be taken as a reference to the latest version of the specification unless the year of issue of the specification is specifically stated. Version 3.0 of the specification have been prepared by RDSO, Lucknow as per DG/RDSO letter No. DG/Misc. dated 10.06.2020

2. SCOPE:

- 2.1 This Specification covers the Functional & Technical requirements of Two-Way Satellite Communication Equipments installed over a Train by System Provider for providing Downlink as well as Uplink with Satellite.
- 2.2 This specification covers the Functional & Technical requirements of On-Train Terrestrial Communication Equipment installed over a Train by System Provider for providing Broadband Internet Coverage when Satellite Communication Link is not available.
- 2.3 This specification also covers the Functional & Technical requirements of Networking & Wireless Equipments installed over a Train by System Provider for providing Wireless Coverage inside all the Coaches of the Train.
- 2.4 This specification also covers the Functional & Technical requirements of Control, Monitoring & Network Security Systems installed over a Train and at Satellite Earth Station by System Provider for Controlling, Monitoring & Ensuring Secured Access to Internet.

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- 2.5 This specification also covers the Functional & Technical requirements of arrangements to be made/ additional equipments to be installed, commissioned and integrated with existing Satellite Earth Station by System Provider for providing communication with Satellite and for providing connectivity to Internet for selected users.
- 2.6 Equipments like Antenna Control Unit, Satellite Modem, 24 Port CORE Switch (if provided)-etc. to be provided by System Provider shall be 19” Rack Mountable and mounted on Standard 19” Rack. There shall also be provision of spare slots in main Rack System for future up-gradation.
- 2.7 It will be the responsibilities of Purchaser to provide required Internet Bandwidth at Satellite Hub. Internet Bandwidth shall normally be provided through RailTel.
- 2.8 Public IP Address, if any required at Satellite Hub of Indian Railway for Remote Control & Monitoring shall be provided by Purchaser.

3. SYSTEM COMPOSITION:

- 3.1 System providing Broadband Internet on Running Trains through Two-Way Satellite Communication comprises of following key components.
- Ku Band Satellite Transponder Bandwidth
 - Augmentation/ Arrangements required for Satellite Earth Station
 - On-Train Satellite Communication Equipments
 - On-Train Terrestrial Communication Equipment
 - On-Train Wireless Broadcasting Equipment
 - On-Train Networking Equipments
 - Control, Monitoring & Network Security Systems
- 3.2 **Availability:** Level of redundancy required for key equipments which may create Single Point of Failure in complete Communication Link may be decided by Purchaser.

4. FUNCTIONAL REQUIREMENTS:

- 4.1. The System shall provide Broadband Internet Connections over Running Trains using Two-Way Satellite Communication in Ku Band.
- 4.2. System shall provide Broadband Internet Connections to upto **500** users simultaneously in a Running Train. Further, System shall be upgradable to provide Broadband Internet Connections to additional 250 Users simultaneously in a Running Train without affecting its performance.
- 4.3 The System shall provide a minimum of 2 Mbps Data Connection (Download) from Internet to each Running Train with BER of 1 in 10^6 for 99.5% of Time Duration in a Complete Year.
- 4.4. The System shall provide a minimum of 512 Kbps Data Connection (Upload) from Each Running Train to Internet with BER of 1 in 10^6 for 99.5% of Time Duration in a Complete Year.

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- 4.5. The System shall provide Broadband Internet coverage for minimum 98% of Train Route. Further, the System shall maintain Internet Session of “On-Train Users”, should the connectivity be interrupted for period upto 5 Minutes.
- 4.6. The System shall not require any Inter-Coach Cabling to be done on the Trains Set for broadcasting of Internet Traffic to Passenger Coaches. This Broadcasting of Internet Traffic shall be on Wireless Media for which License Free Frequency Bands should be used.
- 4.7. The Transmission Mode of Outbound Traffic from Satellite Hub to Train and Inbound Traffic from Train to Satellite Hub shall be suitably selected and implemented utilizing widely accepted techniques for effective spectrum optimization.
- 4.8. System Provider shall carry out Link Budget Calculation for Forward Link(Satellite Hub to Train) and Return Link(Train to Satellite Hub) and submit to Purchaser for review before supply and installation of System.
- 4.9. System shall provide a defined maximum contention ratio of the connection to internet backbone of 1:1 Maximum.
- 4.10. System shall be able to support all common forms of the internet applications including but not limited to : Web Browsing (http), Email-POP3, SMTP, Email-IMAP, Email-Exchange, Instant Messaging, VPN, VOIP, Music Streaming, Video Streaming etc.
- 4.11. System shall be capable of establishing separate VLANs for different category of users. LAN Firewall and WLAN Firewall shall be provided. Firewall shall be 4 or more layered.
- 4.12. Security Software such as Antivirus, Anti-Intrusion Prevention and Secured Authentication Process shall be provided.
- 4.13. System shall direct end users to a dedicated portal page as passengers first open their Internet Browser. At the dedicated portal page, passengers will be required to enter details including at least Name, PNR No and Mobile No. to access Internet Services. On entering Name, PNR No and Mobile No., User Id and Password will be generated by the System and sent automatically to Passenger’s Mobile Phone via SMS. Using these User Id and Password On-Train Internet Services can be accessed by Passenger. Compliance to any other required regulatory provisions for Public Internet shall be responsibility of supplier/ system provider.
- 4.14. System shall provide full Network Monitoring, Performance Logging, Statistics & Management Reporting. Out of band Maintenance Channel between Train and Remote Maintenance Centre shall be provided.
- 4.15. System shall provide Traffic Prioritizing based on Traffic Type. System shall also provide local on-board Web Caching to have better user experience.
- 4.16. The System shall comply with all prevailing Cyber Law and/or Internet Security Law and various stipulations in this regard of Government in India.
- 4.17. All requisite Statutory and Regulatory clearances shall be obtained from DOT, Ministry of Information & Broadcasting, DOS, NOCC, SACFA and WPC by Purchaser/System Provider as applicable.
- 4.18. System Provider shall be required to demonstrate satisfactory working of complete system as proposed to be supplied as detailed under Clause 10.0 of this specification.

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4.19 System shall be capable of providing efficient bandwidth management for multiple trains on move using demand-assignment scheme and use mature / proven open source satellite communication standards, such as DVB-S2 / MF-TDMA/ DVB-RCS.

5. TECHNICAL REQUIREMENTS:

5.1. Satellite Transponder Bandwidth: For providing Broadband Data Communication Link between Satellite Hub and Running Train, INSAT 4CR Satellite shall preferably be used. Salient Technical Parameters of INSAT 4CR are given for System Design:

SN	Technical Parameters	
1	Saturated EIRP	51.5 dBW
2	Saturation Flux Density	-84 to -96 dBW/m ² (-88 dBW/m ² normal)
3	Saturated Rx, G/T Minimum	+3 dB/°K
4	Transponder Bandwidth	36 MHz
5	Input Back-Off	4 dB
6	Output Back-Off	2.5 dB
7	Satellite Tx Antenna Gain	31.5 dBi

***NOTE:** If Purchaser decides to use Ku Band Satellite other than INSAT 4CR, compatible Technical Parameters shall be ascertained by Purchaser and advised to System Provider for System Design.*

5.1.1 Requirement of Transponder Bandwidth at Ku Band Satellite shall be indicated by System Provider to Purchaser which shall be arranged by Purchaser. System Provider shall deploy necessary Hardware & Software to effectively use Transponder Bandwidth for provision of Broadband Internet in Running Train.

5.2. Augmentation/ Arrangement required at Satellite Earth Station: Indian Railways has established its own Satellite Earth Station for Indian Railway VSAT Applications at New Delhi. This Satellite Hub has been set-up by M/s Huges Communication India Ltd. Necessary augmentation of existing HUB shall be ensured by the Purchaser for this purpose.

5.2.1 Above mentioned Satellite Earth Station for Indian Railway shall preferably be used for provision of Broadband Internet connectivity over Running Trains. In case augmentation of existing HUB is not feasible, requisite arrangements for HUB shall be ensured by the Purchaser.

5.2.2 Additional equipments required at Satellite Earth Station for provision of Broadband Internet Connectivity over Running Trains shall be provided by the System Provider and shall generally include *RF Chain comprising of Power Amplifier and Low Noise Amplifiers/ LNB, up and down convertors, wave guide, splitters, combiners, L band HUB, Compatible Satellite Modems, IP Switching Equipments, Manageable Router, Monitoring-Control & Network Security Systems with licensed Security Software, servers, firewall, NOC management etc.*

***NOTE:** If Purchaser decides to use Satellite Earth Station other than that mentioned above, location of such identified Satellite Earth Station shall be informed to System Provider for ascertaining the requirement of additional equipments and their provision.*

5.3 On-Train Satellite Communication Equipments: For providing Broadband Data Communication Link with Satellite, following minimum equipments shall be provided for each rake of the Train: Satellite Modem, Block Up-Convertor, Antenna Control Unit, Satellite Tracking Antenna, Block Down-Converter, Circulator, Connectors, Cables etc. shall be provided at each Train.

5.3.1 On-Train Satellite Communication Equipments should meet the following requirements.

SN	Parameter	Requirement
1	EIRP Stability	+ 0.5 dB/24 Hrs
2	Transmit IM Products	23 dB below two equal carriers at 6 dB output back-off.
3	Transmit Harmonics	Better than -40 dBc upto 2nd Harmonic.
4	Frequency Stability	Better than 1 PPM over the temperature range of -5°C to +60°C
5	Long Term Frequency Stability	Better than 0.1 PPM over a day.
6	Maximum On-Axis Uplink EIRP Density	47.62 dBW/40 KHz.
7	Maximum Permissible Off-Axis EIRP Density Limits (Off Axis Angle in Degree)	(39-25 log ϕ) dBW/40 KHz for $2.5 < \phi < 7$ 18.0 dBW/40 KHz for $7 < \phi < 9.2$ (45-25 log ϕ) dBW/40 KHz for $9.2 < \phi < 48$ 0 dBW/40 KHz for $48 < \phi < 180$

5.3.2 Satellite Tracking Antenna: Satellite Tracking Antenna to be provided for each Train shall maintain connectivity whilst Train is stationary, moving, tilting, accelerating, decelerating, changing directions etc. and should meet with following minimum specification.

SN	Parameter	Requirement
1	Transmission Frequency Range	14.00-14.50 GHz Ku Band
2	Reception Frequency Range	10.70-12.75 GHz Ku Band
3	Type	Aluminium Reflector Or Any other light weight reflector suitable for the specified application in this specification and meeting requisite TEC's Mandatory Technical Interface Requirements.
4	Feed	Cassegrain Feed Or Suitable feed for the specified application in this specification and meeting requisite TEC's Mandatory Technical Interface Requirements.
5	Antenna G/T	16.6 dB/°K Minimum.
6	Polarization	As required for operation with identified satellite & as per Mandatory Technical Interface Requirements

		no TEC/IR/SCB-08/02 SEP 2009 of Telecommunication Engineering Centre (TEC) for Polarization.
7	Tracking Antenna Pedestal :	
	(i) Type	Two-Axis: Elevation and Azimuth, plus stabilized polarization, motorized skew adjustment.
	(ii) Stabilization	3 Dimensional Velocity Mode Servo
	(iii) Stab Accuracy	1.5° Maximum, 0.7° RMS in presence of allowed motion.
	(iv) Azimuth Reference	Closed Loop Tracking on Satellite Signal
	(v) Tracking Rate Roll/Pitch AZ./Turn	> 30°/Second > 20°/Second
	(vi) Range of Motion Elevation Azimuth Polarization	+18° to +80° 680° 180 (Horizontal +/- 45° Or Vertical +/- 45°)
	(vii) Maximum Vehicle Motion Roll Pitch Turn	6° 2° 15°/Second
8	Power Supply	To be provided by Antenna Control Unit.

5.3.2.1 It shall be possible to install Satellite Antenna & it's Tracking system along-with Radome within the cavity (as shown in RDSO layout number CG-12044 of LHB power car) and without any infringement of Schedule of Dimensions (SOD) of IR.

5.3.3 Antenna Control Unit (ACU): Antenna Control Unit (ACU) to be provided for controlling Satellite Tracking Antenna.

5.3.3.1 ACU shall be designed and manufactured so as to be inherently reliable, easy to maintain, and simple to operate.

5.3.3.2 ACU shall essentially permit unattended operation except for Start-Ups or for changing operation with different transponders or satellites.

5.3.3.3 ACU shall be Standard 19" Rack Mountable. ACU Front Panel should have Function Key and Display for selecting desired information to be displayed or changed.

5.3.3.5 ACU should automatically calculate the Elevation, Azimuth and Polarization pointing Angle based on Train Longitude & Latitude and the desired Satellite Longitude Position. Further, ACU should allow automatic scanning of the area of desired satellite if no signal is found.

5.3.3.6 ACU should have necessary Monitoring & Control Interface with Satellite Tracking Antenna Pedestal for supplying Power Supply to Antenna Pedestal and for Monitoring & Controlling it operation.

5.3.3.7 ACU should have inbuilt Satellite Tracking Receiver to keep the Antenna peaked on Satellite if Satellite Input Signal is available. This Satellite Tracking Receiver should allow coverage of L-Band (950-2150 MHz) and should be compatible with communication characteristic of Satellite.

5.3.3.8 ACU shall provide suitable Power Supply to Satellite Tracking Antenna for its Searching & Tracking operations.

5.3.3.9 Further ACU shall meet with following minimum specification.

SN	Parameter	Requirement
1	Input Supply Voltage	110 VAC, 50 Hz
2	Status indicator Display	Display for Tracking, Searching, Target, Power, Initializing and Error.
3	NMEA Interface	External Interface for External Use of GPS Sentences.
4	Ethernet Interface	10 Base T, RJ-45 for viewing and setting ACU Parameters and viewing the current ACU Status.

5.3.4 Block Up-Converter (BUC): Block Up-Converter (BUC) a combination of Block Up-Converter and High Power Amplifier (HPA) shall be suitably located near the Antenna Feed or embedded in antenna pedestal baseplate.

5.3.4.1 BUC shall be supplied as per the requirement of Allocated Satellite Frequency and Link Budget Calculations. However BUC shall meet with following minimum specification.

SN	Parameter	Requirement
1	Input Frequency	950-1450 MHz
2	Output Frequency	14.00-14.50 GHz
3	Input VSWR	2.0 : 1 Maximum
4	Output VSWR	2.1 : 1 Maximum
5	Linear Gain	56 dB Minimum (including variation over frequency and temperature)
6	Output Power @ 1 dB GCP	36 dBm Minimum
7	Power Requirement	Power Requirement to be met through IF Connector.
8	Power Consumption	100 Watt Maximum.
9	I/P O/P Interface	Compatible I/P & O/P Interface

5.3.5 Low Noise Block Down-Converter (LNB): Low Noise Block Down-Converter (LNB) combination of Low-Noise Amplifier and Block Down-Converter shall be provided near the Antenna Feed.

5.3.5.1 LNB shall be supplied as per the requirement of Allocated Satellite Frequency and Link Budget Calculations. However LNB shall meet with following minimum specification.

SN	Parameter	Requirement
1	Input Frequency	10.7-12.75 GHz
SN	Parameter	Requirement
2	Output Frequency	950-2150 MHz
3	Input VSWR	2.2 : 1 Maximum
4	Output VSWR	2.2 : 1 Maximum
5	Conversion Gain	60 dB Minimum (including variation over frequency and temperature)
6	Noise Figure	0.8 dB Maximum
7	LO Stability	500 KHz Maximum
8	Output Power @ 1 dB GCP	8 dBm Minimum
9	Power Requirement	Power Requirement to be met through IF Connector
10	I/P & O/P Interface	Compatible I/P & O/P Interface

5.3.6 Satellite Modem: Satellite Modem shall be provided on each Train for encoding/decoding frequency translation between Base-Band and L-Band. This On-Train Satellite Modem shall be compatible with Satellite Modem provided at Satellite Earth Station. It shall be capable of providing efficient bandwidth management for multiple trains on move using demand-assignment scheme and use mature / proven open source satellite communication standard.

5.3.6.1 Satellite Modem to be provided shall be designed and manufactured so as to be inherently reliable, easy to maintain, and simple to operate.

5.3.6.2 Satellite Modem shall essentially permit unattended operation except for Start-Ups or for changing operation with different transponders or satellites.

5.3.6.3 Satellite Modem shall be Standard 19” Rack Mountable. ACU front panel should have Function Key and Display for selecting desired information to be displayed or changed.

5.3.6.4 Suitable Power Supply to BUC and LNB shall be provided by Satellite Modem through IF Connection.

5.3.6.5 High Stability 10 MHz External Reference to BUC and LNB shall also be provided by Satellite Modem through IF Connection.

5.3.6.6 It shall be possible to upgrade Satellite Modem Firmware and Software downloaded through Ethernet Management Port.

5.3.6.7 Web-User Interface shall be provided for full Remote Control and In-Depth Performance Analysis using web browsers like Internet Explorer, Google Chrome or Firefox, etc.

5.3.6.8 Satellite Modem should have Built-In 1:1 Redundancy Controller for improved reliability.

SN	Parameter	Requirement
1	Modulation Scheme	QPSK or Better
2	Traffic Interface-Electrical	Ethernet(10/100 BaseT) IP Traffic on RJ45 Port with Link and Traffic Indicators.
3	User Traffic Data Rate	128 Kbps to 8 Mbps (or better)
4	User Traffic Data Rate Resolution	1Kbps
5	L-Band Frequency Range	Within 1-2 GHz (Nominal).
6	L-Band Frequency Resolution	100 Hz (Maximum)
7	L-Band Interface	Compatible L-Band Interface
8	Modulator Specification	
	(i) Output Power Level	-5 to -30 dBm
	(ii) Output Level Stability	+0.5 dB
	(iii) Phase Accuracy	+3 ° Maximum
	(iv) Output Phase Noise	Less than 0.5 ⁰ RMS Double Sided , 100Hz to 1MHz
	(v) Output Frequency Stability	0.006 ppm (or better)
	(vi) Harmonics	Better than -55dB c/4 kHz in band
	(vii) Spurious	Better than -55dB c/4 kHz in band
	(viii) FEC Rate Support	½, 2/3, or better
9	Demodulator Specification	
	(i) Input Range Wanted Signal	Minimum Level : -74 dBm
	(ii) Acquisition Threshold	< 2 dB E_b/N_o for QPSK
	(iii) Clock Tracking Range	+100 PPM Minimum
	(iv) Performance Monitoring	Measured E_b/N_o (Range 0 – 15 dB) Measured Frequency Offset (100Hz Resolution) Wanted Signal Level strength indicator centered on the middle of the Rx Input range
	(v) E_s/N_o or E_b/N_o or C/N Output	E_s/N_o or E_b/N_o or C/N Output for Antenna Tracking
10	Station Reference Clocking Input if applicable to the selected technology	50 / 75 Ohm BNC Female Station Clock Connector, Transformer Isolated, 1 MHz to 10MHz in 1 KHz steps. 120 Ohm RS 422 Compatible Input, 1 MHz to 10MHz in 1 KHz steps.
11	Protocols Supported	Requisite Protocols for providing satisfactory Wi-Fi Internet services shall be supported.

SN	Parameter	Requirement
12	Data Interfaces	LAN: Single 10/100, 802.1q VLAN RS-232: RJ45 (Console connection)

NOTE : If Purchaser decides to use Satellite other than INSAT 4CR, compatible Technical Parameters Requirement shall be ensured by System Provider for the Satellite Modem in Consultation with the Purchaser.

5.3.7 Radome& Baseplate: Satellite Tracking Antenna along-with BUC and LNB shall be mounted suitably on the Rolling Stock and shall be covered with Arrow-Dynamic Radome. Radome with Baseplate shall provide IP 66 Class Protection to Satellite Tracking Antenna along-with BUC and LNB installed inside/on it.

5.3.7.1 The Radome & Cradle shall be designed to withstand the inertial and aerodynamic loads, pressure pulse loads, vibration and shock loads and acceleration loads.

5.3.7.2 Radome & Cradle with Antenna, Antenna Pedestal, BUC, LNB mounted on it shall meet the requirement of Shock & Vibration as per relevant clauses of IEC 61373.

5.3.7.3 Radome shall be made of E-Glass/Epoxy which shall not provide a source of nutrients for fungal growth.

5.3.7.5 Electrical Performance defined below shall be achieved with installation of Radome & Cradle :

SN	Parameter	Requirement
1	Transmit Band Frequency Receive Band Frequency	14.00-14.50 GHz 10.70-12.75 GHz
2	Polarization	Antenna Feed Rotates, hence the polarization can be any linear polarization.
3	Scan Angle Range	Azimuth (Minimum) 360 ⁰ Elevation (Minimum) 20 ⁰ to 75 ⁰
4	Transmission Loss	Maximum Transmission Loss shall be < -1.5 dB Average Transmission Loss shall be <-0.5dB.
5	Cross Polar	The Cross Polar shall not be degraded by >7.5 dB for a cross polar level of -27dB.
6	Bore Sight Error	Azimuth BSE shall be <1.0 mRad Elevation BSE shall be <3.0 mRad
7	Beam Width	Azimuth Beamwidth change shall be <+5% Elevation Beamwidth change shall be <+5%
8	Side Lobe	<ul style="list-style-type: none"> The antenna free space azimuth side lobes relative to the main beam shall not be degraded by more than the equivalent of 4.0dB at -40.0dB. The antenna free space elevation side lobes relative to the main beam shall not be degraded by more than the equivalent of 15.0 dB at -40.0dB.

5.4 On-Train Terrestrial Communication Equipment: On Train Terrestrial Communication Equipment shall be provided to ensure Internet Connectivity when Satellite Communication is not available, particularly at Covered Station Platform, Over-Bridges, Tunnels etc. For provision of On-Train Terrestrial Communication, following minimum equipments shall be provided Mobile Access Router, GSM Module, Wi-Fi Module, Multi-band Antenna etc.

5.4.1 Mobile Access Router: Mobile Access Router shall be responsible for managing, monitoring and selecting the connections from Train to WAN Networks.

5.4.1.1 MAR automatically switches to existing GSM or terrestrial Wi-Fi Network when the satellite link becomes unavailable. Even when switching between Satellite and GSM/Wi-Fi, the user's internet session should not be interrupted.

5.4.1.2 Mobile Access Router Software of MAR shall be responsible for monitoring all available WAN links, continually selecting the best available to be used for user traffic. This decision process should depend on a number of configurable criterion such as latency, signal strength and IP link quality.

5.4.1.3 Satellite Control Software of MAR shall be responsible for monitoring and controlling the ACU and Satellite Modem, and providing them with necessary data. This will also receive and interprets the signal from GPS Antenna built into the satellite antenna, and send these data to other interested applications.

5.4.1.4 A firewall at MAR shall be provided for protecting all WAN links against unauthorized access and DoS attacks. Suitable firewall implementation on the MAR to protect against unauthorized access from WAN Links (Only allow VPN Links) shall be done.

5.4.2 LTE Module:

5.4.2.1 LTE Modules should deliver reliable high quality mobile broadband connectivity with variety of advanced air interfaces.

5.4.2.2 LTE Module should offer LTE (4G) compatible with 3G and GSM network access for roaming on high speed networks across India.

5.4.3 Wi-Fi Module: A suitable Wi-Fi Module should be provided for accessing Wi-Fi Network available at Covered Station Platform.

5.4.4 Multi Band Antenna: Multi-Band Antenna which cover Bandwidth of GSM Module and W-Fi Module should be provided. Multi-Band Antenna shall be responsible for searching the terrestrial network available. The Antenna shall comply to following minimum specifications:

5.4.4.1 It shall be Omni-Directional Roof-Top Antenna which shall operates from lowest frequency of GSM-Band to Highest Frequency of Wi-Fi, i.e from 800 MHz to 6 GHz.

5.4.4.2 It shall be compatible with AMPS 800 MHz, GSM 900, DCS 1800, PCS 1900, UMTS 2100, Wi-Fi 2.4 GHz & 5 GHz, Wi-Max 2.6 GHz & 3.5 GHz, GPS/Galileo.

5.5 On-Train Wireless Broadcasting Equipments:

Wireless Coverage of Broadband Internet inside coaches of train shall be provided using 2.4/5.8 GHz Wi-Fi, for which Wireless Outdoor Unit and Wireless Access Point shall be provided in each Coach of the Train.

5.5.1 Wireless Outdoor Units shall form a 2.4/5.8 GHz Wi-Fi Network between Coach installed with Satellite Communication Equipments and Passenger Coaches.

5.5.1.1 Wireless Outdoor Unit enclosure shall be made of weatherproof material with integrated Antenna.

5.5.1.2 Wireless Outdoor Unit should have built-in high performance 12 dBi antenna and should deliver wireless signal upto 3 Km.

5.5.1.3 Wireless Outdoor Unit should derive its power requirement over Ethernet provided for the Coach and separate cable for Power Supply shall not be required to be laid.

5.5.1.4 Wireless Outdoor Units shall be provided as per the requirement of providing reliable Wi-Fi Network between Satellite Communication Equipments and Passenger Coaches. However Wireless Outdoor Units shall meet with following minimum specification.

SN	Parameter	Requirement
1	Standards Compliance	IEEE 802.11b/g
2	Frequency Band	2.4/5.8 GHz
3	Data Rate	108 Mbps or higher
4	Transmission Power	Less than 20 dBm
5	Access Point Interface	Auto MDI/MDI-X Ethernet 10/100Base-Tx: RJ-45
6	Sensitivity	-88 dBm @ 11 Mbps, PER < 8%; -74 dBm @ 54 Mbps, PER < 10%;
7	Antenna Type	Integrated 12 dBi Flat Panel Antenna
8	Wireless Security	64-bit/128-bit WEP encryption; Wi-Fi Protected Access (WPA) and WPA2.

5.5.2 Wireless Access Point: Wireless Access Point shall provide Wi-Fi Coverage inside Passenger Coaches.

5.5.2.1 Wireless Access Point should have built-in high performance 5 dBi antenna and should cover complete Passenger Coach. Additional Wireless Access Point if needed to cover complete Passenger Coach shall be provided.

5.5.2.2 Wireless Access Point shall be provided as per the requirement of providing reliable Wi-Fi Coverage inside Passenger Coaches. However Wireless Access Point shall meet with following minimum specification.

SN	Parameter	Requirement
1	Standards Compliance	IEEE 802.11b/g/n
2	Frequency Band	2.4/5.8 GHz
3	Data Rate	108 Mbps or higher
4	Transmission Power	Less than 20 dBm
5	Sensitivity	-85 dBm @ 11 Mbps, PER < 8%; -70 dBm @ 54 Mbps, PER < 10%;
6	Antenna Type	Integrated 5 dBi Flat Panel Antenna
7	Wireless Security	64-bit/128-bit WEP encryption; Wi-Fi Protected

	Access(WPA) and WPA2.
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5.6 On-Train Networking Equipment: Complete System Network over the Train shall be established for which following minimum equipments shall be provided.

24 port Core Switch, 8 Port Web Based PoE Switch etc.

5.6.1 24 Port Gigabit Intelligent Routing Core Switch

5.6.1.1 24 Port Gigabit Intelligent Routing Core Switch shall meet with following minimum specification:

SN	Parameter	Requirement
1	Ports	24 Nos. 10/100Base-Tx + 2 Gigabits Combo(SFP/GT) + 2 10/100/1000 Base-T
2	Switching Capacity	12 Gbps
3	Forwarding Rate	9.6 Mpps
4	MAC Addresses	8 K
5	ACL Table	1 K
6	Routing Table	256
7	VLAN Table	4 K
8	Queues per port	8
9	L3 Interface	256
10	Anti-Attack & Security	Technologies embedded to efficiently prevent various DoS attacks(e.g. Synfood, Smurf, ICMP Attack), support ARP monitoring, defense Worm, Bluster, Check Sweep and raise alarm.

5.6.2 8 Port Web Based PoE Switch

5.6.2.1 8 Port Web Based PoE Switch shall meet with following minimum specification:

SN	Parameter	Requirement
1	Ports	8 Nos. 10/100BaseT(x) with PoE(Full Power)
2	Standard	802.3, 802.3u, 802.3x, 802.3ad, 802.3af, 802.1Q, 802.1p, 802.1x, 802.1d, 802.1w.
3	MAC Addresses	4 K
4	VLAN Table	4 K
5	Queues per Port	4
6	Security Filter	MAC Address Filtering, TCP/UDP Filtering.
7	Management	Web Management

5.7 Control, Monitoring & Network Security Systems: Control, Monitoring & Network Security Server shall perform all Network Controlling, Monitoring &, Security functions. It shall comprise of at least Access Control Gateway (ACG), DNS Caching Proxy, RADIUS Server, Portal Software and other Network Security System.

5.7.1 Access Control Gateway (ACG):Access Control Gateway (ACG) shall form a boundary between the On-Train WLAN and the WAN Links.

5.7.1.1 The Firewall on the Access Control Gateway shall protect the internal network against attacks from the On-Train WLAN. Strong firewall implementation on the ACG to control access to services and to ensure separation between different VLANs shall be ensured by System Provider.

5.7.2 DNS Caching Proxy shall be provided to speed up the user’s internet experience by caching results of DNS lookups.

5.7.3 Radius Server shall be provided for user Authentication and Authorization for both the Public and Non-Public WLANs. It can act as a proxy for another backend server to provide a synchronized Authentication/Authorization status across Trains. Free Radius AAA Server on the Access Control Gateway machine, with a link to central backend AAA infrastructure shall be provided.

5.7.4 Portal Software on ACG shall intercept all incoming traffic from Public WLAN and blocks it until user is properly authenticated and authorized in the system. HTTP traffic from the user’s browser is intercepted and the user is redirected to the Train Portal. Captive Portal Software shall effectively intercept and inspects all traffic coming in from public WLANs, redirect to portal and uses RADIUS Server for Access Control.

5.7.4.1 On-Train User Portal on ACG is the main entry point to the system for train passengers. It allows the passengers to properly authenticate themselves, after which they will be allowed access to the internet. The portal can be adopted to include information and features as required by Purchaser.

5.7.4.2 All user and VLAN based QoS shall be provided to make sure that bandwidth is equally divided among train passengers, regardless of the number of connections they open.

5.7.5 Network Security Systems

5.7.5.1 Passenger separation should be implemented and one passenger cannot see or access the device of other passenger

5.7.5.2 Access to WLAN should be protected using 802.11i WPA2 Enterprise (AES/CCMP) at the access point level. The access point should communicate with a Radius AAA Server on the Access Control Gateway.

5.7.5.3 Public and Non-Public WLANs use separate VLANs, based on the SSID and separated at the access point level.

5.7.5.4 Monitoring of Wireless Access Points using SNMP shall be possible. It shall be possible to change the configuration of the access points remotely.

5.7.5.6 All traffic from in-train networks leaving the train is encapsulated in an AES-encrypted VPN tunnel created in the accelerator client and routed to the backend infrastructure.

5.8 Monitoring PC provided for human interface to Control & Monitor On-Train Equipments shall be provided. Minimum specifications of the Monitoring PC are as follows:

- Intel Core i7 Processor or Equivalent
- 8GB RAM
- 1000 GB Hard Disk
- Dual Operating System
- Rugged Slim Cabinet
- Four USB Port on Front Panel

- Optical Drive with DVD Writer

6.0 CLIMATIC REQUIREMENTS:

- 6.1 The On-Train Equipments shall be capable of working in non-air conditioned environment on the Train.
- 6.2 The On-Train Equipments shall meet the following climatic and environmental Testing Requirements:

SN	Test	Standard
1	Environmental Testing-Cold	IEC 60068-2-1
2	Environmental Testing-Dry Heat	IEC 60068-2-2
3	3 Environmental Testing-Change of Temperature	IEC 60068-2-14
4	Environmental Testing-Damp Heat, Cyclic	IEC 60068-2-30
5	Salt Mist	IEC 60068-2-52
6	Sand & Dust	IEC 60068-2-68

- 6.3 All Equipments, Wires & Cables, Fixing Arrangements etc. to be installed Inside & Outside Passenger Coaches shall be of Fire Retardant Material and shall not cause fire.

7.0 VIBRATION & SHOCK REQUIREMENTS:

- 7.1 The On-Train Equipments shall meet the Vibration & Shock Testing Requirements as defined in IEC 61373.

8.0 EMC & EMI REQUIREMENTS:

- 8.1 The System shall be suitable for installation on the Trains running in AC/DC Electrified sections as well as Non-Electrified sections. It shall be suitable for all Trains including where locomotives having Thyristor Controlled Single Phase or 3-Phase Induction Motors and where Chopper Controlled EMU Stocks are attached.
- 8.2 The system operation and its safety should not be affected by EMI encountered in 25 KV AC Electrified areas. Properly screened RF Cables should only be used to prevent Electromagnetic interference.
- 8.3 **Radio Interference Test:** The equipment shall be tested for Radio-frequency Interference Susceptibility Test as per Clause 10.2.8.1 of IEC 60571.
- 8.4 **Supply Over-voltage, Surges and Electrostatic Discharge Test:** The equipment shall be tested for Supply Over-voltage, Surges and Electrostatic Discharge Test as per Clause 10.2.6 of IEC 60571.
- 8.5 **Transient Burst Susceptibility Test:** The equipment shall be tested for Transient Burst Susceptibility Test as per Clause 10.2.7 of IEC 60571.

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9.0 INSTALLATION REQUIREMENTS:

- 9.1. Detailed Drawing & Arrangement for installation of various Outdoor & Indoor Equipments and laying/fixing of Wires/Cables shall be prepared by System Provider and submitted to Purchaser for Approval before commencing any installation work on Power Car & other Coaches.
- 9.2. Scheme for installation of Radome with Base Plate and Outdoor Wireless Unit shall be prepared by System Provider and it should comply with requirements of 'Indian Railway Schedule of Dimension'. The arrangement of installation of these Equipments/Fittings under the scheme should not obstruct placement of Engine/Coaches and other operational activities. The scheme so prepared shall be submitted System Provider to Purchaser for its approval.
- 9.3. Fixing Arrangement of Equipments to be installed inside and outside the Power Car/Coach shall be secured and robust to ensure that it does not come out due to Vibration, Shock, and Wind Load etc. as will be encountered in Indian Railway Environment. Fixing of Equipments inside the Coach shall not infringe movement of passengers and their luggage.
- 9.4. 110 V/50 Hz AC Power Supply shall be made available to System Provider at Power Car & other Coaches. Application Interface Panel shall be provided by System Provider. These Electric Interface Panel should not be fixed on existing Electric Panels. Circuit Breaker used shall comply to IEC 60898. All Electric Wiring should be with Fire Retardant, Halogen Free Cables only. Conduit used for Electric Wiring shall be of material Polyamide 6, Fire Retardant & Halogen Free as per IEC 61386.
- 9.5. Requisite Grounding & Shielding arrangement shall be used so that 25 KV AC Electric Traction does not affects working of equipments installed inside & outside the coaches. Electric Wiring shall not result in a Shock to human being.
- 9.6. Any mounting arrangement done by System Provider shall not damage the End-Wall Sheet/Side-Wall Sheet and other fittings on the Coaches/Vehicle. Any hole drilled on the Side-Wall & End-Wall should be sealed with waterproof compound to ensure that water should not enter inside the Power Car/Coaches. Mounting & fixing etc. shall be done under the guidance of competent supervisor nominated by Purchaser.
- 9.7. Metallic surface temperature can go up-to 75° under the sun and can go up to 55°C in shade. As such equipments installed outside the coach like Satellite Tracking Antenna, BUC, LNB etc. will be required to operate in harsh climatic conditions as exist in India. As such necessary cooling arrangement required for satisfactory working of these equipments shall be provided by System Provider.
- 9.8. All the equipments installed inside the coach shall be required to operate satisfactorily in temperature range of -5°C to +55°C.

10.0 TESTS AND PERFORMANCE OF REQUIREMENTS:

- 10.1. The System Provider shall submit detailed test reports for tests done on various equipments proposed to be used, covering the parameters as given in Functional Requirements, Technical Requirements, Climatic Requirements, Vibration & Shock Requirements and EMI&EMC Requirements of this specification. System Provider shall also submit details along-with performance reports of similar system installed by him in any other Railroad System.
- 10.2. In case Purchaser so desire any other test on the equipment shall be conducted by System Provider in presence of Purchaser's Representative to ascertain conformance.

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- 10.3. At least one equipment of each type should be tested for functional parameter by System Provider in presence of Purchaser's Representative. The tests shall be conducted as per Test Procedure proposed by manufacturer duly reviewed and approved by Purchaser.
- 10.4. The equipments tested as above shall be integrated to form the complete system by System Provider to demonstrate the workability of complete integrated system as an initial demonstration.
- 10.5. Once the workability of system has been proved as above, installation may be carried out by the System Provider in consultation with Purchaser.
- 10.6. **System Acceptance Test:** On completion of installation of First Complete System in a rake along-with required modification in identified Satellite Hub, System Acceptance Test shall be carried out as per System Acceptance Test Procedure proposed by manufacturer duly reviewed and approved by Purchaser.
- 10.7. In addition to above 10% of the installed completed system of the rakes shall be subjected to System Acceptance Tests as per test procedure proposed by manufacturer/ vendor and approved by Purchaser.
- 10.8. In case of change of make, model or version of any equipment, test as indicated under clauses 10.3 & 10.4 shall be carried out for the new equipment offered.

11.0 INSTRUCTION BOOKS/MANUALS, MEASURING INSTRUMENTS & SPARES:

- 11.1 System Provider shall submit following documents for each Sub-System/Module as supplied by Sub-System Provider/Manufacturer along-with each System. These documents shall be submitted in 2(two) Hard Copy and 1(one) CD.
 - a) Operating Instruction Manual
 - b) Maintenance & Troubleshooting Manual
 - c) Technical Manual
 - d) Periodic Testing Requirements for the System
- 11.2 System Provider shall submit complete details of the Test & Measuring Equipments required for Testing & Servicing to Purchaser.
- 11.3 System Provider shall submit a list of the recommended spares for a period of 5(five) years to Purchaser.
- 12.0 All the provisions contained in RDSO's ISO procedures laid down in document No. QO-D-7.1.11 dated 19.07.2016 (titled "Vendor-Changes in approved status") and subsequent versions/amendments thereof, shall be binding and applicable on the successful vendor/vendors in the contracts floated by Railways to maintain quality of products supplied to Railways"
