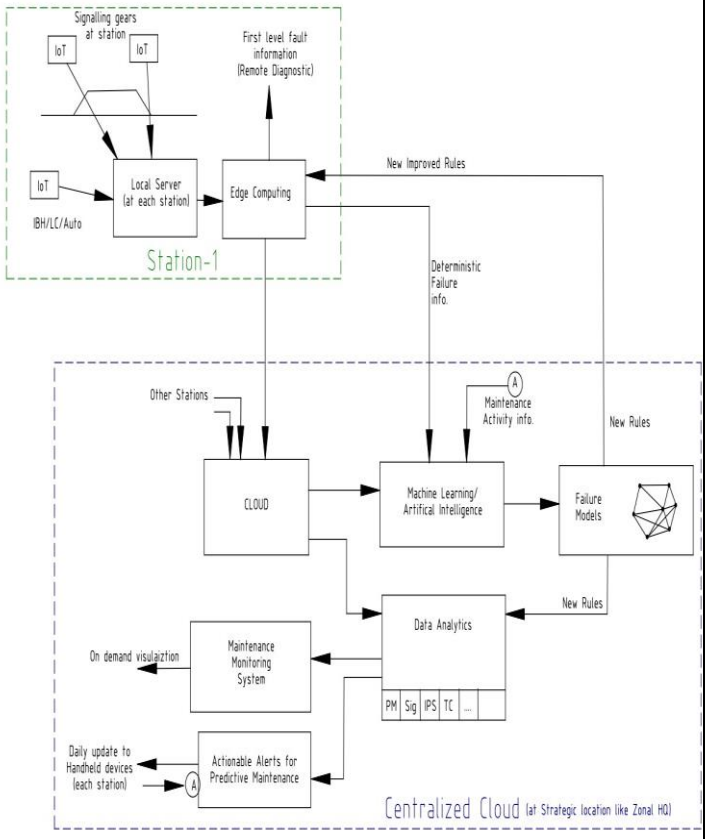
Revised Reasoned Document OF RDPMS:-23.10.2020

Spec. Cl. No.	Specification Clause	Railway / Vendor Comments	RDSO Remarks SSE suggestion on the basis of remark
3.3	The local server is complemented by Edge computing device to generate first level fault and diagnostic information based on the real-time data.  Figure-1 : System Architecture	**TCS:** The figure -1 shall follow a standard IoT architecture, this figure needs updates for following: • There is no representation of sensor layer • The End nodes shall be denoted as EDGE nodes • The local server should be denoted as EDGE gateway and the EDGE analytics will take place here • The communication between Edge nodes and Gateway is not detailed • There is no separate EDGE computing node needed • The cloud box inside the “Centralized cloud” should be changed to Data lake or database • The cloud architecture shall be based on standard IoT reference architecture consisting of IoT services and Hub. We have given the suggested standard IoT structure on page No 4 of this document. **RAVEL:** At each station Server and edge computing can be combined in the station with reliable embedded PC to reduce hardware **RZD:** Figure-1:Itisnecessarytoprovideforthegenerationofreportson maintenance automation both at the central level and on the	Sensor layer will be included. Suggestion of M/s TCS for clubbing of some hardware and renaming ‘cloud box’ to ‘data lake’ are minor issues and does not make any technical improvement. Suggestion included in para 8.1 as a option.

		Local Server.	
3.6	Predictive Maintenance: Mobile app will also be developed which shall be having real-time update on each station gears. The maintenance staff of particular station will be having the handheld device where at the start of each day he can see which gears need the specific attention for maintenance. For critical faults, the sms or automated voice calls may be provided once machine learning is stable and alerts are quite accurate (upto> 60%). The system architecture is depicted broadly in the Figure-1. As Signaling assets are distributed at more than 6000 stations, the decentralization of computing is necessary to handle the requirement for which edge computing at every station is proposed. However, the machine learning need to be centralized for complete Indian Railways so as to use the data from every station as well as streamlining the efforts for machine learning techniques. Hence, the need for one platform is proposed for AI techniques. It may noted that being a developmental scheme, there is a scope to improvise the architecture during system development and the initial trials.	**RAVEL:** Make the system Distributed some very critical diagnostic rules can run in Edge computer to avoid delay as well as to take care of any Communication failure	Already covered in the para, No any change needed in para.

4.2.1	For measuring the currents non-intrusive sensor shall be used. Voltage sensor shall also be preferably non-intrusive. In case of non suitability/non availability of non intrusive sensor for voltage, sensors having High impedance and galvanic isolation can also be considered with minimum withstand voltage of 2.5KV for 60 sec. *Note: Feasibility of non-intrusive voltage sensor to be explored. In case non-intrusive voltage sensor is not feasible and galvanic connection to monitor voltage is unavoidable, then proper plan to demonstrate that EMI noise/surge is not transferred from monitoring probe to delicate equipment power supply like Axle counters etc to be given.*	**BITCOMM:** For voltage sensing non intrusive sensor may not possible therefore the voltage sensors having high impedance and galvanic isolations can be considered. Generally for measuring the isolation VISO i.e. Maximum withstands isolation voltage is specified. According to UL1577 standard it is specified as more than 2.5KV for 60 sec. **RAVEL:** Smart sensors also have to besecured. Currently 99% of them are not secured.Sensor Supply can be isolated and digital isolators can be sued to connect to processing. Analog isolations have non linearity reed relays can be used for digitalIsolation **RZD:** We consider it inappropriate to use contactless voltage measurement sensors due to the large inaccuracy of dynamically changing signals. **SANARTI:** Non-Intrusive Voltage measurement is in very nascent stage. Hence therewill be challenges related to complexity and accuracy of measurement. Galvanic method has many ways to implement, hence the best suited can be used taking care of noise immunity **SJE7:** The remote Analog signals shall be scaled to a suitable limit using signal conditioner before converting to digital signal. Each analog input shall be isolated,(at least 2KV isolation voltage) from the system and one another.	As per feedback non-intrusive sensor is not available. Voltage sensors having high impedance and Galvanic isolations can be considered with isolation voltage 2.5KV (min).

		While tapping analog input, it shall not load the analog channel/ field gear by more than 5ma. DC & AC analog currents shall be measured with suitable calibrated sensors which provide galvanic isolation to the source being monitored. Each analog input shall be connected through a fuse / isolation diode or circuit of suitable capacity say 100 ma fuses, IN 4007 diode, or similar in series.	
4.2.2	The accuracy of sensors should be such that it will not cause noise in the data being used for machine learning. Proper accuracy and stability of sensors is very important for end goal of predictive maintenance. If the raw data is noisy and not reflecting true value of ~~site~~field gear, the machine learning will be inaccurate.	**BITCOMM** To reduce the effect noise, spurious and sensor stability the signal processing techniques like low pass filter, moving average can be considered	Suggestion added in next para.

		RAVEL: Every sensor will need a good set of Digital Filtering. Also Machine learning should include statistical methods to remove noise **SANARATI:** ** It is for this reason (A) and (B), above have been recommended. The(A) type information shall be Sacro scent based on the accuracy and stability of the sensors and diagnostically stable at the signalling gear itself. The (B) type information can have minor affect of counting errors+ the affect of the medium of transmission. methods exist which can minimize this. It is necessary though that the medium and its method should not be affected by the induced voltage. ***Type (A) information can have AC immune transmission even on power supply Copper Conductors. We have tested methods to do Fail Safe Interlocking with Induced AC present on the line using the Signaling gear Power Supply Conductors for Type(A) information both for AC powered and DC powered Systems. **SJE7:** When data is collected over IOT, noise is possible which can originate from various sources and process. Data processing component of machine learning should be able to efficiently remove any such noises which are part of streaming in data.	

4.2.3	Most of the sensors would be transducers converting current, voltage, vibration, etc to very weak electrical signals. Hence, proper safeguard against EMI effects on the stability and accuracy of readings should be taken. Protection arrangement for sensors against surges coming from lightening/power line/ OHE shall be made. Appropriate signal processing technique and filtering shall be used to remove unwanted signals. For example, in the RE area, the induce voltage is dynamic varying due to change in OHE current during presence or absence of train. Hence, the length of cables/wires from transducer/sensor to IoT device shall be such that induced voltage are within limit to ensure desired accuracy of stable readings. Further, the transducer/sensor wires should not run parallel to dynamic current carrying conductors which may alter the readings of the sensors. Note: "SEM para 22.6.2.1 The induced voltage in the underground- Unscreened cable shall be reckoned as 116 volts/km on single line and 95 volts/km on Double Line." This is when the catenary current is maximum i.e. 600Amp per catenary. This comes to around 100mV (AC) per meter which can disturb accuracy of sensor very badly. Furthermore this induced voltage is variable due to varying catenary current (upto Zero) as per number trains and their locations in the feeder section. So calibration will not help due to variable noise. This variable voltage should be tackled by suitable installation practices (use of twisted pair, etc).	**BITCOMM** To reduce the effect noise, spurious and sensor stability the signal processing techniques like low pass filter, moving average can be considered. Coaxial cable also can be considered with proper ducting. **RAVEL:** Local monitoring is very essential under such harshenvironment **SANARATI:** a. Sensor Measurements unaffected by Induced AC can be easily achieved. It is necessary for Signaling gear predictive maintenance in RE area that the Signaling gear operation itself should be immune to Induced AC particularly for the operating parameters being measured. In other words for example if the DC voltage in a system can be increased or decreased by the Induced AC, error condition may manifest itself as OK and vice versa. In such case each signalling gear operation will have to be first quantified wrt to Induced AC for (B) type of information. The (A) type information would be more useful and reliable as simple proving unit at the signalling gear can remain unaffected b. ""*Type (A) information is proven	During discussion on 21.10.2020 through VC to firms, it is pointed out by SJE7 that protection of sensor from surges is very important issue and protection arrangement for the same may be needed. Para modified to include provision for protection of sensor. Provision of signal processing & filtering also included.

	This specific requirement is very important for consistent and accurate reading and the correct machine learning for AI model. -Due to above reason, comments are also invited for feasibility of monitoring the Signals at Signal post itself, Points “at point machine enclosure” in place of Location Boxes.– Industry experts to specifically comment	Predictive Go-No go information like a proven contact and it is transmitted Electronically over the medium without any affect of Induced AC and can have long lengths of transmission cables. This can be easily demonstrated for Signals. Similarly for Points machine as well this can be provided C. Type (B) information accuracy can be subjective to its type and dynamic range/nominal value. Affect of induced AC on the Signaling gear and it may get optimized on case to case basis. We have developed and tested new methods for remote Fail Safe detection & common proving of various parameters through adding function, both absolute and predictive for AC and DC powered Devices . In this regard we shall be writing under separate cover related to theimprovement on existing signaling operation.	
4.2.4	Proper rated sensors shall be used as per parameter monitoring range of gear type to be monitored. Since the machine learning will depend on the variation of data to capture health signature, the least count of sensor for each category of equipment would be different. ~~Details of sensors and their accuracy should also be brought out on specification~~. For initial trial accuracy of sensors may be kept as 2%.	**RAVEL:** Every sensor will need a good set of Digital Filtering. Also Machine learning should include statistical methods to remove noise. **RZD** We suggest adding the values of the allowed basic inaccuracy - 2.5 % for measurements of direct and alternating currents and sinusoidal voltages, - 5 % for measurements of pulse voltages and currents and complex signals; - 10 % for insulation resistance measurements;	The required sensitivity and accuracy of sensor could not be defined at this stage and may be defined after gaining experience. As per feedback from vendors, 2% accuracy of sensor will be adequate for trial.

		- 0.2 % for frequency measurement; 1 % for duration measurement. **SANARATI:** The Nominal Value should be high for more dynamic range of Data generated and together they should be substantially more than the noise in the system. It is the responsibility of the vendor who is supplying the signaling gear with diagnostic ports to furnish this information for the gear. Where SSDUs are being developed this can be well taken care of at the design stage. The accuracy levels will differ for different parameters being sensed (voltage, current, vibration etc.). Though and error level of a5% can be adopted which can be optimized to +2% or better , based on trial outcomes	
4.3.1	Signals The following data shall be recorded for each aspect of Signal: i) AC Current. ii) AC Voltage. iii) Illumination of aspect(optional) iv) Status of local signal controlrelays at Location boxes.	**BITCOMM** There will be Install ion difficulties for installing the illumination sensor at signal location. Also transferring information from signal post to nearest location box needs to be defined . Option1:Illumination/LUX Transmitter having RS485 or 4-20mA Output Option2: There should be a interface specification for illumination sensor and it can be part signal itself **TCS:** There is absolutely no need to monitor the status of relays at location boxes as this solution is for monitoring the end field gears and not to create another data logger. The complexity of the system will increase multifold if relays are again monitored by the IoT based solution. **SANARATI:**	IIlumination sensor may be made optional, as Voltage & Current at location box/signal be sufficient. Status of field relays are not available with data logger hence status of field relay may be monitored for accurate prediction.

		Signals have clearly defined boundaries of Acceptable operation hence Type (A) information is considered adequate with suitable boundary limits for predictive maintenance on short term basis of the Signal Lighting Unit itself. Status of local signal relays is a contact read out and its suitable logic for Diagnostic IoT can be easily provided. In our Opinion Raw data Transmission will only assist in further microscopic analysis on long term basis for the Signal together with the medium and contacts and source. Accurate &Fail Safe Electronic Transmission of Proven Predictive maintenance information of TYPE(A) is considered suitable for the Lighting Unit (See *** above). **SJE7:** IIlumination may be dropped for trail, as Voltage at field &Current at relay room may be sufficient. Cutting relay status may be included.	
4.3.2	Points: The following data shall be recorded for each end of the Point: i)DC operating Current. ii)DC operating Voltage. iii)Vibration. iv) Movement of point machine slides (Drive, lock & Detector). ~~v) Status of local point controlling/detection relays at Location boxes.~~	**BITCOMM** The Installation location of Vibration sensor shall be specified. Type of vibration to be specified. What are the exception reports expected from vibration analysis shall be specified. **SANARTI:** In addition it would be useful to detect the operating time to be in the required limits **We can design a Local Unit near the signaling gear to validate its operation to be within the designed limits and produce Type (A) information. Type(B) information for can	Vibration sensor should be located inside the point machine to get better results. No local relay is available for point machine hence deleted. Movement of various slides needs to be monitor for analyzing working of point machine.

		be additionally sent out by the IoT device along with Type (A). It is possible to Transmit the Type (A) information on the power feed cable itself to the Station, if Railway so desires, or through IOT device	

4.3.3	DC Track Circuits: The following data shall be recorded for each Track Circuit: i)DC feed end and relay end voltage. ii)DC feed end and relay end current. iii)Track relay position. ~~iv) Track charger potential free contact (or output voltage where PF contact is not available~~ v) Input voltage &output current of track feed charger. vi) Voltage & charging/discharging current of battery.	**BITCOMM** Battey charging voltage, charger output and drop across choke/rheostat can be added as measuring points **TCS:** The track relay position can be correlated from Data logger, no need to have EDGE node to monitor relay position. **RZD:** We suggest adding measurements of: - battery charge current; - battery voltage; - choke voltage; - resistor drop voltage; TPR current. **SANARTI:** Can be provided in Type (A) and Type(B) In principle Track circuit proving is superior to other techniques, even more in RE area. Today it is possible to develop the next generation of this, where proving length limitations and requirements for non-welded Rails can be removed. **SJE7:** DC feed end may be dropped as TR is already considered along with both end currents. Choke may be considered in RE area. Charging Current instead may be recorded.It will ensure charger health as well as charging status.	Instead of potential free contact, Track feed Charger's input voltage & output current will be included. Health of battery may also be monitored. Choke voltage & voltage drop across resistance not needed at this stage as we keep no of sensors to optimum level hence only important parameters needs to be monitored.
4.3.5	Diagnostic data from Diagnostic port of Axle counter evaluator shall be captured through data port. This shall be based on	**SJE7:**Supply Voltage of Axle Counter & Channel Voltage across RX,TX shall be recorded.	Supply voltage and current and vital relays may be monitored.

	recommendation of different OEMs of Axle counters of different makes. – Axle counter OEMs for specific comments if any.	Supply Voltage & voltage at AFTC Equipment shall be recorded.	
4.3.7	Level Crossing Gates: The following data shall be recorded for each Boom: i) AC/DC operating Current of Electrical Lifting Barrier.* ii) AC/DC operating Voltage of Electrical Lifting Barrier.* iii) Status of open close position for each boom iv) Locking status of gate. Note *: Scanning rate shall be kept as 20ms for generating voltage &current signature of Motor.	**SANARTI:** These contribute 8.1% of failures. Type (A) and type (B) information canbe provided by SDDU	Locking status of LC gate added in item to be monitored. A note is added for generating voltage/current signature of motor.
4.4.8	Battery: The health of battery to be monitored by using time proven techniques available in other industries using IoT. – Industry experts for suggestion and comments Note: The IPS battery set consists of 55 Numbers of individual 2V Lead Acid cells connected in series for 110V DC backup. Whether monitoring of each cell is recommended or there is any established technique to monitor health using overall Voltage/Current.Any other established technique (which does not require to monitor each cell) available for monitoring of battery health may also be deployed. (comment regarding availability of such system may be provided)	**SANARTI:** Independent monitoring of each cell is a better option, but it will increase cost and complexity. A calculated decision w.r.t cost and complexity is needed to be taken.	Current (charging/discharging) and individual cell voltage & temperature may be monitored. Lot of wiring and use of many sensors will be require to monitor each cell. Decision regarding monitoring of individual cell will be taken as per feedback received against this para.

4.4.14	Any other equipment not in above list or any additional parameter of above listed equipment as found suitable for better predictive maintenance will be incorporated. However, to avoid unnecessary wiring for monitoring, it is recommendatory to monitor only required gears and parameters. – Comments required in specific.	**SANARTI:** It should be defined in prior as to what parameters need to be sensed,so that a proper judgment on wired or wireless sensing can be taken.	Mostly all the gears are included but as contingency majeure this clause need to be there, minor addition/deletion during project planning may be done.
4.5	Due to issue of proprietary protocols in signaling equipments, which is causing issues in interfacing various electronic signaling equipments, Indian Railways is working for uniform protocols like EULYNX.	**TCS:** EULYNX standard is for new signaling installations, what about existing equipment of proprietary protocols, will IR give some kind of interface to IoT solution	Para may be modified as under" Due to issue of proprietary protocols in signaling equipments, which is causing issues in interfacing various electronic signaling equipments, Indian Railways is working for uniform protocols like EULYNX. In this regard following will be followed: (i) OEM of equipment will provide protocol of his system. In future only EULYNX std shall be followed by all OEM. (ii) OEM of RMPM system has to follow EULYNX standard.

5.1	The IoT device shall be software embedded system preferably COTS (commercially off the shelf) and will do the basic function of capturing the parameters from the Signalling devices using the sensors and diagnostic ports and transmit the data to Local Server through Gateway at the station.	**BITCOMM** COTS Item may not be suitable in case of customization or further update . **TCS:** This device is called EDGE node in standard IoT architecture, this needs to follow the Cyber security requirements of ISA/IEC 62443.	'IOT device' is widely used name of this device and may be kept unchanged. Provision for cyber security will be added .
5.2	For monitoring at IBS/LC/Auto Signalling gears, the IoT device shall be linked to nearest station and its local server.	**TCS:** What are the wireless communication protocols allowed between EDGE node and Gateway, pls specify.	It shall be as per EULYNX standard. (Given in annexure). Covered in para 7.8.4
5.3	It shall work on available 24V DC power of IPS as available at site.	**BITCOMM** The 110VAC power is also at Location box. IOT devices shall work on both 24V DC and/or 110V AC Power. Card may cause failure of complete interlocking of station.(Requires modification in Para no.5.1.1 of Draft spec.) **SANARTI:** 12VDC supply would be a standard and can be adopted as an universal supply to all modules can be considered as a standard as available options (power adapters) in this range are huge and easily available. **SJE7:** Shall work on 24v as well as 110v -220v AC	The110VAC power supply is not from IPS hence it is availability will depend on local supply, hence 24VDC supply coming from IPS shall be used.
5.5	It is imperative that the IoT device will continuously monitor the sensors for the parameters depending on scanning interval. Scanning interval to be defined	BITCOMM The AC voltages are normally 50Hz, this gives time duration as 20 msec. The Signal Aspect	Scanning rate shall be kept 20ms or less but data transmission and

	keeping in mind requirement for machine learning & AI and availability of COTS IOT devices. However, device should support scanning interval of 20ms or less, it should be possible to program scanning interval.	AC current is non sinusoidal, therefore for AC current is required to be measured as true rms. For true rms AC current measurement, 20 msec scanning rate do not provide ample measuring points. So atleast for AC current measurement less than 10 msec scanning rate is required. TCS: The scanning time of 20 ms is too high for signaling equipment which does not change the status very frequently, this will only be an over kill and the amount of data will be tremendously high, we need to the time accordingly for different asset classes: RZD: We propose to control signals with periodicity of 50 ms. SANARTI Scanning time of 20mS is a fair choice at trial stage. It can be reduced further (5-10mS) depending upon signaling requirements for a faster response of AI/ML platform. SJE7: Scanning digital input status with a frequency of 20 ms is required in case of data logger where it is scanning cluster of relays which is part of a single circuit and corresponds to train movement where whole field function executes within a time interval of less than second so tracking relays individual operation time needs millisecond scanning. Also major channels of data logger are digital input which do not require additional signal conditioner or current sensor hence major cost of product arises from	storage may be done at a lower rate as per requirement of Signaling gears as explained in para below.

		high end processor which can scan, process and store data with high frequency .but when its related to this system, it is meant to track single entity like cutting relays of signal, relays related to gate status etc where information of pick / drop is sufficient in time of failure point tracking. And since major portion of this system is analog channel, which requires either signal conditioner or current sensor per channel, it would be wise that major cost arises from signal conditioner and current sensor quality. Taking use case of RMPMS into consideration and making it economically feasible solution it would be good if scanning is done over 1sec interval and major expenditure is made towards high quality signal conditioner and current sensor rather keeping high end processor for millisecond scanning as well as high quality signal conditioner , current sensor simultaneously which could else increase over cost. To this there shall be exception in context to point machine where scanning is required very fast to observe curve of operation.	
5.6 5.6.1	Further, the data captured by IoT device will be transferred to Local Server. However, if the data is transferred every cycle, there would be two issues: first is the bandwidth requirement for channel and second is the large data (50 packets per second per parameter) which may difficult to handle and will be ignored at processing level at higher stages. Hence, selective methodology is required to be made for each type of device. Some examples for ready reference are as below:	**SJE7:** IOT device shall have 2 behaviors: DATA Streaming and DATA logging. DATA streaming: In context to MTTR and ongoing failures, a complete circuit of any signaling asset may spread over different locations ,for example a track circuit have some part at feed end location, some at relay end location and some at relay room, so it requires that data streaming shall stay on standby but once dashboard is opened IOT system should able	Scanning interval & data capturing rate is added for clarity & standardization.

	i) Track circuits and Signal Lamp which operates continuously, the operationalparameters may be sent conditionally whenever change of reading is more than specific percentage (say 2%) of last sent value. ii) However for Point machine, ELB motor which operates only for few seconds when operated, the operating current for every scanning cycle will be important to capture its current signature. The current signature may help in deciding machine learning to predict cases of less lubrication, friction clutch issue, stone obstruction and gap, etc. For such application data will be captured and stored at an interval of 20ms.	to connect with all gears in real-time and update on clock of every few seconds, once dashboard is closed data streaming may again change its state to standby without this, essence of real time may not be achieved Data logging: May be done per minute basis Use of LORA and WLAN as 2 media to connect field device to one at station would provide sufficient bandwidth for any such operations Use of Standard RS 485 modbus protocol may be adopted to communicate with field device and local server at station	
5.7	Accordingly, the methodology for sending data from IoT device to server shall be laid down for each equipment. The IoT being embedded system shall be customizable to get the rules changed by the firmware update ~~preferably~~ remotely.	**RAVEL:** It has to be remotely done to take care of any rules or update. This is feasible **SANARTI:** Scanning time of 20ms is a fair choice at trial stage. It can be reduced further (5-10ms) depending upon signaling requirements for a faster response of AI/ML platform. **SJE7:** Main unit shall have unique MAC address & Web Server Interface to allow remote access for ➢ Updating firmware	Para modified for remote update.

		➢ Operating System ➢ Data log &export configuration, also provision to export data to any desired IP ➢ Configuring polling interval, Calibrations of Field unit channels ➢ Configuring wireless channel for each Fieldunit from either RF/LORA/WLAN ➢ Field unit configuration, should be generic in type to support any MODBUS RS 485 devices.	
6	Network and Communication protocols between subsystems: The exchange of information from IoT device to Local server and to Centralized Cloud shall be on standard format for interoperability between different systems. The network architecture and communication protocols for Diagnostic data as defined in EULYNX standards shall be followed. These are covered in Annexure-C.	**SJE7:** URL string may be used such that The cloud portal shall listen for data .For example ,at the following URL: http://xyz.com/data/setdatacsv/ •Majority of IOT device adopts RS 485 Standard MODBUS protocol,same shall be used for commutation with field units to keep system interoperate with any systems and generic in standard	Standard protocol as per EULYNX shall be followed for uniformity & interoperability
6.3	It is planned for adoption of standard protocols for all Signaling equipment in future. Hence, this system will be compatible for direct interfacing with the diagnostic ports of various equipment like Electronic Interlocking, Axle counters, etc. Note: The manufacturers of all Software embedded electronic signalling equipment are asked to adopt EULYNX standard. Till that time, the protocol conversion may be done on the IoT device form these devices. As diagnostic is not a safety critical system,	**BITCOMM** COTS Item may not be suitable in case of customization or protocol conversion.	Standard protocol as per EULYNX shall be used.

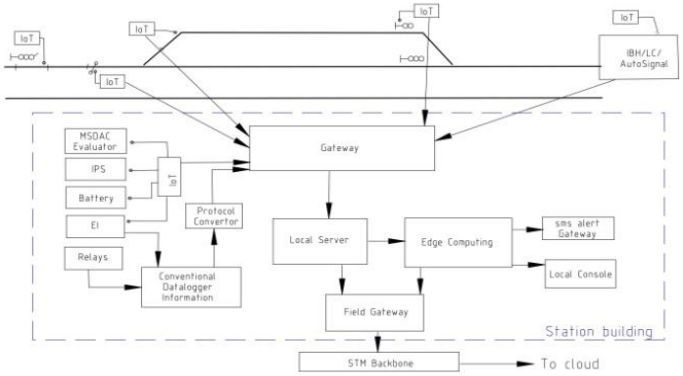
	the activities like ISA validation will not be required for such protocol conversion. The concerned OEMs of Axle counter, MSDAC, EI, AFTC, etc shall provide existing protocols of equipment in use on Indian Railways for development of IoT device firmware.		
6.4	As defined in EULYNX, the protocols SNMP v2c or OPC-UA shall be used to transfer diagnostic data from the connected systems (IoT) to the service function Diagnostics collector (Local server/Edge device).	**SJE7:** • Communication media between field IOT deice& station server shall be wireless as wired media establishment will increase cost many fold and also increase installation complexity. • So wireless commutation protocols like MODBUS RTU & MODBUS TCP shall be used. to increase wide range inter opeartibilty system must shall able to communicate over MODBUS TCP & MODBUS RTU as & when required. •For diagnostic purpose it shall be made provision that if any sensor or embedded device in field goes down sms alert may be generated for restoration of the same.log of the same shall also be recorded at station server unit	Wired or wireless media can be used as per availability & planning. Protocol as mentioned in EULYNX std may be kept. This is a good suggestion para added(para 5.8)
6.5	The time synchronization is an important requirement between various IoT devices for data interpretation in machine learning. This has been taken care in the standard protocol. For master clock, the IRNSS (Indian Regional Navigation Satellite System) clock or SNTP protocol shall be taken for reference	**SJE7:** • SNTP may be added as additional option	Suggestion incorporated.
6.7	At Physical Layer suitable network media		

	shall be used. The EULYNX standard requires OFC and RJ45 (Copper) media which runs along with the equipment. However, on Indian Railways the field devices not having inbuilt diagnostic port shall be connected using IoT devices for which wireless media can be used.	RZD We propose to include the possibility of using spare cores of an existing copper cable. **SJE7:** Wireless commutation protocols like MODBUS RTU & MODBUS TCP shall be used. To increase wide range inter operability system must shall able to communicate over MODBUS TCP & MODBUS RTU as & when Required	
6.8.1	For communication from IoT device (in station yard near point, signals and other equipments) to Gateway at station – i) Wireless media on LoRA, NB-IOT, Zigbee or any opensource technology in free band of wireless spectrum. ii) Optical fiber LC interface [IEC 61754-20] (mandatory for outdoor field IoTs) iii) Copper cable. (RJ45 interfaces [IEC 60603-7]) iv) Wi-Fi communication *Note: Use of Wireless technology is preferable as laying of additional wires and OFC will make system complex and costly. Further, LoRA, Zigbee, NB-IOT technology seem to work on long distance so it seems suitable for electrically noisy environment (RE area and dynamic variation of line of sight signals due to train movements)having but having lower data rates. The average rate of data from one IoT device will give idea on the suitability of ~~LoRA~~ these wireless technology for Physical layer. Scheme for this has to be worked out with justification.*	**RZD:** We propose to enable the ability to use WiFi networks to transfer data from IoTdevices. **RZD:** LoRa networks usage for transmitting large amounts of data is difficult. In addition, this will cause significant delays in obtaining data and, 2s a result, in identifying malfunctions. **SJE7:** >The remote measurement unit shall be able to send measured data over IOT communication setup to centralized location (Station) via RF module and WLAN. Event shall be sent on a periodic interval. The periodicity shall be remotely configurable. Two wireless media shall be used to ensure redundancy .Use of LTE at every location shall be prohibited which	NB-IOT &Wi- fi is also added.

		or else will cause use of 20-25 sim card for each station. Ensuring 2 wireless media would be sufficient.	
6.8.2	For communication from outdoor type IoT devices (for field gears like signal, point, track circuits, etc) to Gateway at station, the wireless connectivity is mandatory along with optional Fibre connectivity (Type LC connector). Redundant communication path (wired/wireless) must be kept for reliability.	**RZD:** We propose to include the possibility of using spare cores of an existing copper cable. **SJE7:** 2 different wireless connectivity shall be used like RF/LORA/WLAN,/ZIGBEE etc	Provision of redundant communication added
6..8.4	~~Communication Scheme to be used~~ For far away field IoT's like for IBH, LC gates wired media like OFC or wireless system like LTE may be used. ~~and wireless to be worked out.~~	**SANARTI:** GSM/LTE based wireless data transmission technology can be used for a larger distance scenario, but in that case the network coverage shouldbe good at that area.	Para modified as per suggesation.
6.8.5	For communication from Station to Cloud, existing optical fibre network of Railtel may be used. Option For redundancy LTE may also be worked out. used along with OFC network .	**SJE7:** LTE shall be added as additional option, dependency upon only one media would not be a wise option	Suggestion included.
6.9	The details of higher network layers, data packet structure, etc are defined in Annexure-C which has been taken from EULYNX. In this connection, the firmwares of IoT devices and other backend softwares of system shall be designed in such flexible manner to carry out minor update on change of protocol whenever required in developmental stage.	**BITCOMM** COTS Item may not be suitable in case of customization or further update. **TCS:** The EULYNX is not the right standard for defining the data exchange formats between EDGE and the cloud, the standard IoT data exchange protocols like MQTT and JSON	Protocol as per EULYNX shall be followed. Para is ok.

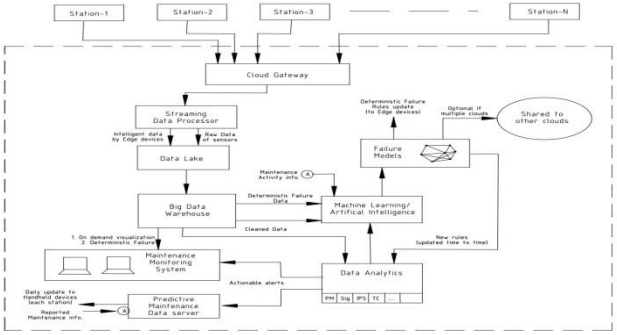
		formats need to be used.	
7	7.1 At each station there shall be centralized setup consisting of Gateway to collect the data from various IoT devices and a set of Local server with Edge computing. One integrated unit with capability to work as gateway to collect field data ,edge computing etc can also be used.The basic architecture at station is depicted in Figure-3. 7.2 The Gateway shall have interface to collect data from various media like wireless, OFC and copper. It shall also be able to collect data from conventional Data Logger for indoor relays status. 7.3 The edge computing shall be employed to decentralize the computing and handling the big data and alert mechanism for each station. 7.4 Edge computing shall be done by suitable PC based system. Industrial grade hardware shall be used for 24x7 operation unmanned functioning. 7.5 The following is the broad functions of Edge computing device: 7.5.1 Scrutinizing the local data of signalling gears to generate realtime alerts on the "deterministic failures". For example – A Point has no indication of Normal or reverse for more than 10 second. The system will detect this as failure and using the data of voltage/relay monitoring at relay room, point motor, etc, it should generate an alarm that	**SJE7 comment:** ➢ >Field Gateway, Gateway to cloud, Edge Computing, Local Server are just functions which station unit shall cater, rather using one device to cater on function, it is advised that there shall be one integrated unit which shall have capability to work as gateway to collect field data ,edge computing ,webserver,media for wireless transmission of data logger and in fact every other function required to perform by main station unit. ➢ >Considering IOT setup and functional requirement of preventive maintenance system, a generic, interoperable system, station unit shall may possess following functional features Variant of 256/512/1024 data unit, to intercept various data units arising from different field gears spread over the yard. Main unit shall have 50/100/150 analog channel,5/10/15 digital input/output,1/2/3 one wire port for temperature sensor in respective version of 256/512/1024 data units' variant ➢ . >Any analog module to be used in RTMS shall be of generic in nature and shall follow standard Modbus RS 485 protocol so that can be easily integrated with any system ➢ >For Cloud networking, main unit shall	As per suggestion of SJE7 one integrated unit at station may also be kept having all functions. Provisions in FRS are generic in nature technical details may differ from vendor to vendor hence not being included.

	“Point No. 101 of Station ‘ABC’ has failed. Probable reason is – detection contact problem at A end” There shall be equipment specific deterministic failure patterns which shall be evolved during development. Systematic and Formal approach is required for writing these rules. 7.5.2 Sending the alert to maintenance staff through sms using “SMS Alert Gateway” over GPRS/LTE. 7.5.3 This alert shall also be sent to Cloud which shall be used for improving machine learning algorithms using AI techniques. 7.5.4 The edge computing device will update itself by new rules of deterministic failures detection sent by the Cloud based on Machine learning. 7.6 The Local server at each station of suitable size shall be provided. The detail requirement would be evolved during development. 7.7 There shall be a local monitoring maintenance system at each station which shall display realtime data and on demand information from local server. 7.8 The complete setup for Local server and edge computing shall be provided in Relay room or Maintainer room or any suitable location at the station. However, the local monitoring maintenance system shall be provided in Maintainer room.	have provision for USB DONGLE, as well as ETHERNET port option to increase redundancy ➢ >In order to have wide interfacing, main unit shall have provision of RS 232, RS 485,TCP/IP to connect with any IOT module/sensors. ➢ >main unit shall have provision to be configured as AP, CLIENT, AP+CLIENT in order to achieve easy and flexible access ➢ >main unit shall have provision for wireless networking of Data logger & UTS system with control ➢ >main unit shall have Web Server Interface to allow remote access for ➢ Updating firmware ➢ Operating System ➢ Data log &export configuration, also provision to export data to any desired IP. ➢ Configuring polling interval, Calibrations of FTU channels o Configuring wireless channel for each FTU from either RF/LORA/WLAN ➢ FTU configuration, should be generic in type to support any MODBUS RS 485 devices. ➢ >Min 16gb Micro SD card to store local data in case Cloud Connectivity goes out ➢ >main unit shall have provision to connect with Field unit over RF/LORA & WLAN to ensure dual network for communication	

		➢ >main unit shall be able to communicate with other main unit at IBS, HUTS, in order to integrate monitoring for hut - power cabin setup where distance between power cabin & hut can be comparatively large	
7.5.1	Scrutinizing the local data of signaling gears to generate real-time alerts on the "deterministic failures". For example – A Point has no indication of Normal or reverse for more than 10 second. The system will detect this as failure and using the data of voltage/relay monitoring at relay room, point motor, etc, it should generate an alarm that "Point No. 101 of Station „ABC" has failed. Probable reason is – detection contact problem at A end" There shall be equipment specific deterministic failure patterns which shall be evolved during development. Systematic and  Figure-3 : Arrangement at Station Formal approach is required for writing these rules.	BITCOMM The number of equipment at station can be minimized. Since there is provision to have Zonal as well as Unified cloud, edge computing can be done on local server to some extent. Also Railway is going towards IPMPLS implementation, we would propose to have IP/Ethernet interface as gateway to zonal/central cloud .	Para is ok.

8	8 Field Gateway: 8.1 At each station there shall be field Gateway which filters and pre-processes the data to be sent to and received from Cloud. 8.2 Field gateway will transmit/receive the data to cloud over the STM backbone of Railtel.LTE communication may also be used form redundancy.	**SJE7:** Shall be integrated part of main unit as commented in previous section	LTE communication added.
9.1	The power supply for IoT devices near the outdoor equipments shall be taken from signaling equipment supply with suitable rating fuse. Where power is not existing, 24V DC may be extended from nearby location box.	**RAVEL:** We would also need the Battery backup for the same. **SJE7:** ➢ >24 v DC coming at location for TPR shall not be used to supply field unit,Rather a small battery should be In-house field unit which can be charged using 110v Ac so that field unit may still work even if there is 110v/AT cut due to any fault or maintenance purpose. This will ensure & prevent any loss of data. Also since remote measurement unit is already equipped with 2 media to transmit data to send to station unit as well as cloud ,shall have only volatile memory to store data for sometime till it has been recorded by station unit or cloud rather than having local storage. As making provision for local storage will cause different set of hardware and will increase cost. If field unit gets faulty anyhow it won't store data but if its	Provision of battery in IOT device in field is not being considered due to maintenance & replacement issue.

		working can send data on any 2 media and adding local storage may not be cost effective ➢ >The remote Measurement Units/ Sensors installed in the functions or Location box for data acquisition shall have own power backup of 2-3 hours and can run on 110v AC.	
10	10 Central cloud and Data Analytics: 10.2 For optimum outcome, it is proposed that there shall be integrated single cloud for all stations of Indian Railways. However, if concern for interoperability is proven or single platform is developed, the cloud can be per Zonal Railway or a group of Zonal Railways. A mirror cloud shall be setup for data backup.	**SJE7:** Cloud at zonal railway may be preferable,at the same time API should be there at each zonal cloud to share data across other zonal railway as and when required	Single cloud may be more appropriate from point of view of ML & AI as sufficient data to develop ML & AI may not be available if it is done zone wise.
10.3	It is desirable that Cloud and AI shall be based on open source platforms and AI algorithms developed shall be property of Indian Railways. There shall be no propriety of industry partners on the intellectual property so emerged during trials and development of the system. Note for 11.1 & 11.2: The issue of redundant efforts to develop machine learning and AI analytics need to be seen. Developing AI algorithms and machine learning is a time taking job. The present Specification assumes one single platform to avoid wastage of time and efforts on developing AI machine learning algorithms.	**BITCOMM** In such case, it would be recommended that Indian Railway develops and owns base model for different purpose which could be used by industry partners	Common cloud needs to be developed. One firm can take up this job in coordination with all the stakeholder, Railway may coordinate it.

	 Figure-4 : System Architecture at Cloud level		
10.4.1 10.4.2 10.4.3 10.4.4 10.4.5	10.4.1 Cloud Gateway: It ensures safe data transmission and provides connectivity to various field gateways from each station. Intermediate Gateways at division level may be used if number of stations are large in number. 10.4.2 Streaming Data processor: The sensor data received through cloud Gateway enters to streaming data processor. Its purpose is to allow continuous flow of data and quickly and efficiently transmit data streams to a data storage. 10.4.3 Data Lake : A data lake stores the data gathered by sensors. It is still raw, so it may be inaccurate, erroneous or contain irrelevant items. It is presented as a number of sets of sensor readings measured at the corresponding time. When the data is needed for insights about equipment's health, it is loaded to a big data warehouse. 10.4.4 Big Data Warehouse: The big data warehouse stores cleansed structured data. It contains various parameters of equipment measured at a particular time and	SJE7 Suggestion: In order to achieve purpose of Data Analytics, the system software may consist of following component. ➢ Collect: The Main unit of RMPMS must have MQTT installed to stream in data over cloud through local server for the purpose of using Analytics. Standard practice of MQTT protocol like channels, topic filters in various formats and frequencies can may be used ➢ Process: Traditional analytics and business intelligence tools are designed to process structured data. IoT data often comes from devices that record noisy processes (such as temperature, motion, or voltage or current). As a result the data from these devices can have significant gaps, corrupted messages, and false readings that must be cleaned up before analysis can occur. This is done at local server/Edge server. ➢ Cleanse and filter – Tools to define	Para is ok, suggestion given has gone through. Only Eulynx protocol will be used (MQTT not needed). Standard technique of data processing, filtering, enriching etc can be used for ML & AI, these details are not being provided as it will evolve with trial.

	contextual information about equipment like equipment installation details (make, DOI, etc), previous history of maintenance, failure, age, number of operations, etc. 10.4.5 Machine Learning / Artificial Intelligence : The data received is used by the AI algorithms to improve the failure models and predictive models. Initially, supervised learning will be done and gradually the learning will be more automated using AI techniques. The failures and maintenance activity data shall also be used for selecting and neglecting the raw data respectively. For example, if deterministic failure is reported by Edge device, the machine learning will analyse deep data screening to relate failure pattern and update its model. While, if maintenance activity is taken where disconnection or forced shutdown of equipment is done, the machine learning algorithm will discard such data to prevent wrong learning. 10.4.6 Data Analytics*: The existing failure models and predictive models are updated time to time by the Machine learning above. The realtime data of signalling gears is analysed with these machine learning models. The ML algorithms are applied to reveal hidden correlations in data sets and detect abnormal data patterns. The recognized data patterns are reflected to generate the predictive health information of signalling equipment.	functions may be used and can be triggered when IoT Analytics detects missing data, so can run code to estimate and fill gaps. May also define max/min filters and percentile thresholds to remove outliers in streaming data. Shall be implemented to discard data arising due to train movement or any other hardware malfunction. ➢ Transform –IoT Analytics may transform messages using mathematical or conditional logic already defined, so that it can perform common calculations like Ampere into milli ampere conversion etc. ➢ Enrich – IoT Analytics can enrich data with external data sources such as a length of track, point machine or gate associated with track to mark higher leakage as compared to other tracks. Similarly for other field functions Date: 31st may 2020. SJ E7 IT SERVICES PVT LTD comments for Draft Specification for Remote Diagnostic And Predictive Maintenance for comments ➢ Time-Series Data Store - IoT Analytics may stores the device data in an optimized time-series data store for faster retrieval and analysis. Can also manage access permissions, implement data retention policies and export data to external access points. ➢ Store Processed and Raw Data - IoT Analytics may store the processed data and also automatically stores the raw ingested data so that it can be processed at a later time. o Analyze	

		➢ Run Ad-Hoc SQL Queries - IoT Analytics may provide a SQL query engine so that can run adhoc queries and get results quickly. For example, might run a quick query to find the number of fail prone gears for each station. ➢ Time-Series Analysis - IoT Analytics may supports time-series analysis so that can analyze the performance of devices over time and understand how here they are being used, continuously monitor device data to predict maintenance issues, and monitor sensors to predict and react to environmental conditions. ➢ Hosted Notebooks for Sophisticated Analytics and Machine Learning - IoT Analytics may includes support for hosted notebooks like Jupyter Notebooks etc for statistical analysis and machine learning. The service may includes a set of notebook templates that contain authored machine learning models and visualizations to help you get started with IoT use cases related to device failure profiling, forecasting events such as low remaining life that might signal the maintainer to replace the gear, or segmenting devices by rest remaining life levels or gear health. ➢ Prediction - statistical classification through a method called logistic regression may be implemented. May also use Long-Short-Term Memory (LSTM), which is a powerful neural network technique for predicting the output or state of a process that varies	

		over time. May use pre-built notebook templates also to support the Kmeans clustering algorithm for device segmentation, which clusters gears into cohorts of like devices. These templates are typically used to profile gear health and gear state such as write to itself for tracks, bubbling effects for aftc, loose packed point machines etc. Date: 31st may 2020. SJ E7 IT SERVICES PVT LTD comments for Draft Specification for Remote Diagnostic And Predictive Maintenance for comments ➢ Build/Visualize ➢ IoT Analytics may provide dashboard to visualize data sets. May be provision made to visualize the results or ad-hoc analysis in the embedded third party Notebooks like jypteretc	
10.4.3	Data Lake : A data lake stores the data gathered by sensors. It is still raw, so it may be inaccurate, erroneous or contain irrelevant items. It is presented as a number of sets of sensor readings measured at the corresponding time. When the data is needed for insights about equipment's health, it is loaded to a big data warehouse.	BITCOMM We are proposing Data Lake, this means, we are expecting unstructured and structured data. We should define how the source is going to produce unstructured data and what structured or transformation would be required. If the devices are expected to workon standard guidelines then what is specific need for having a Data Lake.	May be incorporated after gaining experience.
10.4.4	Big Data Warehouse: The big data warehouse stores cleansed structured data. It contains various parameters of equipment measured at a particular time and contextual information about equipment like equipment installation details (make, DOI, etc), previous history of maintenance, failure, age, number	BITCOMM Asset Management, MIS and Signaling Maintenance Management System shall be defined more in detail.	Existing maintenance register may be used for getting details of various gears.

	of operations, etc		
10.4.7	*Important Note: Depending on the experience, the Data Analytics and Maintenance monitoring systems may be decentralized to strategic locations like at every division at later stage of mass deployment.	BITCOMM There should be a subsystem or integration with MIS to differentiate the records from those which were created due to routine or ad hoc testing	Data related to testing may be stored separately and may not be used for ML.
11.1	During initial development of system, the supervised machine learning will be required and slowly it will switch to unsupervised machine learning using Artificial Intelligence (AI) techniques.	BITCOMM Supervised and Unsupervised is completely different approach. Supervised and Unsupervised solve different set of problem and differently.	As more data get available it will use unsupervised learning with re-enforcement.
11.2	The initial development rules include defining the allowable parameter limits. For example, if monitored 24V power supply for and equipment like axle counter of so and so make goes below “x” volt (as per equipment manual), it is likely to fail.	BITCOMM Such complex pattern analysis and prediction can be handled by Unsupervised Learning algorithms. By definition, Unsupervised Learning is a type of machine learning that looks for previously undetected patterns in a data set with no pre-existing labels and with a minimum of human supervision. This could be helpful to detect anomalies in ageing devices with varying stable parameter limits and changing environmental parameters	As more data get available it will use unsupervised learning with re-enforcement.
11.4	As our machine learning processes identify these patterns, we integrate them as new rules into the proactive workflows to provide the customized rules for each equipment.	BITCOMM Is machine learning processes will be shared by RDSO/Railway. Who will do the integration new rules into proactive workflows ..	Will be coordinated by Railway.

Annexure A.2	The details of Voltage and Current ranges of sensors for Point Machine, DC track Circuits and signal lamps are given below:	We suggest adding paragraph 5 "Measurement of insulation resistance" to the Point Machines and Signals tables. For Track Circuits - battery charge current; - battery voltage; - choke voltage; - resistor drop voltage; - TPR current.	Not needed as this stage, if required may be added later on.
Annexure-C	Network layers and Protocol information (Brief information based on EULYNX standard. Details will be shared on later stage) C.1 For the use of the Standard Diagonostic Interfaces (SDI) the following definitions shall be applied. a) The higher layers (transport layer and application layer) together form the Standard Diagnostics Interface (SDI), designated as SDI-XX. They are defined in [EULYNX Document No. - Eu.Doc.77]. b) The lower layers (network layer, data link layer and physical layer) are defined by the PoS-Signalling, as defined in [EULYNX Document No. - Eu.Doc.100]. C.2 Lower Network Layers: The lower layers of the protocol stacks of the standardised interfaces of the EULYNX system are as below: a) Physical Layer: For the physical layer, the standard [IEEE 802.3] Ethernet protocol over copper RJ45 interfaces [IEC 60603-7] or fiber LC interface [IEC 61754-20] shall be used. For IoT devices, wireless media like LoRa shall be provided for monitoring those equipments which require external sensors like Points, Signals, Track circuits, etc on Indian Railways. – Note: Requirement for	Architecture: The current setup of scada system used is such that it's a standalone device in relay room and inputs to be measured are in same room .There may be various component in scada system to perform various functions but to interface an analog input either voltage & current interface is required, which is a part of data logger assembly and tapping is done via wires. In scenario where inputs are scattered over the yard ,in such scenario every things remains the same except that to tap such input interfacing circuit is required to moved to field and a media preferably wireless is required to relay input value from filed to the unit at station .So it is advised especially keeping system economics into consideration that field unit should be a light weight device whose function is to just collect data and relay to station unit. It may have provision to use 2 media to increase redundancy and shall use standard wireless protocols like MODBUS RTU or MODBUS TCP to relay data over LORA/RF or WLAN respectively with some small volatile memory to retain data until its been relayed . Wireless transmission either for field to station using rf/Lora/wlan and from station to cloud using LTE must be a part of system. Wired media can be kept in addition in view of redundancy	Scheme & protocol as per EULYNX std will be followed.

	wireless media added in addition to EULYNX standard (where only RJ45 (Cu) and OFC interface is covered) to keep monitoring system simple on existing yards for devices not supporting inbuilt Diagnostic ports. b) Data link Layer: For the data link layer, the Ethernet [IEEE 802.3] protocol shall be used. c) Network Layer: For the network layer, both IPv4 [RFC0791] and IPv6 [RFC8200] shall be used. IP addresses and port numbers at the transport layer shall be adjustable. C.3 The Standard Diagnostic Interface is used for resolving issue of interoperability of various sub-systems for use on Indian Railways. This is as per EULYNX standard. This interface is telegram based interface and it is composed of Transport Layer and Application layer. a) Communication requirements i) The protocols SNMP v2c or OPC-UA shall be used to transfer diagnostic data from the connected systems (IoT) to the service function Diagnostics collector (Local Server). ii) The service function Diagnostics collector (Local Server) shall support both SNMP and OPCUA to receive diagnostic data. iii) The connected systems (IoT) shall support either SNMP or OPC-UA via HTTPS/SOAP. C.4 Transport Layer: OPC-UA and SNMP-v2c protocol. a) Structure of telegrams when using OPC-UA. i) OPC-UA uses a strict client server model . ii) The connection shall be encrypted using HTTPS/SOAP. iii) When establishing the connection, the signature of the connected system (IoT) shall be checked for authenticity and validity by the service	..	

	function Diagnostics collector (Local Server). b) Telegram definitions OPC-UA: i) The communication between the OPC-UA client and the OPC-UA server is session-oriented. ii) For OPC-UA, a "telegram" consists of a communication session in which several OPC-UAspecific messages are exchanged between the client (IoT) and the server.		