No. EL/3.1.35/17             Dated: As signed

**PEDEE (Dev),**

Railway Board, Rail Bhavan,

New Delhi – 100001

<div align="center">

**(Kind Attn.: Dharm Veer Yadav, DEE/Dev)**

</div>

**Sub: Specification of Smart Locomotive.**

Ref: (i) This office letter of even no. dtd. 05.08.2022.

   (ii) Railway Board's letter No. 2022/Elect(Dev)/225/18 dtd. 09.07.2024.

Reference (i) above, Functional Requirement Specification No. RDSO/2022/EL/FRS/0032, Rev. '0' was issued. Railway Board vide letter under ref. (ii) stated that some of the features included in the FRS are covered under other project, hence advised RDSO to review and revise the aforesaid FRS.

In view of above, revised Functional Requirement Specification No. RDSO/2022/EL/FRS/0032, Rev. '1' is enclosed herewith for kind information.

Encl: As above.

SANJAY -sd-
KUMAR TIWARI
For Director General (Elect.)

Digitally signed by
SANJAY KUMAR TIWARI
Date: 2024.08.06
16:41:14 +05'30'

Copy to:

**Principal Chief Electrical Engineer,**

South Central Railway, HQs Office,

Rail Nilayam, Secunderabad – 500 071

*For kind information and necessary action.*

Encl: As above.

SANJAY
KUMAR TIWARI
For Director General (Elect.)

Digitally signed by
SANJAY KUMAR TIWARI
Date: 2024.08.06
16:41:45 +05'30'

GOVERNMENT OF INDIA

MINISTRY OF RAILWAYS

# FUNCTIONAL REQUIREMENT SPECIFICATION

# FOR

# DEVELOPMENT OF SMART LOCOMOTIVE PROPULSION KIT

# FOR

# 3-PHASE ELECTRIC LOCOMOTIVES

Specification No: RDSO/2022/EL/FRS/0032, Rev. '1'

Issued in: August'2024

| Approved by | Signature |
|---|---|
| PED/Traction/RDSO | |

**Issued by:**

ELECTRICAL DIRECTORATE

RESEARCH DESIGNS AND STANDARDS ORGANISATION

MANAK NAGAR LUCKNOW-226011

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# ABBREVIATIONS

The following abbreviations are used in these Specifications and Standards:

| Abbreviation | Full Name |
|---|---|
| AI | Artificial Intelligence |
| CLW | Chittaranjan Locomotive Works |
| CVVRS | Crew Voice and Video Recording System |
| DDS | Diagnostic Data Set |
| ELS | Electric Loco Shed |
| FDU | Fire Detection Unit |
| FIFO | First in First out |
| HMI | Human Machine Interface |
| IoT | Internet of Things |
| LED | Light Emitting Diode |
| LTE | Long Term Evolution |
| LTE-R | LTE for Railways |
| MCB | Miniature Circuit Breaker |
| MSU | Motor Suspension Unit |
| MVB | Multifunction Vehicle Bus |
| NVR | Network Video Recorder |
| OCB | Oil Cooling Blower |
| OHE | Over Head Equipment |
| OEM | Original Equipment Manufacturer |
| POE | Power over Ethernet |
| PUs | Production Units |
| RDSO | Research Designs & Standards Organisation |
| SSD | Solid State Drive |
| TMB | Traction Motor Blower |
| TFT-LCD | Thin-Film Transistor – Liquid Crystal Display |
| VGA | Video Graphics Array |
| VUCA | Volatile, Uncertain, Complex and Ambiguous |

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## CHAPTER – 1

## GENERAL DESCRIPTION, OPERATING AND ENVIRONMENTAL CONDITIONS
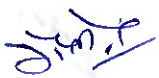
### 1.1 Foreword

With hundreds of components onboard, it is not possible to know the extent of utilization of each component within a rolling stock by any offline methods or analysis. However, by providing suitable onboard monitoring systems, the healthiness of many vital components can be precisely monitored and reported to a base station on real time basis. At the base station, a large repository of such data for the all the locomotives can be created, which will provide timely alerts when a locomotive falls due for maintenance or user can define various parameters so as to define when to take a locomotive for maintenance. In today's VUCA (Volatile, Uncertain, Complex and Ambiguous) world, digitization of the asset management would mean having a strong digitally backed eco system with connected management of equipment and processes in place to ensure secure data transfer to the cloud and further data base management systems.

The idea is to develop such a repository of which can be connected to all custodians of locomotives simultaneously using IoT based solutions. Further, the proposed scheme shall facilitate remote monitoring of locomotives and during times of unusual the depot can help by way of centralized expert advice or mobilize quick response teams to the site with necessary materials so that line failures can be avoided. The idea is to develop IoT enabled solution for rail environment and building machine learning models which are based on the data available from equipment and development of software to enable predictive maintenance and condition monitoring of locomotives using AI (Artificial Intelligence) modules. Introducing such a frame work would require stringent service level agreements in place to ensure several parameters like data collection, data security, accuracy, equipment down time etc. This would help in better reliability, availability and safety of locomotives.

### 1.2 Scope

This document lists the functional requirements of a system for predictive maintenance and monitoring of Electric Locomotives on Indian Railways, encompassing a data aggregation hub, wheel and bearing health sensors, vibration and sound monitoring system, on board audio interaction system in the event of troubleshooting and condition monitoring of on-board auxiliary motors (TMBs/OCBs), Gear case oil level indication system, linear fire alerter system, panto acceleration monitoring. The system takes advantage of advances in modern computer technology by integrating several functions into a single Industrial Computer System to carry out all affairs.

The specification covers basic features of equipment. It is the responsibility of the manufacturer/supplier, to carry out site survey, develop circuit/detail design of various

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onboard equipment and hardware, software development using IoT based tools and AI modules to meet the requirements of this functional specification.

## 1.3 Scope of Supply

1.3.1. The modern IOT based smart locomotive kit shall include the following features long with associate components as mentioned below.

**(i) Smart loco propulsion kit** (1 loco set consists of the following items)

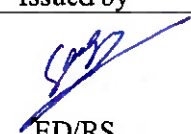| SN | Item Description | Quantity |
|---|---|---|
| 1. | Wheel and Traction Motor | 1 Loco Set |
| | a. Vibration sensors | 24 nos. (12 for MSU bearing + 12 for Axle Box bearing) |
| | b. Speed sensor | 6 nos. |
| | c. Temperature sensors | 36 nos. (12 for MSU bearing + 12 for Axle box bearing + 12 for TM bearing DE/NDE side) |
| 2. | Condition Monitoring of Auxiliary Motor (OCB/TMB) | 1 Loco Set |
| | a. Voltage Sensor | 4 nos. |
| | b. Current sensor | 4 nos. |
| | c. Vibration sensor | 4 nos. |
| | d. Temperature sensor | 4 nos. |
| | e. Air flow meters for condition monitoring of air flow readings of auxiliary machines like OCB, TMB, MRB and Hotel Load Converter. | 8 nos. |
| 3. | Gear case oil level system | |
| | a. Level Sensors | 6 nos. |
| | b. Data logger | 1 |
| | c. Signal cable | As per requirement |
| 4. | Linear fire alerter system | 1 Loco Set |
| | a. Heat detector + Smoke detector | 8 nos. |
| | b. Controller unit | 1 no. |
| | c. Alerter | 1 no. |
| 5. | Pantograph acceleration monitoring system | 1 Loco Set |
| | a. Vibration sensors | 2 nos. |
| | b. Camera | 2 nos. |
| | c. Suitable transducer/sensor for contact force measurement | 2 nos. |
| | d. Wires and cable | As per the requirement |

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| 6. | Main Transformer | 1 Loco Set |
|---|---|---|
| | Suitable sensors/transducers for monitoring of following in transformer oil <br> a. Water content <br> b. Partial discharge <br> c. Degree of polymerization <br> d. Volatile gas analysis | 1 no. each |
| 9. | Suitable Data Aggregation HUB with inbuilt serial interface and SSD memory for wireless sensors | 1 Loco set |
| 10. | Ethernet Switch | 2 nos. |
| 11. | Antenna | 2 nos. |
| 12. | TFT- LCD 10.4" display | 2 nos. |
| 13. | Intercab communication unit | 1 set |
| 14. | Data communication unit | 1 set |
| 15. | Hardware components | As per requirement |

**(ii) Central Server** (1 set)

| 1. | Server set up / Application Hosting and server maintenance cost for 2 years | 1 Set |
|---|---|---|

1.3.2. Firm shall design, develop and manufacture the smart locomotive kit including various features mentioned above and provide detailed interfacing scheme and wiring scheme before commissioning in the locomotive.

1.3.3. Supply of detailed instruction for installation of the equipment on the locomotives. For this purpose, the supplier shall also depute his representative during installation of the first two equipment in the locomotives at each location (PUs/ELS/Workshop). The supplier shall supply suitable software for evaluation of data downloaded from the system.

1.3.4. The design of the equipment shall be carried out as per requirement given in this specification. The detailed design shall be submitted to RDSO for scrutiny and approval before commencement of the manufacturing. Here 'approval' means the 'approval of design features' only. The suppliers shall be fully responsible for the performance of the complete system.

1.3.5. The complete system shall be upgradable to fulfill the future requirement and functions of this specification.

1.3.6. **MODIFICATIONS:** The supplier shall be responsible for carrying out all the modifications, which may arise due to bad design or manufacturing defect, necessary for satisfactory performance of the equipment, at his own cost during the period of

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warranty. The decision of RDSO with regard to fixing the responsibility (for bad design or manufacturing defect) shall be final and binding on the supplier. Moreover, modification, if any required on the basis of the experience gained during the field trials of prototype equipment, shall be incorporated by the supplier without any extra cost. Such modification shall be finalized in consultation with RDSO.

1.3.7. **INSTALLATION INSTRUCTIONS:** Installation instruction shall be provided in acceptable form e.g. instruction card/manual. These instructions shall include the method of inter-connection, type of cable and grade of cable, maximum resistance and whether the cable is screened. Details of any special precaution necessary shall also be stated.

1.3.8. **INSTRUCTION MANUAL:** The manufacturer/ supplier shall supply sufficient copies of instruction manual. This shall include system description and operating, maintenance, calibration and troubleshooting manual. List of spares with part no./tech. specification shall also be included. Number of copies to be supplied shall be 10% of the number of equipment ordered, subject to a minimum of 2 copies per order.

## 1.4 Operating and Service Conditions

The equipment shall be sturdy and suitable for the following service conditions normally to be met in railway rolling stock service:

**(i)** **Ambient:** - -20 to 55 degree Celsius

**(ii)** **Train Speed (Max):** 200 kmph

**(iii)** **Relative Humidity:** upto 100% during rainy season

**(iv)** **Altitude:** Max 1776 meter above sea level

**(v)** **Atmosphere:** Extremely dusty, foggy and desert terrain in certain areas. The dust concentration in air may reach at high value of 1.6mg/cubic meter.

**(vi)** **Rainfall :** Very high in certain areas

**(vii)** **Coastal Area:** The equipment shall be designed to work in humid salt laden and corrosive atmosphere. The maximum values of the condition shall be as under:
  a. Max pH value      : 8.5
  b. Sulphate         : 7 mg/liter
  c. Max. Concentration : 6 mg/liter of chlorine
  d. Max. conductivity  : 130 micro Siemens/cm

**(viii)** **Vibration:** The vibration and shock levels recorded on various sub-systems in existing locomotives of IR are generally more than the limits given in IEC 61373 particularly at axle box, and traction motor

Accelerations over 500 m/s2 have been recorded at axle box levels during run. Vibrations during wheel slips are of even higher magnitude

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High level of vibrations above 30g have been measured at traction motor on IR's locomotives, which increase up to 50g with worn gear-pinion.
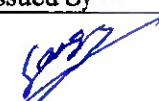
Because of track irregularities, level of shocks and vibrations to which traction motors are exposed are far more than actually given in IEC for TM mounting arrangement. Supplier to carry out instrumented trials if considered desirable on existing stock for measurement of shocks and vibrations in consultation with IR at design stage. The suspension system and the mounting arrangement of underslung / bogie mounted equipment shall be so designed that the equipment performance is not adversely affected due to such high vibrations and shocks.

**(ix)** Snow and hail: 705 (mm) in certain areas.

**(x)** Ice load: 5% loading in certain areas.

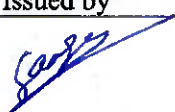**(xi)** Solar radiation: $1 \text{ kW/m}^2$

## 1.5 REFERENCE TO VARIOUS SPECIFICATIONS:

Assistance has been taken from the following standard specification information of this specification.

| Referenced Specification/Document | Description |
|---|---|
| RDSO Specification no. RDSO/PE/FRS/022 (Rev.0) | Functional Requirement Specification (FRS) of Microprocessor based Smart Switch Board Cabinet (MSSBC) For LHB EOG AC type coaches of Indian Railways |
| RDSO Specification no. RDSO/PE/SPEC/0192-2018 (Rev.1) | Specification of Microprocessor based Smart Switch Board Cabinet (MSSBC) For LHB EOG/HOG type AC coaches of Indian Railways |
| MCF/RBL specification no. MMDTS:19030 Rev1 | Schedule of technical requirements for GPS based PAPIS system with digital destination board and online condition monitoring system (OBCMS) of LHB coaches (SMART coach) |
| EN 50155 | Regional standard for electronic equipment used on rolling stock for railway applications |
| IS 2500 | Sampling inspection procedures |
| ELRS/ SPEC/SI/0015, Oct'2001 | Reliability of electronics used in rolling stock application |
| UL 60950 | For safety of mains powered equipment |
| IEC-60812 | Failure modes and effects analysis (FMEA and |

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| IEC-60077-1 | Railway applications – Electric equipment for rolling stock Part 1: General service conditions and general rules |
| IEC-60529 | Degrees of protection provided by enclosures (code IP) |
| IEEE1482.1 | Rail Transit Vehicle Event Recorder |
| H.264 | Video compression standard for HD digital video |
| G.711 | Pulse Code Modulation standard for IP |
| IEC 60571 | Railway applications-Electronic Equipment used on rolling stock |
| IEC 61287 | Railway applications – Electronic Power Converters mounted on board rolling stock |
| EN6137 | Aerospace recommended practice |
| BIS IS 2175 | Specification for heat sensitive fire detectors for use in automatic fire alarm system |
| IEC 61373 | Rolling stock equipment - Shock and vibration tests |
| IEC 62236-3-2 | Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus |
| IEC 61375-1 | Electronic Railway Equipment-Train Communication Network (TCN) – Part 1: General architecture. |

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## CHAPTER – 2

## TECHNICAL REQUIREMENTS

### 2.1 Wheel Vibration and Temperature Sensors

2.1.1. The vibration and temperature of bearings of axle boxes and MSUs play a vital role in locomotive safety. The temperature of roller bearing is a key component of trains having salient feature of high load capacity against axial and radial loads. The propose scheme shall monitor the temperature and vibration of the axle box bearing. The wireless sensors shall be mounted on the wheels for monitoring the wheel bearings to provide alertness for damage. Both Vibration and temperature sensors are wireless with a self-energy harvesting mechanism.

2.1.2. In addition to the above, the wireless temperature sensors shall be mounted on the DE/NDE bearings of traction motor, to detect any abnormal increase in temperature.

2.1.3. The proposed scheme shall consist of contact based wireless temperature monitoring sensor with unique identification and shall be customized to meet installation requirement. The proposed scheme shall provide long life, rugged and reliable solution. The system shall generate real time alerts along with cloud interface for remote monitoring.
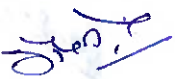
### 2.2 Condition Monitoring of Auxiliary Motors of Three Phase Locomotives

2.2.1. A suitable smart-sensor may be developed for condition monitoring of OCBs/TMBs which consists of vibration sensors/current sensors/temperature sensors/voltage sensors mounted at appropriate location for each motor.

2.2.2. The proposed scheme shall consist of contact based wireless temperature monitoring sensor with unique identification and shall be customized to meet installation requirement. The proposed scheme shall provide long life, rugged and reliable solution. The system shall generate real time alerts along with cloud interface for remote monitoring.

### 2.3 Gear case Oil level Monitoring System: 
Suitable supersonic sensor shall be mounted one on each gear case to quantify the oil level in the gear case. Based on the real time monitoring system, suitable alerts shall be generated when the oil level reaches or falls below critical minimum level required for safe operation.

### 2.4 Linear Heat Detector/Smoke detector system

2.4.1. The existing Fire Detection System of three phase locomotives consists of a FDU (fire detection unit) and a piping arrangement with openings at identified locations. When smoke appears, the FDU will suction the smoke through the openings which actuates smoke detectors equipped inside the FDU.

2.4.2. The proposed scheme shall provide linear heat detector sensors near the traction

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converters which provides for expeditious and reliable detection of fire or overheating. The system consisting of liner heat detectors and smoke detectors will be in-addition to the existing FDU. The sensors shall comply with MIL standards and these sensors can be monitored remotely and based on abnormality suitable alert messages shall be generated for the crew and also possible to see the alert messages remotely.

**2.5    Pantograph and Roof-Mounted Equipment Surveillance System**

2.5.1.  The proposed system shall monitor the roof top pantograph area and dynamic interaction between pantograph and contact line. The system shall be capable of monitoring the wave behavior and propagation speed of catenary system, contact wire irregularity and associated vibration in the pantograph-catenary system.

2.5.2.  The monitoring system shall consist of vibration sensor and sophisticated camera one for each pantograph. All the parameters shall be captured on real time basis and shall be displayed for locomotive crew and also monitored remotely by centralized monitoring system. The proposed system shall be capable to measure total contact force of the pantograph being exerted of contact wire and transverse movement of pantograph.

**2.6    Data Aggregation Hub (DAH)**

Data Aggregation Hub is an Open Platform Industrial Computer with GSM and GPS connectivity installed in the locomotive that,

a.   Operates as a locomotive data aggregator that polls data stored in locomotive mounted devices and posts it to an internal database for eventual synchronization with a cloud-based server.

b.   Queries the Wireless Sensor Nodes installed on the Wheels to predictively analyze the health of wheels and bearings.

**2.7    Ethernet POE Switch**

An EN 50155 certified Ethernet switch with POE to power and connect the various cameras installed in either side of the locomotive and also any other ethernet devices that may require data connectivity to the Data hub.

**2.8    10.1" LCD TFT Display**

A 10.1" Touch screen to allow the driver to view the live footage of the pantograph, rear view camera and non-operative driver cab, to take timely action against any pantograph entanglement and other emergencies.

**2.9    Auxiliary Power Supply Unit.**

The supplier should design a suitable power supply unit for powering the TFT LCD unit and other equipment from 110V DC source available in the locomotive.

**2.10   Inter Cab Communication Unit**

The supplier shall develop an intercom device enabling the crew on either of the two

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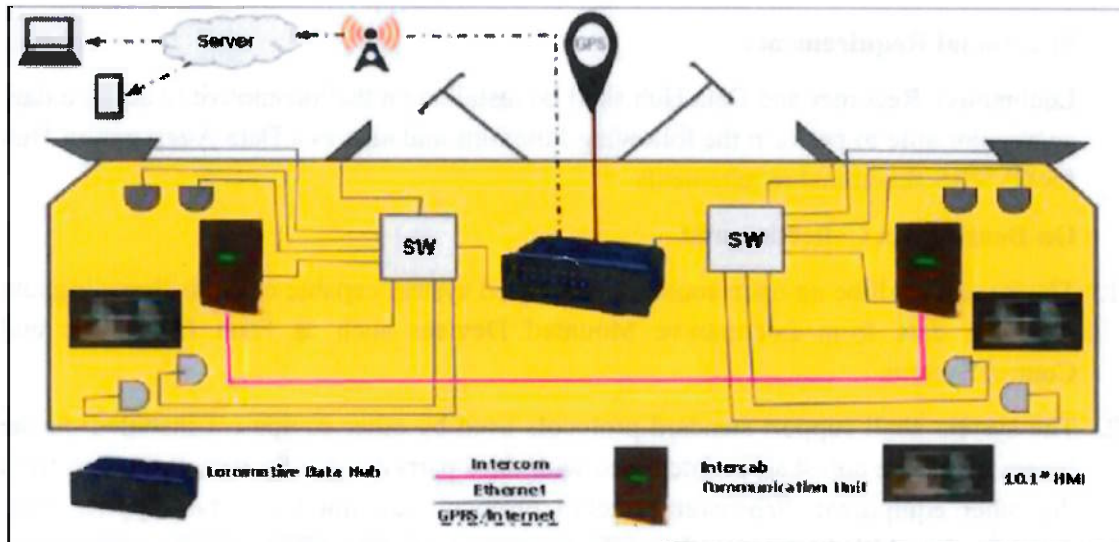cabs to establishvoice communication with each other in real time.

## 2.11 Remote monitoring software

2.11.1. A web server-based application for visualization of the status of the equipment on the locomotive and remote management of the video footage of locomotives enabling secure remote download. Further the remote monitoring software shall also gather various data that is being generated by locomotive propulsion system and few important parameters related to brake system like A9 control pressure, Brake Pipe (BP), Feed Pipe (FP), Air flow & Brake Cylinder (BC) pressures data etc. is necessitated to facilitate as an event recorder for investigation of unusual incidents and also to facilitate the on-board crew for online troubleshooting of locomotives. At present different OEMs are generating data related to locomotive on MVB and the vendor has to develop suitable interfaces compatible with each OEM of propulsion system and shall also ensure that the MVB accessing by remote monitoring system shall not cause any MVB disturbance or affect the performance of locomotive. Pressure Sensors at appropriate location for sensing the health and operating characteristics of MR/BC/BP may be provided.

2.11.2. The remote monitoring system shall generate customized reports and shall facilitate in condition monitoring/predictive maintenance of locomotives by building AI based machine learning models.

2.11.3. Proposed system shall be capable to detect change/deformation in physical shape and size of Pantograph and based on which alertness in the form of audio/video, alarm shall be generated for attention of crew.

2.11.4. All locomotive data are very crucial and strategic in nature for access and use by the Employer and should be secured, safe, reliable and accessible and should be proof to any tampering by external forces or agencies who should not be privy to such data of momentous importance being strategic in nature. Cyber security shall be ensured as per standard CLC/TS 50701.

## 2.12 Cable Harnessing/Hardware and Mounting Arrangements

The supplier shall design and develop standard arrangement of cable harnessing and connectors, mounting arrangement of various equipment along with hardware requirements for mounting and installation of various equipment on locomotives.

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**System Layout:**



**Figure – 1**

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# CHAPTER – 3

# FUNCTIONAL REQUIREMENTS

## 3.1 Functional Requirements

Locomotive Recorder and Data Hub shall be installed on the locomotive to act as a data aggregator able to perform the following functions and also as a Data Aggregation Hub for CVVRS functional requirements

## 3.2 On Board Data Collection unit

3.2.1. The system shall be an open-source Linux based system capable of multi-threading and receiving data from Locomotive Mounted Devices such as Fault Diagnostic and Control System.

3.2.2. The system shall support standard protocols used by other equipment installed on the locomotive. The hub shall be interfaced with third party devices for data extraction from the other equipment. Wherever standard protocols are not used, the supplier shall develop the API based on the API document of the OEM of the equipment. CLW/RDSO shall extend necessary support for the same. Various DDS messages of Propulsion system shall be made available for remote monitoring.

3.2.3. The system shall also be capable of hosting third party applications provided by the OEM's for extracting data from the equipment provided by such third-party devices. The application service should be installable without any dependence on the system provider and hosted on an abstraction service on the DAH / application management layer, such that one application does not impact the working of other applications.

## 3.3 Data Communication Unit

3.3.1. The data hub shall have an inbuilt Dual GPRS radio with independent SIMS for data communication to the web server.

3.3.2. The unit shall be capable of seamlessly connecting to servers using industry standard communication protocols like HTTP, FTP, SMTP, IMAP etc. The unit should also be able to send alerts on occurrence of pre-configured set of faults or events to the remote health monitoringsystem.

## 3.4 On Board Audio Communication System

3.4.1. In the event of any unusual incident, to guide the working crew, it must be possible to directly communicate with the on-board crew with the help of on-board communication system. For this purpose, a SIM card with mobile phone arrangement shall be provided through which one can communicate with the on-board staff. Further, similar to any-desk kind of arrangement, it shall be possible to access the locomotive cab display and perform operations of isolation of motors through screen or access some vital parameters or post some alert messages on the screen remotely to
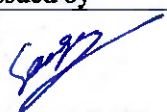
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guide the on-board crew during online troubleshooting.

## 3.5 Remote Health Monitoring

3.5.1. The locomotive data hub should be capable of recording, storing and relaying data as stipulated in CLW specification No. CLW/C-D&D/ES/3/0546, Alt. A to a cloud-based server. There shall be provision for interfacing locomotive health data with the locomotive data hub and same shall be relayed to server. The data/signal/parameter to be stored on the server shall be decided during Design Stage. Cloud Services of the Ministry of Electronics and Information Technology (MeitY) empaneled Cloud Service Providers (CSPs) may be used, who are audit compliant for their Information Technology (IT) requirement in its technical specification particularly for monitoring of data or the central server shall be provided by the Contractor at a place to be nominated by the Employer.

3.5.2. A web server based application for visualization of the status of the equipment on the locomotive is to be provided. The remote management of the video footage of locomotives should be through a secured remote download. The software should be able to provide alerts in form for SMS for configured set of faults. The software should be able to generate reports of trip/journey.

3.5.3. The software should enable predictive maintenance based on data analytics. The system shall generate predictive maintenance alerts in advance for equipment like

a) Wheels (i.e. wheel skid marks/ovality), bearings likely to develop defects over the next 3 months,

b) Pantograph imaging and analysis with Vibration sensor also.

c) Current and tractive effort monitoring.

d) Bearing and coil health of the motor.

e) DDS messages of Propulsion system

f) Auxiliary motor sensors status

g) Gear case oil level indication

h) Continuous log of few selected vital parameters status like A9 control pressure, Brake Pipe (BP), Feed Pipe (FP), Air flow & Brake Cylinder (BC) pressures data etc. in addition to OHE voltage and Primary Current. This forms as a data logger of locomotive as in the existing system of DDS generation; these details are made available only when faults occur in the locomotive. The proposed system shall log these faults at a sampling rate mutually decided by both parties so that the data is generated on real time basis continuously and this acts a data logger of locomotive.

The above analytics are indicative and further analytics may be included in the scope.

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## 3.6    Locomotive Tracking

3.6.1.  The locomotive data hub should keep sending its GPS/GPRS location and  speed to the server. The server should alert the driver in case of over speeding and the same shall be logged with timestamp and location.

3.6.2.  The location of the locomotive should be trackable on a real time basis on maps on the remote website. The log of the entire journey of a locomotive should be stored in the server for future reference and record keeping.

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# CHAPTER – 4
## MISCELLANEOUS FUNCTIONAL REQUIREMENTS

**4.1. MISCELLANEOUS FUNCTIONAL REQUIREMENTS OF REMOTE WEB BASED MONITORING**

4.1.1. To provide an intelligent, time saving infrastructure that provides capability to identify and grade locomotives in real-time for proper planning of maintenance and prevention of line failures. The data shall be collected from the locomotive computer, relayed to the remote server via a GPRS link. The data shall be stored on the server, analyzed as per pre-defined or user defined rules and presented via simple and easy to use web interfaces.

4.1.2. Remote Web Based Monitoring Software shall be a cloud-based application hosted on a MEITY approved server by the service provider.

4.1.3. It shall be fully automated and shall provide contextual views to the operator in order to identify locomotives requiring immediate attention along with a health index, locomotive requiring attention in the next week and so on.

4.1.4. A digital twin of the selected locomotive shall be visualised on the webserver.

4.1.5. The server shall retain historical data of the locomotives and compare the current values for trends in order to predictively determine fault likely to occur. Appropriate alerts shall be generated.

4.1.6. The onboard hub equipment shall interface to the locomotive Vehicle Computer (propulsion specific data) in a manner such that all parameters acquired by the vehicle computer are available for further processing. This equipment shall have its own independent GPS system for getting the geographical location. Further it shall be possible to remotely access the DDS Display of locomotive to carry out isolation of some equipment or check the status of various subsystems in the event of unusual incidents.

4.1.7. **Communication system:** Locomotive on-board equipment shall be equipped with GPRS/EDGE/CDMA/4G/5G based communication system for relaying of acquired data. Further these shall also provide mechanism for direct interaction of crew in case of unusual incidents.

4.1.8. **Data logging servers:** These servers shall be located at the data centre of the supplier / service provider. These servers shall log data relayed by the locomotive on-board devices.

4.1.9. **Data analysis and presentation systems:** These shall be server-side applications running at the data centre of the provider and shall analyze the data as per predefined / user defined rules. This software shall also prepare the information generated for

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display on the internetportal.

4.1.10. **Internet Portal:** A secure internet portal shall form the user interface of the system. All users shall interact through the portal.

4.1.11. **Client applications:** PC and mobile applications shall form the applications for interaction for users. Additionally, data analysis and visualization application shall be provided on the PC for further analysis as required by the user.

4.1.12. **Geo-fence development:** The LTMS provider shall be required to develop geo-fences for identification of locomotive location. These fences shall demarcate boundaries of railway zones and divisions.

## 4.2. MISCELLANEOUS FUNCTIONAL REQUIREMENTS OF INTERCAB COMMUNICATION SYSTEM

4.2.1. The 2 units installed in the driver desks in the 2 cabs enable the driver and assistant to communicate over the intercom in case of need. Considering the noisy environment of the locomotive the mic provided along with software is featured with noise cancellation technology. Also all the conversation is recorded in the locomotive data hub and can be retrieved on date, time and location basis.

4.2.2. **Detailed Technical Requirements of Equipmetnt**: Details of technical requirements have been given in following paragraphs.

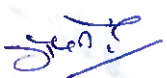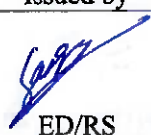**4.2.2.1. Intercab communication unit.**

- IEC61373, IEC60571, IEC61000 compliance.
- Integrated Alarm Push button, 2*16 LCD, Mic and Speaker
- Digitally recorded call log. Uses existing unshielded train line wires.
- Inbuilt Automatic Gain control and a Class-D amplifier.
- Compact Anti-vandal Stainless Steel to IS:304 enclosure unit for flushmounting on the cab wall/desk.
- Inbuilt recessed Emergency Call button.
- Inbuilt Directional Microphone, speaker and Amplifier for hands free operation.
- Inbuilt power supply compliant to IEC 60571.
- Communication interface RS 485
- Interface for the audio recording during conversation in the DAH.
- Full duplex voice communication.
- Communication through the ETB unit should be satisfactorily audible during normal working conditions of a train.

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- Interface for provision of audio recording in ETB response unit at thedriver's cab.

- Hands free communication between driver/Guard and assistantsincluding volume parameters adjustment feature

### 4.2.2.2. Locomotive Data Hub.

- Processing System: Multi core Intel X86 machine Fanless design.

- Suitable for Real time video recording and playback

- Linux based OS kernel 2.6 or better operating system

- 4G, 5G, GPRS, GSM, GPS, Wi-Fi (Optional) connectivity

- Compliance to EN50155 (Railway Application) or IEC 60571(Railway Application)

- Built in quad band GSM/HSDPA/HSUPA/UMTS/LTE modem with following features

- Antenna Impedance: RF Antenna Interface with 50Ω impedance.

- Frequency Range: Quad Band (850 / 900MHz and 1800/ 1900/2100 MHz)

- SIM Interface: External SIM 1.8V 13V

- SMS: Text mode

- AT Commands: GSM 07.07, 07.05 latest AT Commands

- EDGE data rate: Class 12 (237 kbps (downlink))

  - : Coding schemes CS 1, 2, 3, 4

  - : Compliant to GSM phase 2/2+

- Compliant to GSM phase 2/2+

  - : Class 4 (2 W a8501 900 MHz)

  - : Class 1 (1 W @ 180011 900MHz)

- Protocol: TCP/IP

- RF Receive sensitivity:

  - -109dBm (Typical)

  - -107dBm (Max)

- LED indication for Power on /Power good (low or high voltage) indication in front side of the system, system shall have HDMl/DVl output, Reset push button.

- Locomotive Data Aggregation Hub shall have at least four independent and

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isolated RS485 channels to connect to the various equipment of the locomotive to collect control and processing data.

- The hub shall have an internal surge protection and power supply for working on the voltage rails provided in the locomotive.

- The hub shall have at least one removable SSD slot and one removable SD card slot for upto 64GB with anti-theft protection for standby storage.

- The data hub shall be able to accommodate two Sim cards for two separate network operators for redundancy.

- The Data hub shall have M12 connectors as per IEC 60947-5-2 for power and data interconnections.

- The datahub shall have ingress protection as per IP65.

- M12 VGA connector for external display

- Internal GPS module compliant to the following specification.

  - L1 frequency, C-A code (SPS) with 50 independent trackingchannels.
  - NMEA-0183 compatible output.
  - Update rate 1 Hz or better
  - Cold start better than 35seconds
  - Hot start better than 5seconds.
  - Antenna- external, active passive with built-in Antenna biascircuitry.
  - Built in Antenna supervisory circuit for determination of activeantenna open or short state.
  - Should be provided with an externally mounted active antennapowered directly through GPS receiver.
  - Autonomous positional accuracy shall be better than 10 meters

### 4.2.2.3. Wheel and Bearing Vibration Monitoring System

Wireless Sensor Nodes (WSN) shall be placed for monitoring the health of the wheel and bearings and provide predictive alerts for damage in order to prevent mid-section failure of locomotives. Similar sensors shall also be placed on the traction motors for monitoring their vibrations and determining impending mechanical failure in advance.

The WSN shall be powered using an energy harvesting mechanism and shall not require external power.

The WSN shall be as per OBCMS/DCM/N/1.

### 4.2.2.4. Linear Heat Detector/ Fire and Smoke Detector unit.

Railway approved Fire and Smoke Detector unit shall be placed in the locomotive at necessary locations for detection of rising temperaturesand smoke emission.

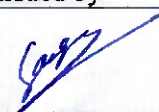| Prepared by | Checked by | Issued by |
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The status of the sensors shall be displayed on the surveillance monitor and also be relayed to the web based remote monitoringsystem.

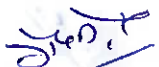### 4.2.2.5. Sensor Nodes for Equipment room:

- Sensor nodes shall be placed on a RS485 sensor bus of the locomotive.

- Temperature and pressure monitoring sensors nodes using RS485 communication shall be installed on appropriate equipment to enable their monitoring, data logging and reporting to the Data Aggregation Hub for onward transmission to the Remote Web Server.

- It shall be possible to add sensor nodes on the bus as per requirement to monitor additional parameters.

- The parameters to be monitored at the remote web server shall be determined in consultation with IR. Sensors shall be placed at necessary locations to monitor the various parameters.

- It shall also be possible to interface to the Fault Diagnostic and control system to extract the data stored therein for analysis.

### 4.2.2.6. Ethernet Switch

- Two Ethernet switches with the following specifications shall be provided with a data hub. Switches shall be POE enabled as per IEC802.3af/at and suitable for interfacing with POE enabled cameras

- Ethernet Switch shall be sealed to IP65.

- 8 Port PoE 10/100/1000Mbps network "Active type" Compliant to IEEE802.3 aflat having MI2 Connectors. Switch should be EN 50155 compliant for rolling stock applications having 8 Ethernet ports (MI2 connector). The switch should support Auto - negotiation, auto MDl/MDX and flow control.

- Interface- 1011 00M Ethernet Port (RJ45)IM12 Supporting PoE

- Button – WPS/Reset, Power On/Off

- Antenna Type - 3*5dBi Detachable/internal Omni Directional

- Frequency - 2.4-2.4835GWz or 5 GHz

- Signal Rate- 11n: Up to 450Mbps(dynamic)

- Transmit Power - <20dBm(EIRP)

- Enable/Disable Wireless Radio;

- WMM (Wi-Fi Multimedia)

- Wireless MAC Address Filtering

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- Wireless Statistic
- Wireless Security Management- 641/128/152-bit WEP / WPA / WPA2, WPA-PSK / WPA2-PSK SNMP.

4.2.2.7. 10.1" Pantograph Surveillance and rear view display. The specification of the display will be as followed:

- TFT Interface : LVDS 18bit
- CTP Interface: Micro USB
- Display Mode : Transmissive / Normal White
- Screen Size(Diagonal) : 10.1"
- Number of dots : 1024 x 600
- Pixel Pitch : 0.2175 x 0.2088 (mm)
- Pixel Configuration : RGB Stripe
- Backlight : LED
- Surface Treatment : AG
- Operating Temperature : -15 ~ +70°C
- Storage Temperature : -30 ~ +80°C
- Memory: DDR4 SODIMM slot x 2, up to 32GB
- Graphics: Max up to 1920 x 1080 resolution, HDMI 1.4b up to 3840 x 2160, VGA up to 1920x 1200
- SATA: Integrated Serial ATA Host Controller 2 SATA port, SATA Gen3 Data transfer rates up to 6.0 Gb/s (600 MB/s).
- LAN: 1 Intel I219LM Giga Phy & 2 Intel I210-IT LAN chipset with 10 / 100 / 1000 Mbps for PCIe x 1 V2.1
- I/O Chip: F81966D I/O chipset for 6 ports RS232/RS422/RS485 auto switch by BIOS
- USB: 4 type A USB 3.0, 3 USB 2.0
- Sound: Support line in, line out and MIC in, Two channel Class D Audio Amplifier
- WDT/DIO: Hardware digital Input & Output, 16 x DI / 16 x DO (Option)
- / Hardware
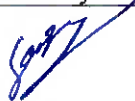- Watch Dog Timer, 0~255 sec programmable

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- Expansion interface: one full-size PCIe Mini card for PCIe x 1 / mSATA (auto-detect) and USB interface, one full-size Mini PCIe card for PCIe x 1and USB interface

- SIM: 1 SIM socket pair with MPCE2

- TPM: SLB 9665 TT 2.0 Trusted Platform Module (Optional)

- BIOS: Insyde UEFI BIOS

- Power: On board DC +9~36V

### 4.2.2.8. Auxiliary Power Supply Unit

An auxiliary Power supply shall be provided to power the 10.1" LCD display unit. It shall be an IP65 sealed fanless Power supply unit of 100W. The unit shall have an internal power backup and line interactive feature interface over RS485 interface for safe shutdown of the connected load. The auxiliary unit shall have the following features:

- Connectors: Power Input M12 connector with Fuse at Input.

- Wattage: 100 Watt.

- Input Voltage: As per Voltage Rail Available on the Locomotive.

- Output Voltage 24V DC+/- 2V.

- Efficiency > = 85% at Full load.

- Passively cooled, fanless.

- Wide input voltage range: 66-160V

- Low no-load power

- Isolation voltage 3000VDC

- Operating temperature range: -15°C~+70°C

- Input under-voltage protection, output over-voltage, over-current,short-circuit, over-temperature protection

- Meets railway standard EN50155

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