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No. R&T/RAMS **Date: 11.09.2024**

M/s. Hitachi Rail
A-153, Sector 63 – Noida (U.P.),
201301.

M/s. Apna Technologies &
Solutions Private Limited 201301
820, Tower C, Noida One
Plot B-8, Sec 62, Noida (U.P.)
201309,

M/s. Schaeffler Technology Solutions
India Pvt. Ltd, M-Agile, 8th Floor,
Sr. No. 33 (Part),
Pancard Club Road, Baner
Pune (Maharashtra), 411045

M/s. Adani Digital Labs Private
Limited Adani Corporate House,
Shantigram, Near VaishnoDevi
Circle, SG Highway, Khodiyar,
Ahmedabad (Gujarat), 382421.

M/s. A_Paul Software Systems Pvt. Ltd.
D-6/3 Okhla Industrial Area Phase-I,
New Delhi – 110020,

M/s. Schaeffler Technology Solutions
India Pvt. Ltd. M-Agile, 8th Floor,
Sr. No. 33 (Part), Pancard Club Road,
Baner,Pune(Maharashtra), 411045

M/s. Siemens Industry Software
(India) Pvt. Ltd.E-20, 1st & 2nd Floor,
Hauz Khas, New Delhi - 110016

M/s. SKF India Limited, 611 - 617,
6th Floor, Bestech Chambers,
B-Block, Sushant Lok, Phase-I
Gurgaon, Haryana, 122002,

M/s. Televic Conference India
Private limited, No-367, 3rd Floor
Vegas Commercial Tower,
plot no 6, Sector 14 Dwarka,
Delhi, Delhi, 110078

M/s. Wabtec India Technology
and Engineering Center
6th Floor, Southwest Tower,
ITC Green Centre,18, Dodda New
Banaswadi, Main Rd, Maruthi
Sevanagar, Bengaluru, Karnataka-560005.

Tata Autocomp Systems Limited
TACO House, Damle Path,
Off Law College Road, Pune
(Maharashtra) 411004, India

Dassault Systèms India Pvt Ltd
DLF Cyber City Phase II
Floor # 5, Block C, "Building # 8"
Gurgaon (Haryana) 122002

Sub: Request for Comments/Suggestions on Draft Tender Document for Proof of Concept (PoC) for the Implementation of EN 50126 RAMS Standards for the Prototype of Rolling Stock of Indian Railways

We have prepared a draft document outlining the scope of work for the Proof of Concept (PoC) project focused on the implementation of EN 50126 RAMS Standards for the Prototype of Rolling Stock of Indian Railways.

Given your expertise in this field, we highly value your input and would greatly appreciate it if you could review the draft and provide your comments, suggestions, or feedback.

Please send your responses to the following email addresses: kumar.manoj17@gov.in or avadha.4776@gov.in by 30th September 2024.

Your prompt feedback will be instrumental in further refining the project scope to ensure its success. We look forward to receiving your valuable insights and suggestions.

Please note that if no feedback is received by 30th September 2024, it will be treated as nil comments.

Thank you for your continued support and collaboration.
Best regards,

DA: Copy of draft documents on POC for comments**.**

MANOJ KUMAR

Digitally signed by MANOJ KUMAR
DN: cn=MANOJ KUMAR, c=IN, st=MADHYA PRADESH, o=CENTRE FOR ADVANCED MAINTENANCE TECHNOLOGY GWALIOR, ou=CENTRE FOR ADVANCED MAINTENANCE TECHNOLOGY GWALIOR, serialNumber=EEBA539BE3D26E7E938C8B978EB901E7FF76C9E530EEF18C46134D51022C3ED2
Date: 2024.09.11 19:17:47 +05'30'

Manoj Kumar
Director/Testing/HQ

C/- PED(SPL)/RDSO: For kind information, please.
C/- PED R&T /RDSO: For kind information, please.

Draft Scope of work for Proof of Concept (PoC) for Implementation of EN 50126 RAMS Standards for the Prototype of Rolling stock of Indian Railways

1. Introduction

1.1. Purpose

The purpose of this tender document is to solicit proposals for a proof of concept (PoC) for the implementation of Reliability, Availability, Maintainability, and Safety (RAMS) and Prognostics and Health Management (PHM) for our railway rolling stock.

1.2. Background :

Indian Railways (IR), the backbone of India's transport sector, is undergoing a significant transformation. This includes upgrading tracks and bridges for higher speeds, introducing the automatic train protection system (Kavach), deploying high-speed Vande Bharat train sets, installing advanced overhead equipment, and modernizing railway stations. With a vast inventory of assets including wagons, coaches, locomotives, tracks, and signaling systems, IR is striving to meet stringent requirements for reliability and availability. Currently, maintenance of these assets is primarily time schedule-based, leading to high costs. The move towards condition-based maintenance (CBM) is critical to reducing these costs and enhancing asset availability.

2. Project Scope

2.1. Long term objectives

- Enhance the safety and reliability of railway rolling stock.
- Implement predictive and condition-based maintenance strategies.
- Reduce maintenance costs and downtime.
- Improve lifecycle management of components and systems.

2.2. Scope of Work

- Preparation of the sensorisation map of each rolling stock as per the list of sensors given in this specification

- Data Acquisition: Install necessary sensors and data collection systems. Development of APIs for acquiring data from existing various sensors fitted on the OEM equipment on rolling stock. Running of APIs on the onboard data acquisition and storage system. Collecting data from some of existing sensors on the rolling stock through a suitable Open Protocol Communication Universal Architecture (OPC-UA)

- Fitment of data acquisition and data transmission systems on the rolling stock as given below

- On board AI based algorithms for alarms generation,

- Setting-up cloud based server for collecting the data from the rolling stock wirelessly. Cloud server to be physically based in India.

- Development/ modification of existing AI-based algorithms for diagnosis and prognosis of failures/ faults. Data Processing and Analytics: Develop and implement algorithms for health assessment and predictive maintenance.

- Set up a structured AI-based RAMS system through commercial software to implement EN50126 RAMS Standard on Indian Railways for its rolling stock, hardware and software to be at RDSO.

- Collection of data from the wayside monitoring systems and store in the cloud server for further analysis (Wheel Impact Load Detection, Acoustic Bearing condition monitoring system, Hot box detection system)
  .
- Decision Support: Create a dashboard for actionable insights and maintenance planning.
- Testing and Validation: Conduct tests to validate the offered system. Testing on the prototype vehicle regarding the functionality of the installed onboard sensors, APIs, onboard data acquisition, storage, and transmission system with approval by RDSO.

2.3 Detailed Scope of supply :

- Supply of new sensors to be fitted on the rolling stock as per annexures.
- Supply of on-board wireless data acquisition, data storage, and wireless data transmission system.
- Supply and Install cloud hardware and software.
- Development and supply of analytic software for condition monitoring, diagnostics and prognostics. Development to be done jointly with Indian Railways team.
- Supply of software and hardware for RAMS analysis for installation at RDSO.
- The location of the project for implementation will be as follows:
  - Vande Bharat Train - Train Set Maintenance Depot Shakurbasti, Northern Railway, Delhi Division
  - LHB Coach - At Bombay Coaching Depot, Western Railway, BCT division.
  - BCN Wagon ROH Depot- Ludhiana, Firozpur Division, Northern Railway.
- Control command center Supply, Installation, and commissioning of the RAMS and PHM software on the client computers and testing the same. Location - RDSO
- Training RAMS & PHM for Indian Railways personnel including hardware, software, networking, etc. at RDSO.

The products/services required for PoC of RAMS project details are below:

SN	Item Description	Total Qty/Unit
1	Required Sensors/Hardware for Condition Monitoring of **01 Basic Unit of Train Set** (Sensors details at Annexures)	1
2	Required Sensors/Hardware for Condition Monitoring of **Smart LHB coach** (Sensors details at Annexures)	5
3	Developmental and validation charge for 1 **smart wagon** one-time charge (Sensors details at Annexures) ,	1
	Required Sensors/Hardware for Condition Monitoring of Smart Wagon.(Sensors details at Annexures)	4
4	Hardware, software, and Human resources for integration of data provided by railways through existing systems e.g. OCMS, TCMS, FOIS etc *(Hardware will include DAQ/EDGE Boxes to which raw data, as acquired through the existing systems, will be directly supplied by IR/agency engaged for fitments.)*	1 Set
5	IT Network & Cloud Services 1. Data Gateway Hardware 2. Cloud Server for RAMS & PHM 3. Digital Backbone subscription charges 4. Cloud subscription charges	1 set
6	RAMS & PHM Software	1 set
7	1. Development of relevant Digital Twins, Diagnostic Engine, and User Interfaces (Digital Twins development will be done jointly with RDSO) 2. Analytics for diagnosis & prognosis Axle Box Bearings and Traction Motor Bearings, Traction motor, Suspension system, Brake system, Other on-board equipment etc.	1
8	IT & Infrastructure Items	
	1. Wall Screen (98")	1

	2. Rugged Notebook (industrial laptop)	4
	3. LAN Server	1
	4. Multifunction Printer	1
9	Training in RAMS & PHM for Railway personnel	
10	AMC cost for per year	

VB /Train Set- 01 Basic Unit (04 coaches)

SN	Description	Qty per coach	Total Qty
1	Axle box bearing condition monitoring - uniaxial accelerometer and integrated temperature sensor (i.e. required one sensor per axle box) [SKF-Model: CMSS 2200RT-100]	8	32
2	Vertical and Lateral Vibrations accelerometers on bogie center [SKF-Model: CMSS 2200RT-100]	---	2
3	Traction motor bearing monitoring - uniaxial accelerometer and integrated temperature sensor only for Motor Coach, for both driving and a free end. i.e. required 2 nos of sensors per motor (total 8 nos of motor coaches & 4 numbers of the motor per coach) [SKF-Model: CMSS 2200RT-100]	8	16
4	Gearbox bearing monitoring for gear case pinion side & gear case wheel side (i.e. required 2 nos of sensors in gearbox & 4 numbers of the motor per coach) [SKF-Model: CMSS 2200RT-100]	8	16
5	Track-Shock Detection: Speed Sensor + GPS module, dual channel [SKF- Technical Specification No. TS_KEP KRMM-8101 01-L-38]	---	2
6	Power cable & Connectors for Data Acquisition system & Edge devices	----	9

7	Bracket for Vibration Sensors	----	68
8	Data Acquisition & Edge device, for data acquisition from sensors and transmission to the cloud (Measurement of vibration & temperature on Axle box Bearing + TM Bearing and vibration on Gearbox bearing) [SKF Integrated IMx Rail designation: TS_KEP KRMM-8101 B40]	---	9
9	Mounting bracket for Data Acquisition & Edge devices	----	9
12	Installation, Commissioning & Interfacing	---	---

Smart LHB Coach

SN	Description	Qty per coach
1	Axle box bearing condition monitoring - uniaxial accelerometer and integrated temperature sensor [SKF-Model: CMSS 2200RT-100]	8
2	Vertical and Lateral Vibration accelerometers on bogie center [SKF-Model: CMSS 2200RT-100]	2
3	Track-Shock Detection: Speed Sensor + GPS Module [SKF- Technical Specification No. TS_KEP KRMM-8101 01-L-38]	1
4	Power cable + Connector for Data Acquisition system & Edge devices	2
5	Bracket for Vibration Sensors	10
6	Mounting bracket for Data Acquisition & Edge devices	2
7	Data Acquisition & Edge device, for data acquisition from sensors and transmission to the cloud (Estimated based on total channels) [SKF Integrated IMx Rail designation: TS_KEP KRMM-8101 B40]	2
8	Air Spring Pressure sensor [Baumer Model: PP 10R]	4
9	Brake Pipe pressure sensor [Baumer Model: Y 91]	2
10	Installation, Commissioning & Interfacing	1

Smart Wagon

SN	Item Description		Qty per unit
1	**Wagon instrumentation, verification, and validation cost (one time)**		
	a	Development of Smart Sensor • Mechanical design of individual smart sensor which measures vertical load and vibration along with temperature. • Submission to RDSO for approval along with FE Analysis for Sensor, Elastomeric Pad, and Bearing Adapter • Submission to RDSO of the drawings for approval for all the components to be mounted on each bogie. • On approval of the design one prototype to be developed and submitted for approval to RDSO for a prototype of just the smart sensor and the other of a smart sensor installed on the bearing adapter. • Cable/Conduit Design in consultation with RDSO to reduce the risk of pilferage • Battery box design to be submitted to RDSO for approval.	1
	b	Installation on 1 Wagon: · 8 Smart sensors for Axle box bearing condition monitoring - uniaxial accelerometer and integrated temperature sensor (i.e. required one sensor per axle box) · Vertical and Lateral Vibrations accelerometers on bogie center · 2 Edge Accumulators · 2 LFP batteries suitable for Railway Applications with a minimum 18 months recharging period. These are to be placed in battery box design approved by RDSO · 2 GPS units with antennae · 2 4G Modems · Required cables, wires, conduits, connectors, and any hardware as per approved design	1
	c	Field Trials, Data Collection & Analysis. This will be an iterative process to be repeated two to three times to ensure that 15 days of trial data is consistently published	1

		to the cloud. Modifications to the prototype might be made based on learnings from the trials.	
2	Regular installation		1
3	BP pressure sensor		2

3.0 Project plan with Milestone-wise Payment schedule

Milestone-wise Payment Schedule: The maximum period for completing the work is **18 months**. The payment schedule for implementing RAMS (Reliability, Availability, Maintainability, and Safety) and PHM (Prognostics and Health Management) systems for railway rolling stock is structured around key project milestones. This ensures that payments are made based on the completion of specific, measurable tasks and deliverables.

Phase	Activity	Timeline	Payment schedule
Phase -I	Issue of LOA/Signing of contract agreement, initial meeting.	D	30%
	Supplier to submit the list of documents and data etc. required from RDSO.		
	The submission of a detailed design plan by the supplier for the LHB Coach and approval.	D+2 month	
	Complete analytics RAMS, PHM software modules, and digital twins & models, preliminary testing. Digital twins will be made by the RDSO personnel under guidance from the experts provided by the contractor		
	Call for inspection of components for the prototype and laboratory-level validation of the analytics software/algorithm used in RAMS and PHM.		
	Completion of the fitment of components/instrumentations on the prototype coach		
	Field trial of a functional prototype for 3 months for verification and validation of the system		

	Testing reports, and validation against requirements.		
	Comprehensive testing reports (unit, integration, system), validation against requirements		
	Comprehensive testing reports (unit, integration, system), and validation against requirements.		
	Deployment of the system for pilot testing, user training sessions, and initial user feedback.		
	Fitment of 04 more LHB coaches, their field trials, and clearance by RDSO. Full system deployment, final user training, system documentation, user manuals as per contract, etc.		
	Total allowed time for Phase -I, activities	06 Months	
Phase-II	Submission of a detailed design plan by the supplier for the Wagon.	D + 2 months	30%
	Approval of detailed design plan for Wagon by RDSO.		
	Complete analytics RAMS, PHM software modules, and digital twins & models, preliminary testing		
	Call for inspection of components for the prototype, and laboratory-level validation of the analytics software/algorithm used in RAMS and PHM.		
	Completion of the fitment of components/instrumentations on the prototype		
	Field trial of a functional prototype for 3 months for verification and validation of the system		

	Testing reports, and validation against requirements.		
	Comprehensive testing reports (unit, integration, system), validation against requirements		
	Comprehensive testing reports (unit, integration, system), and validation against requirements.		
	Deployment of the system for pilot testing, user training sessions, and initial user feedback.		
	Fitment of 04 more Wagons, their field trials, and clearance by RDSO. Full system deployment, final user training, system documentation, user manuals as per contract, etc.		
	Total allowed time for Phase -II, activities	06 Months	
Phase-III	Submission of a detailed design plan by the supplier for 01 BU of the Vande Bharat Train set Rake	D+2 months	30%
	Approval of detailed design plan by RDSO.		
	Complete analytics of RAMS and PHM software modules and digital twins & models, preliminary testing.		
	Call for inspection of components for the prototype, and laboratory-level validation of the analytics software/algorithm used in RAMS and PHM.		
	Completion of the fitment of components/instrumentations on the prototype of 01 BU of the train set.		
	Field trial of a functional prototype for 3 months for verification and validation of the system		

	Testing reports, and validation against requirements.		
	Comprehensive testing reports (unit, integration, system), validation against requirements		
	Comprehensive testing reports (unit, integration, system), and validation against requirements.		
	Deployment of the system for pilot testing, user training sessions, and initial user feedback.		
	Full system deployment, final user training, system documentation, user manuals as per contract, etc.	06 Months	
Post-commissioning Deployment Support and Final Acceptance.	Post-deployment support, final adjustments	3 years after the issue of LOA.	10%

4.0 Penalty clause for POC Project:

This is a research & developmental project in which the first phase is Proof-of-concept. Therefore, penalties as levied in normal works/ service/ supply contracts are not attracted. However in order to safeguard the interest of Indian Railways following penalties will be applicable after mutual agreement between RDSO and the Contractor. Mutual agreement has been incorporated due to the research & developmental nature and PoC project.

1. Delays in Project Milestones

Penalties for delays ensure that the project stays on schedule and encourage the timely completion of each milestone.

Definition: Delay of up to 1 month and beyond the agreed milestone date.

Penalty: 0.5% of the total contract value per delay, capped at 5% of the total contract value for the milestone.

2. Non-Compliance with Specifications:

Penalties for non-compliance ensure that the deliverables meet the specified quality and technical standards.

Non-Compliance

- **Definition**: Non-compliance that can be rectified without significant rework or additional cost.
- **Penalty**: 5% deduction from the payment due for the respective milestone.

3. Performance Issues

Penalties for performance issues ensure that the system functions as intended and meets the required performance criteria.

3.1. Failure to Meet Performance Metrics

- **Definition**: Failure to achieve the agreed-upon performance metrics during testing or deployment.
- **Penalty**: 0.5% deduction from the payment due for the respective milestone, with an additional penalty of 1% of the total contract value for each subsequent week until the performance metrics are met.

3.2. System Downtime

- **Definition**: Unplanned system downtime exceeding the agreed-upon limits (i.e. beyond 24 Hrs) during the operational phase.
- **Penalty**: 0.1% of the total contract value per hour of downtime, capped at 5% of the total contract value.

4. Breach of Confidentiality or Intellectual Property Rights

Penalties for breaches in confidentiality or IP rights ensure the protection of sensitive information and proprietary technologies.

- **Definition**: Unauthorized disclosure or use of confidential information.
- **Penalty**: 10% of the total contract value, plus liability for any damages incurred as a result of the breach.

5. Other Penalties

Penalties for other breaches ensure overall compliance with the contract terms and conditions.

5.1. Non-Adherence to Safety Standards

- **Definition**: Failure to comply with the agreed safety standards and regulations.
- **Penalty**: 5% of the total contract value per incident, plus costs incurred to rectify safety issues.

5.2. Inadequate Training and Support

- **Definition**: Failure to provide adequate training and support as specified in the contract.
- **Penalty**: 1% of the total contract value per missed training session or support incident, capped at 5% of the total contract value.

6. Technical Eligibility Criteria for the Tenderers:

6.1 Definition of Similar Nature Work: The work of similar nature is defined as**:**

Projects involving the design, implementation, and validation of RAMS (Reliability, Availability, Maintainability, and Safety) systems and/or PHM (Prognostics and Health Management) systems in the railway sector or other transportation sectors such as aviation, automotive, or maritime.

OR

Projects that include the installation of sensors and data acquisition systems, development of predictive maintenance algorithms, integration of safety and reliability analysis tools, and creation of decision support systems for operational efficiency.

7. Minimum Eligibility Criteria:

The Tenderers must submit documentary proof for qualifying against the minimum eligibility criteria as per Para no. 2.6.1 of GCC for Service of Indian Railways. The said para 2.6.1 of GCC-Services is reproduced below (in italicized font) for ready reference:

Work Experience: *The bidder should have satisfactorily completed *in the last three previous financial years and the current financial year upto the date of opening of the tender, one similar single service contract **for a minimum of 35% of advertised value of the bid.*

**Completed service contract includes on-going service contract subject to payment of bills amounting to at least 35% of the advertised value of the bid.*

***Similar service contract means any contract that is so specified by the competent authority.*

Similar single service contract for the purpose of this tender shall mean **"***Projects involving the design, implementation, and validation of RAMS (Reliability, Availability, Maintainability, and Safety) systems and/or PHM*

(Prognostics and Health Management) systems in the railway sector or other transportation sectors such as aviation, automotive, or maritime.

OR

*Projects that include the installation of sensors and data acquisition systems, development of predictive maintenance algorithms, integration of safety and reliability analysis tools, and creation of decision support systems for operational efficiency**".***

Work experience certificate from private individual shall not be accepted. Certificate from public listed company/private company/Trusts having annual turnover of Rs. 500 crore and above subject to the same being issued from their Head Office by a person of the company duly enclosing his authorisation by the Management for issuing such credentials.

[The format for experience certificate is placed as ***Appendix -II***]

Note:-
The bidder shall submit details of work executed by them in the prescribed format along with bid for the service contract to be considered for qualification of work experience criteria clearly indicating the nature/scope of contract, actual completion cost and actual date of completion for such contract.
[Format prescribed for details of work executed is furnished at ***Appendix -I***]

Financial Standing: *The Bidders will be qualified only if they have minimum financial capabilities as below:-*

(i) ***T1-Annual Turnover:*** *The bidder should have an annual financial turnover not less than 1.5 times the advertised bid value during the last three previous financial years and in the current financial year upto the date of opening of the tender. The audited balance sheet reflecting financial turnover certified by chartered accountant with her stamp, signature and membership number shall be considered.*

(ii) ***T2-Liquidity:*** *The bidder should have access to or has available liquid assets, lines of credit and other financial means to meet cash flow that is valued at 5% of the estimated bid value net of applicant's commitments for other contracts. The audited balance sheet and/or banking reference certified by chartered accountant with her stamp, signature and membership number shall be submitted by the bidder along with bid.*

Banking reference should contain in clear terms the amount that bank will be in a position to lend for this work to the applicants/member of the Joint Venture/Consortium. In case the Net Current Assets (as seen from the balance sheets) are negative, only the banking references will be considered. Otherwise the aggregate of the Net Current Assets and submitted banking references will be considered for working out the Liquidity.

The banking reference should be from a Scheduled bank in India and it should not be more than 3 months old as on date of submission of bids.

In case of JV firms overall liquidity of JV firm shall be assessed by arithmetic sum of liquidity of all members of JV.

Other Criteria: *Based on the nature of services required, type of contract and other such considerations, the competent authority may include any other criteria as it deems fit in the minimum eligibility criteria for the qualification of bidders. A sample of technical eligibility criteria has been attached as "Bid evaluation-Technical Criteria" for illustrative purposes.*

1 The tender**,** when submitted, shall not constitute an agreement and the tenderer shall have no cause of action or claim against the R.D.S.O. for rejection of his offer. The RDSO shall always be at liberty to reject or accept the offer at its own discretion and any such action will not be called into question and the tenderer shall have no claims in that regard against R.D.S.O.

2 Acceptance of tender shall be communicated by FAX/ Telex / Telegram /Express Letter/Email, or a formal letter of Acceptance of Tender. When acceptance is communicated by FAX/ Telex/ Telegram/ Express Letters/Email, the formal letter of acceptance will be sent to the Tenderer as soon as possible. But the FAX/ Telex/ Telegram/Email or express letter should be deemed to conclude the contract.

3 The successful tenderer shall be required to execute one or more agreements as necessary with President of India acting through Director General/Executive Director (Testing)/ RDSO as the case may be for carrying out the work as per agreed conditions.

8. Evaluation Criteria for the Bid:

The bids conforming to the technical specifications, terms and conditions stipulated in the bidding document and considered to be acceptable after subjecting to Bid Evaluation Criteria will be considered for further evaluation.

Bids will be evaluated by the method of Quality and Cost Based System (QCBS) mentioned in para 2.6 (C) of GCC-Services. The weightage for the 'Quality' is 70 (seventy) and the weightage for the 'Quoted' price is 30 (thirty).

The evaluation would consist of following phases:

1. Phase I: Evaluation of Technical Bids.
2. Phase II: Evaluation of Financial Bids.
3. Phase III: Combined Evaluation of Technical and Financial Bids.

Financial bid will be opened only after the technical bid is found suitable. The bidder whose technical offer is not found suitable, their financial offers shall not be opened.

Phase I : Evaluation Criteria of Technical Bids.

The marks allocated against various sub-sections under 'Quality' of Bid shall be as hereunder:

SN	Criteria	Marking Scheme	Max. Marks
1.	**Past experience** of the Organization (Record of Accomplishment) in Railway sector in similar project in last seven years in India/globally.	1 similar project done in last seven years – **5 marks** 2 similar projects done in last seven years – **10 marks** 3 similar projects done in last seven years – **20 marks**	20
2.	**Competency:** Market standing of the bidder regarding capability in condition monitoring of moving assets	Last seven years – **5 marks** Last fifteen years – **10 marks** Experience with IR or any other class I railway – **10 marks**	20
3.	**Capability of the firm**	In-house manufacturing with requisite qualified and experienced staff – **10 marks** In- house design capability with requisite qualified and experienced staff – **10 marks**	20
4.	**After sale service (ASS)**	Agreeing to provide ASS for 3 years – **10 marks** Agreeing to provide ASS for 5 years – **20 marks**	20
5.	**Documentation** a. Operating Manual b. Maintenance Manual c. Spare parts	Full marks if all three are provided, disqualification in case the firm does not agree to provide documentation	20
		Total Marks	**100**

Eligibility Criteria: Minimum-qualifying marks is ninety (90) for opening of Financial Bid.

Analysis of technical bid

(i) The technical bid will be evaluated and the technical bid marks shall be assigned to each bidder on the basis of above mentioned evaluation matrix.

(ii) Each criterion will have specific score and only those Technical Bids receiving marks greater than or equal to cut-off marks i.e., ninety (90) will be eligible for consideration in financial bids. If required, the Authority may seek specific clarifications from any or all Bidder(s) at this stage. The Authority shall determine the Bidder that qualify for the next phase after reviewing the clarifications provided by the Bidder(s). The bidder may be asked to make a

presentation before the Purchase Committee to explain the points on the basis of which Technical bids will be evaluated.

(iii) Technical Bid Score: The Technical Bid Score 'St' of the Bidder shall be derived as under

$$S_t = \frac{S_{tm}}{S_H} \times 100$$

[Taken from

https://bidplus.gem.gov.in/bidding/bid/downloadBuyerDoc/2509198/1626500147575.pdf

bid document]

Where

S_t is the Technical Bid Score
S_{tm} = Score obtained by the concerned bidder
S_H = Highest total technical bid marks amongst all evaluated bids.

(iv) The Authority reserves the right to modify the evaluation process at any time during the Request for Proposal (RFP) process, without assigning any reason, whatsoever, and without any requirement of intimating the Bidder of any such change. At any time during the process of evaluation the Authority may seek specific clarifications from any or all Bidder(s).

Phase II: Evaluation of Financial Bids

The financial proposal shall be evaluated to determine the lowest bidder, In case, the evaluated financial offers of two or more technically qualified bidders are lowest and same, than the bid of the bidder who has obtained higher marks in technical bid evaluation shall be considered as the lowest. If the marks in the evaluation of technical bids of the lowest bidders are also found to be equal, then the bid of the bidder with the higher cumulative annual financial turnover over the last three years and the current financial year shall be considered as the lowest.

In this phase, the Financial Bids of the Bidder, who are technically qualified in Phase I, shall be considered. The following criteria shall be applied for evaluation of Financial Bid of the Bidder(s).

- Total price quoted by the bidder inclusive of all taxes shall be arrived at as per their bid.

- The financial bid evaluation shall have two parts for marking/evaluation. Part 1 will be out of 80 marks and part 2 will be out of 20 marks. Thus the total marking will be out of 100 marks for Financial Bid.

- The marks obtained by each bidder in part 1 and 2 will be added to arrive at total marks out of 100 in Financial Bid evaluation.

SN	Criteria	Scoring method
1.	In part 1, the lowest bid shall be given 80 marks.	Scoring: Maximum marks under this head is **80**.

	The other bids shall be given proportionately lower marks according to their total bid value.	
2.	In part 2, the marking will be out of 20 marks: With more marks being given to bids which are more below the estimated value of the tender.*	Scoring: Maximum marks under this head is **20**. ▪ 0 marks if bid value is more than estimated value ▪ 5 marks if bid value is from 95% up to 100% of the estimated value. ▪ 10 marks if bid value is from 90% up to less than 95% of the estimated value. ▪ 15 marks if bid value is from 80% up to less than 90% of the estimated value. ▪ 20 marks if bid value is less than 80% of the estimated value.
	Total Marks	**100**

* The bidders should not give non-justifiable low commercial bids which may lead to unworkable price and lead to failure of the project.

Analysis of financial bid

(i) In case the rates are quoted in currency other than Indian Rupee, the amount in Rupees for the purpose of evaluation shall be arrived at by considering the B.C. (Base currency) selling exchange rate established by the State Bank of India prevailing as on the date of Tender opening. All payments shall however be made in Indian Rupees only.

(ii) Formula to determine the scores for the Financial Bids shall be as follows.

$$S_f = \frac{F_L}{F} \times 100$$

[Taken from https://bidplus.gem.gov.in/bidding/bid/downloadBuyerDoc/2509198/1626500147575.pdf bid document]

Where

S_f is the Financial Score

F_L is the value of lowest Commercial Bid among the responsive bids

F is the price quoted by the concerned bidder in the bid under consideration

Phase III: Combined Evaluation of Technical & Financial Bid

The Total score of the Bidder will be determined as under

Total Score (T_S) = (0.70 x S_t) + (0.30 x S_f)

The Evaluated Bid Score **(T_S)** shall be considered up to two decimal places.

- The Bid of the Bidder, who obtains the highest $\mathbf{T_S}$ value, will be rated as the best Bid. In the event of a tie, the bid with the highest technical score (S_t) will be rated as the best bid. Beyond that, Authority will decide the matter in its full discretion.

- The three proposals in the combined technical and financial evaluation were ranked as

H-1
H-2
H-3

- In case the bidder obtained highest score shall be recommended for award of contract is not ready to accept the offer/found inappropriate, the proposal shall be made to subsequent bidders.

- To ascertain the inter-se-ranking, the comparison of the responsive bids will be made subject to loading for any deviation.

Care in submission of tenders:

1. Before submitting a tender, the tenderer will be deemed to have satisfied himself by actual inspection of the site and locality of the works, that all conditions liable to be encountered during the execution of the works are taken into account and that the rates he enters in the tender forms are adequate and all-inclusive to accord with the provisions in Clause-37 of the Standard General Conditions of Contract for the completion of works to the entire satisfaction of the Engineer.

2. Tenderers will examine the various provisions of The Central Goods and Services Tax Act, 2017(CGST)/ Integrated Goods and Services Tax Act, 2017(IGST)/ Union Territory Goods and Services Tax Act, 2017(UTGST)/ respective state's State Goods and Services Tax Act (SGST) also, as notified by Central/State Govt. & as amended from time to time and applicable taxes before bidding. Tenderers will ensure that full benefit of Input Tax Credit (ITC) likely to be availed by them is duly considered while quoting rates.

3. When work is tendered for by a firm or company, the tender shall be signed by the individual legally authorized to enter into commitments on their behalf.

4. The Railway will not be bound by any power of attorney granted by the tenderer or by changes in the composition of the firm made subsequent to the execution of the contract. It may, however, recognize such power of attorney and changes after obtaining proper legal advice, the cost of which will be chargeable to the Contractor.

Payment Terms:

1. Payment shall be made after successful completion of all activities as mentioned in scope of work.

2. Payment will be made after submission of Bill (in Duplicate) by the Contractor. The Bill should be addressed to principal executive Director, Resource & Testing, RDSO, Lucknow.

3. The Bill will be verified & forwarded for e-payment after deduction of penalties, if any. Taxes in vogue, if any, shall be deducted from the bill due for the payment.

Tenderer shall mention his/her Bank details like Name of Bank, A/C No., IFC Code (of Bank), MICR Code, PAN No. and Contract Agreement Number etc. on the bill. The Contractor, who signed the Contract Agreement, should sign the Bill.

9. Verification and Validation Conditions for POC for the Prototype of Rolling Stock:

- **Supply and Fitment of all Sensors:**

  Verification: Verify the delivery and specifications of sensors against the order list attached in (Annexure -I).

  Validation: Cross-check the sensors with physical inspections of the rolling stock to confirm the accurate placement of sensors along with functionality on the rolling stock.

- **Supply and Fitment of On-Board Data Acquisition, Storage, and Edge Gateways**

  Verification: Confirm that the data acquisition and edge gateways are supplied as per the technical specifications (Annexure II).

  Validation: Perform functional testing on the installed data acquisition system to ensure proper data collection and transmission.

- **Development of APIs for Data Acquisition for existing on-board and wayside equipment/sensors:**

  Verification: API documentation and code for compliance with the specifications.

  Validation: Conduct integration tests on the rolling stock to ensure that APIs correctly acquire and transmit data from sensors.

- **Supply of hardware and software for acquiring data from existing onboard sensors.**

  Verification: The raw data from existing sensors will be acquired by using suitable OPC-UA (open protocol communication -universal architecture) of hardware and software.

  Validation: Conduct a Functional Test to confirm the acquisition of raw data from the existing sensors.

- **Provision of service of Cloud Hardware and Software by the supplier:**

  Validation: Test the integration and functionality of the cloud system, ensuring it can handle data transmission and pre-processing effectively

- **Supply and Installation of PHM and RAMS Server:**

  Verification: Verify the delivery and specifications of the PHM and RAMS server as per scope.

Validation: Test the connectivity and data transmission between the cloud server and the analytics/RAMS servers to ensure adequacy in speed and data handling.

- **Development of AI-Based Diagnostics and Prognostics Models:-** It is understood that these models will require legacy data of defects, failures, and fault investigations of Indian Railways. Successful firm will work in collaboration with Indian Railways teams to develop these models.

  Verification: Ensure the development of AI-based models for fault detection, isolation, and predictive maintenance.

  Validation: Test the AI models using data from the prototype sensorised rolling stock to validate real-time fault detection and isolation capabilities. It is expected that the diagnostic and prognostic models will initially have a **30% accuracy level** in the predictions at the time of delivery and with continual improvement and acquisition of additional data and further training of the AI models, this accuracy will improve and reach a level of 90% in next five years after commissioning. The supplier will train IR personnel in the different codes and programs and work with IR personnel to improve the accuracy of diagnostic and prognostic models can be calculated as per methods given in (**Annexure-III)**

- **Development of RAMS Models:-** It is understood that these models will require legacy data of defects, failures, and fault investigations of Indian Railways. Successful firm will work in collaboration with Indian Railways teams to develop these models.

  Verification: Verify the adoption of Systems Engineering and model-based approaches in developing RAMS models.

  Validation: Test RAMS models using legacy failure data provided by RDSO to validate their accuracy and reliability.

- **Development and Testing of Dashboards :**
  1. Alarms dashboard for the loco pilot. guard and train running staff.
  2. Alarms dashboard for control office.
  3. Integrated dashboards for Alarms, Diagnosis, and Prognosis dashboards for maintenance depots/sheds.
  4. Integrated dashboard for all of the above for the RDSO command center.

  Verification: Dashboard as specified by the RDSO for guidance for (**Annexure-IV)**

  Validation: The experiment will be conducted on an instrumented running train to validate the dashboards as specified by the RDSO.

- **Training of Indian Railways Personnel:- Fifty (50)** Indian Railways personnel will be trained in RAMS software, PHM software, and AI-based codes and programs. The course structure and syllabus for the training are given in (**Annexure-V**).

  Verification: Ensure that the training programs are as per the course and syllabus cover all aspects

Validation: Conduct training sessions and gather feedback from participants to validate the effectiveness of the training program:

10. Other Terms and Conditions

10.1. Confidentiality

Definition of Confidential Information

Confidential information refers to any data, documents, or materials, whether in written, electronic, or oral form, that are disclosed in the course of the project and are designated as confidential or should reasonably be understood to be confidential, including but not limited to:

- Technical specifications and designs.
- Data acquisition and analysis methods.
- Predictive maintenance algorithms.
- System performance metrics and reports.
- Personal data of employees or customers.

10.2. Intellectual Property

- A joint patent of RDSO and Firm shall be owned for intellectual property generated during the execution of PoC.

10.3. Liability and Warranty, AMC

- The supplier shall confirm the warranty of the complete system for a period of at least **24 months** from the date of successful commissioning and also **01 year of comprehensive maintenance after completion of the warranty period.**

10.4. Submission of documents/ICD

Test certificates: Test records, test certificates, evidence for conformance to this specification & IP ratings of enclosures, sensor's datasheet, performance curves from OEM (if applicable), and its warranty, etc. Results of all inspections and tests, whether witnessed or not by IR personnel, shall be supplied as soon as practicable after the performance of each inspection or test. One set of above-mentioned documents shall be supplied properly bound in books. The softcopies of the said documents should also be provided by the firm.

System Literature: The supplier shall provide following literature in two copies to consignee along with the delivery of the Measurement System.

- Complete drawings and system architecture.
- Operating manual
- Maintenance Manual
- Troubleshooting manual
- Calibration Manual

- Spare part catalogs
- The tenderers shall provide a list of literature to be supplied with the system in their offer.

11. Environmental Conditions, Operational Requirement, and Safety Requirement:

The system should conform to following technical/operational requirements:

S.N	Technical/Operational parameters	Requirements
1.	Operating Speed	0 - 160 Kmph
2.	Degree of Protection for Electronics	IP 66
3.	Degree of Protection for Optics if any.	IP 66
4.	Degree of Protection Sensors	IP 67
5.	Ambient Temperature Range	0˚ to 70˚C
6.	Relative Humidity	up to 100%

Safety Requirements:

1.1 The system shall be designed using fail-safe principles, and adequate safety margins must be incorporated into the design for systematic and random failures.

1.2 The system shall be protected from external EMI/EMC/RFI interferences and electrified OHE (Overhead Equipment).

1.3 The system shall be so designed that it shall not hamper signal, track, communication, electrical systems, etc. in service in IR.

1.4 The functioning of the system shall not be affected by the usual environmental and train conditions like vibrations from existing and passing trains, track maintenance vehicles/equipment, heavy rain and water, lightning, animal trespassing, direct sunlight on the sensors, and heat from the sunlight.

1.5 The system should be adequately protected from waste discharge from the coaches.

1.6 System shall be designed and installed in such a way that it should be well protected during accident-free train operation and routine maintenance and should have reasonable anti-pilferage mechanism as per good industry practices.

1.8 Train passing events are often associated with dust-laden environments. Therefore, the system should be adequately protected and designed to faithfully collect information in a dusty environment.

1.9 The system shall have a suitable dust barrier and sensor cleaning arrangement to get optimum results in case of dust or moisture entrapment.

1.10 The system shall be designed and installed in such a way that it should be fire-resistant, non-corrosive & electrically non-conductive.

12. Special Terms and Conditions for Tenderer:

- The tenderer must ensure the highest standards of data security and privacy, complying with ISO/IEC 27001 and other relevant regulations. A detailed data security plan must be submitted. The tenderer must ensure compliance with all applicable local and international regulations and standards related to safety, reliability, and data protection.

- The tenderer must ensure that the system complies with relevant industry standards, including EN 50126, EN 50128, and EN 50129 for railway applications.

- The tenderer must provide a warranty for all delivered systems and components for a minimum **period of two years**. They must also assume liability for any defects or failures during this period.

- The tenderer must provide technical support and maintenance services for a minimum of 01 year post-implementation/after warranty whichever is later. This includes a 24/7 support line and regular system updates.

- The tenderer must conduct extensive verification and validation (V&V) activities as per the provided V&V plan as per Para 7. This includes component-level, system-level, and end-to-end testing.

- The tenderer must submit a detailed project plan, including timelines, milestones, and deliverables. The plan must cover all phases of the project from initiation to completion.

- The tenderer must appoint a dedicated project manager with sufficient experience in managing similar projects. The project manager will be the primary point of contact and responsible for overall project execution.

- The tenderer must guarantee a system uptime of at least 99.5%. They must also provide a comprehensive recovery plan in case of failure/malfunction of the whole system.

13. List of Appendix

- Appendix – I : Format for Details of the Previous Works/Services by the Bidder
- Appendix – II : Work Experience Certificate

14. List of Annexures

- Annexure-I: Specification for various sensors.
- Annexure II: Specifications for Data Acquisition, Storage, and Edge Gateways.
- Annexure-III: Methods for Validation of Diagnostic and Prognostic Models.
- Annexure-IV: Template for Various Dashboards.
- Annexure-V: Training Module for Railway Staff.

Appendix-I

Format for Details of the Previous Works/Services by the Bidder

Sl No	**Name of the Work**	**Brief Scope of Work** *(Indicate activities covered under the scope, especially those which relate to technical evaluation of your bid)*	**Agreement Number and Date**	**Details of Firm/Client for whom work was done**	**Experience certificate from Firm/Client enclosed? (Yes/No)**	**Value of Work as per Agreement indicating currency unit (in figure and words)**	**Due date of completion** *(in case of continuing work)/* **Actual completion date**	**Amount received against the work from Firm/Client indicating currency unit (in figure and words)**	**Financial Year* in which the payment was received from Firm/Client**
1.									
2.									
3.									
4.									
5.									

***Financial Year is taken from 1st April of a year upto 31st March of succeeding Year e.g. the period of 1st April 2015 to 31st March 2016 is taken as Financial Year 2015-2016.**

In case payment for a single work has been received in different financial years, indicate payment received against each financial year for that work.

Signature of Bidder

Appendix-II

On the Issuing Firm/Client's Official Letterhead

Reference No:_____ Date of Issue: _____

Work Experience Certificate

It is certified that *M/s bidder/executing agency's name* having their offices at _____ have completed/in process of completing* the following work/services for *Certificate Issuing Firm's Name and address*. *(Strike out whichever is not applicable)*

Sl No	Item	Details
1.	Name of Work/Service	
2.	Agreement Number with date and, name & address of agency to whom the work awarded	
3.	Brief scope of the work/service.	
4.	Agreement Value indicating currency unit (in words and figures)	
5.	Due date of completion as per agreement	
6.	Number of extensions granted	
7.	Actual Date of completion of work/service (if completed)	
8.	Total Value of Payment released to the executing agency against the agreement indicating currency unit (in words and figures)	
9.	Remarks about quality of performance of the executing agency under the agreement	

It is also certified that I, *Mr/Mrs/Ms*_____ working as _____ in the *Issuing Firm's Name*, am authorized to issue this certificate to *bidder/executing agency's name* on behalf of *Issuing Firm's name* having offices located at *address of issuing firm*.

Affix Office Seal/ Stamp here

(Signature)

Full Name

Designation

Contact details

ANNEXURE-I

CMSS 2200T

Industrial sensor, side exit, acceleration and temperature

The CMSS 2200T is a cost-effective, dual output sensor ideal for light to medium-duty applications, where both vibration and temperature measurements are required. The CMSS 2200T is typically used in the following industries:

- Pulp and Paper
- Food and Beverage

Common applications include general purpose machines such as pumps, motors and fans.

Features

- For use with SKF on-line systems and protection systems (note that DMx requires adapter module CMMA 9700); recommended sensor for the WMx
- Measures both acceleration and temperature
- Low profile
- Rugged, corrosion resistant and hermetically sealed for installation in high humidity areas
- 100 mV/g sensitivity to optimize use in multiple applications
- 10 mV/°C temperature output sensitivity
- CE approved, meets EMC requirements
- ESD protection
- M6 and 1/4-28 captive mounting bolts provided
- Reverse wiring protection

Recommended connector/cable assembly

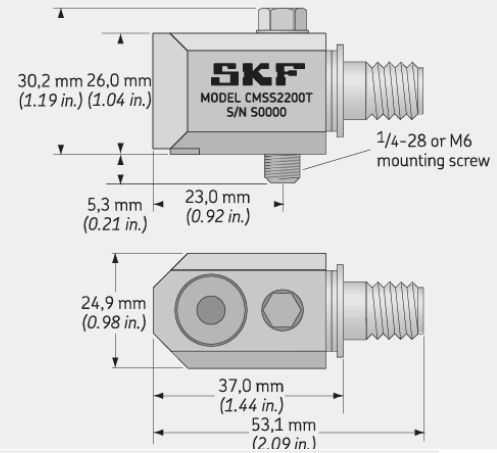
- CMSS 933 series, three pin connector, IP 68 locking, collar or twist lock

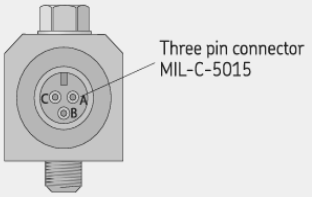
Specifications

Dynamic

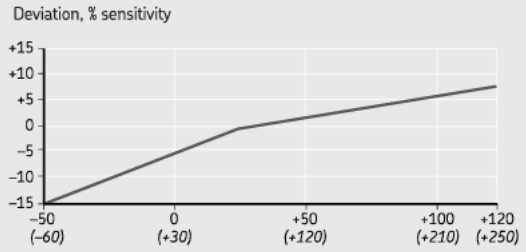
- Sensitivity: 100 mV/g
- Sensitivity precision: ±5% at 25 °C *(75 °F)*
- Acceleration range: 60 g peak
- Amplitude linearity: 1%
- Frequency range:
  - ±5%: 1,0 to 5 000 Hz
  - ±10%: 0,7 to 10 000 Hz
  - ±3 dB: 0,5 to 12 000 Hz
- Resonance frequency, mounted, minimum: 22 kHz
- Transverse sensitivity: ≤ 5% of axial
- Temperature response: See graph
- Temperature output sensitivity:
  - ±1,5 °C *(±2.7 °F)*: 10 mV/°C *(18 mV/°F)*
- Temperature measurement range: 2 to 120 °C *(36 to 250 °F)*

Dimensions

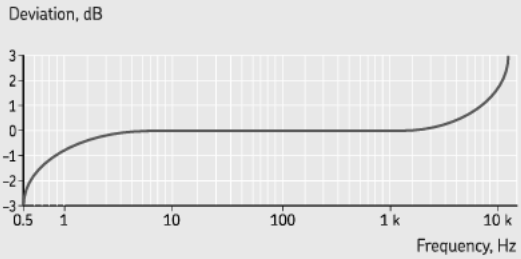




Typical temperature response



Typical frequency response



Electrical

- Power requirements:
  - Voltage source: 20 to 30 V DC
  - Constant current diode: 2 to 10 mA
- Electrical noise, equivalent g:
  - Broadband:
    - 2,5 Hz to 25 kHz: 700 µg
  - Spectral:
    - 10 Hz: 10 µg/√Hz
    - 100 Hz: 5 µg/√Hz
    - 1 000 Hz: 5 µg/√Hz
- Output impedance: ≤ 100 Ω
- Bias output voltage, nominal: 12 V DC
- Grounding: Case isolated, internally shielded

Environmental

- Temperature range: –50 to +120 °C *(–60 to +250 °F)* operating temperature
- Vibration limit: 500 g peak
- Shock limit: 5 000 g peak
- Electromagnetic sensitivity, equivalent g, maximum: 70 µg/gauss
- Sealing: Hermetic
- Base strain sensitivity: 2 mg/µstrain

Physical

- Dimensions: See drawing
- Weight: 145 g *(5.1 oz.)*
- Case material: 316L stainless steel
- Mounting: M6 and 1/4-28 mounting studs provided
  - Black stud = M6
  - Silver stud = 1/4-28
- Mounting torque: 3,4 Nm *(30 in. lbs.)*
- Connections:
  - Pin A: Accelerometer power/signal
  - Pin B: Accelerometer common
  - Pin C: Temperature sensor signal
- Mating connector: CMSS 933-68LC or CMSS 933-68TL, three pin, IP 68, locking collar or twist lock
- Recommended cable: CMSS 933-SY-XXM, three conductors, twisted pair, single shielded, yellow

Ordering information

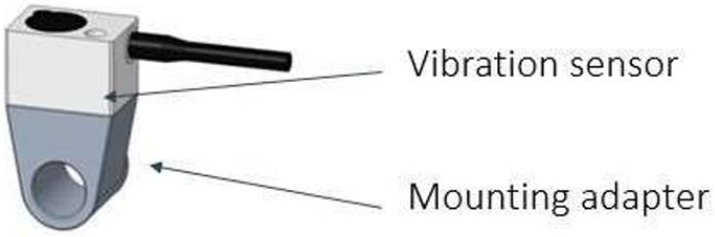
CMSS 2200T Industrial sensor, side exit, acceleration and temperature, with MIL-C-5015 three pin connector.

- 1/4-28 and M6 mounting studs provided. Calibration sensitivity is provided for each accelerometer package with nominal sensitivity etched on each unit.

Uniaxial **Accelerometer** and integrated Temperature Sensor: ┤

SKF vibration and temperature sensor

Conformity to:	
Railway applications -Electromagnetic compatibility Part 3-2	EN 50121-3-2:2016
Electronic Equipment used on Rolling Stock	EN 50155:2007 + EN 50155:2007/AC:2012
EFT/Burst Test – Rolling Stock Environment	IEC 61000-4-4, 2kV Passed
Conducted RF	IEC 61000-4-6, 10Vrms
Salt Mist Test : 35°C for 168hr	According to ASTM B117
Thermal Test @ -40°C , +120°C for 120hr	According to EN50155
Insulation Measurement Test at 500 VDC	More than 50GΩ
Shock and Vibration	EN 61373 cat.3 (2010 Edition)



Sensor mounting adapter by SKF

Technical specification: TS_ KEP-KRMM 8101 B-40

IMx Rail	
SKF Integrated IMx Rail designation	KEP-KRMM 8101 B-40
Part Code:	CMON 4116-R-110

IMx Rail Hardware :	
Supply : Power Module 110 V DC Nominal input	43 to 160 V DC (Recommended supply fuse 1 A slow blow (T1AL))
Analogue Inputs	16 (A1 to A16)
Digital Inputs	4 (D1 to D4)
Digital Outputs	3 Relay drivers (24 V DC) Max Current available 70 mA across all relay coils
Power over Ethernet (*Optional)	Nominal voltage 48 V, 13 W maximum
Measurement types	Temperature, acceleration, velocity, acceleration enveloping (gE*)
Communication Protocol	Modbus RS485
Mobile Data (LTE/GSM)	Network supports 2G, 3G, 4G (micro-SIM or eSIM)
Ethernet: Wi-Fi	Standard 802.11n
Ethernet: RJ45	Network support 10/100 Mbit/s
Integral lid antenna Supports	AMPS,GSM,3G,Wi-Fi,DCS, PCS, LTE, 4G/LTE
Optional GPS module	External to IMx-Rail
Analog Ch Supported Sensor Type : 2 Wire	
Current accelerometers	Constant accelerometers
Voltage signals	4-20 mA (requires external load resistor to be fitted)
Temperature sensors and measuring range	PT1000 (channels A9 to A16 only) and –50 to +100 °C ±4 °C
Vibration measurement accuracy	Amplitude: ±2% (up to 20 kHz), ±5% (20 to 40 kHz), Phase: ±3° (up to 100 Hz)
Crosstalk rejection	–110 dB @ 1 kHz

Digital Ch Supported Sensor Type : 2- and 3-wire	
TTL level and other pulses	Up to +24 V
PNP sensors	Yes
Sensor power & Short circuit protection	24V DC, peak demand up to 30 mA per sensor & Yes
Frequency range	From 0,016 Hz to 20 kHz (1 cpm to 1,2 Mcpm)
Speed accuracy	0,05% of measurement value (typically 0,01% up to 2,5 kHz)

(IMx Rail/110 V DC input)

Mechanical Feature	
Size (excluding protrusions)	Size (H x W x D): 260A x 160 AB x 90C mm (10.24 x 6.30 x 3.54 in.)
Weight	8 725 g (19.2 lb)
Mounting	4-point internal to enclosure
IP Protection Rating for Enclosure	IP66/IP67
IP Protection for optional External GPS module	IP69K
Enclosure description	Black, powder coated, die cast aluminium
Operating temperature range	–40 to +65 °C (–40 to +149 °F)
Storage temperature range	–50 to +85 °C (–58 to +185 °F)
Gland holes detail	22 cable entry points(Pre-drilled and tapped (on three sides)) Front: M12 (x17 no.s) & M20 (x1 no.) Back: M12 (x2 no.s) & M20 (x1 no.) Left side: M32 (x1 no.)

Mounting Environment	
Internal	Internal car/coach mounting
External	Bogie mounting, Car chassis mounting

System Interfaces	
IMx-16Plus top connectors	LTE/GSM and Wi-Fi antenna, RJ45 LAN, USB A
MAC address	A single device MAC address
Measurement data storage	
On-board/internal buffering	4 GB (non-volatile/Flash memory)
Data time stamping support	Internal clock calendar (backup power capacitor for about 1 week)
Modes	Data storage on time (Measurements linked to GPS)
Self-diagnostics	Built-in Automatic hardware monitoring and diagnosis
Customer security/protection	IMx devices data is encrypted

Software/database/App support	
Main software	SKF @ptitude Observer
Software capabilities	Measurement configuration, data storage, assessment, analysis, reporting Automatic (IMx-Rail device) firmware update
Supporting software	SKF Multilog IMx Manager Apps for iOS and Android
App capabilities	Network configuration, Measurement configuration, Report generation and data viewer

Conformity To:	
EMC	EN/IEC 61000-6-4, EN 50121-3-2, ETSI EN 301 489-1, -17
Railway standards Compliant	EN 50155:2017 and EN 50121-3-2
CE certified (EU)	2014/53/EU (RED) including ETSI EN 300 328, ETSI EN 301 908-1
FCC certified (North America)	FCC Part 15B 107/109, ICES-003, FCC Part 15C 15.247 (d), RSS-447 sect. 5.55.5 FCC Part 22H 917/RSS-132 sect. 5.5, FCC Part 24E 328/RSS-133 sect 6.5, FCC Part 25.53(h)/RSS-139 sect.6.6
Vibration & Shock	EN 61373 cat II

Salt mist test	96hours
Fire & Smoke	EN 45545-2:2013 + A1:2015

Technical specification: TS_BY-KLS-KRMM 8101 01-L-38

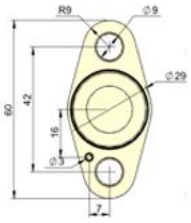
Single Head Speed Sensor	
SKF Integrated sensor designation	**BY-KLS-KRMM 8101 01-L-38**

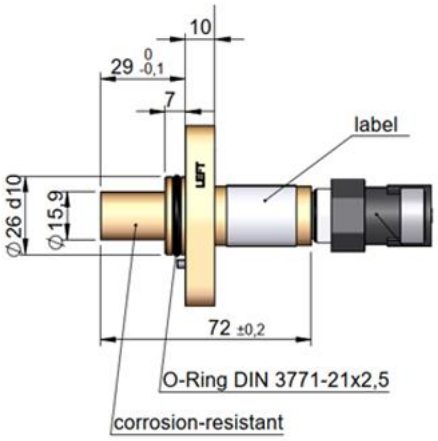
Dual Channel Speed	
Transducer	
Operating principle for speed transducer	Magnetic flux variation
Type of detection	Based on contactless
Signal output	Voltage digital transition
Signal waveform	Square
Supply voltage	+ 8 VDC to + 24 VDC
Min high level output	Vb-2.0 Volt
Max Low level output	<1.5 Volt
Duty cycle	50%±20
Current demand without load	≤ 25 mA
Max switching current	25mA
Frequency range	0-20k Hz / True Zero-Speed
Output Signal	Two right angle signals 90 º phase shifted
Output A	Square wave signal
Output B	Square wave signal phase shift 90 º ±10° to Output A

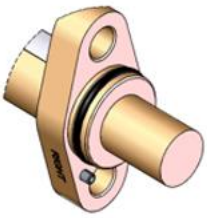
Mechanical features	
Material (sensor body)	Brass
Electrical connection	Free-Wires
Cable	3Wires+ Shield
Environmental features	
Operating	-40º to 110ºC
Storage	-40º to 125ºC
Accessories	
Shims : 0.25 mm thickness	6 no's

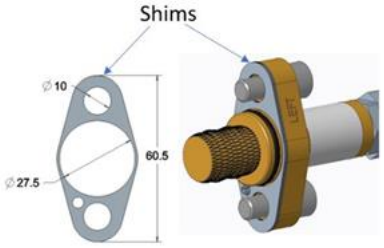
Conformity	
ESD- Protection	EN60947-5-2; Liv. A
EMC	EN50121-3-2
Vibration & Shock	EN61373 Cat3.
Fire Protection	EN45545-2
Insulation Resistance	>100 MΩ / 500 VDC
Protection against wrong polarity of power	Yes
Output Short circuit proof	Yes

Pin Out	
Wire1 Supply	8 to 24VDC
Wire2 Ground	0 Volt
Wire3 Output	A
Wire4 Output	B
Shield	Shield connected to sensor body









Pressure measurement

PP10R

pressure sensor for railway applications

Overview

- Tested according to EN 50155
- Relative pressure measurement from -1 to 50 bar
- Robust ceramic measuring cell
- Stainless steel housing
- Compact design
- Relative pressure and vacuum measurement
- Designed for a wide range of railway applications as e.g. pantograph pressure control, coolant recirculating pumps and pneumatic and hydraulic brake systems

EN 50155 CE

Technical data

Performance characteristics	
Pressure type	Relative (gauged)
Compensated temperature range	-25 … 85 °C
Long term stability	≤ 0.3 % FSR/a
Max. measuring error	± 1.5 % FSR Including zero-point and span error, nonlinearity (by terminal base line), hysteresis and non-repeatability (EN 61298-2)
Max. measuring span	50 bar
Measuring range	-1 … 50 bar
Step response time	≤ 5 ms
Standard error of measurement (BFSL)	± 0.5 % FSR Including non-linearity, hysteresis and non-repeatability according BFSL
Min. measuring span	1.0 bar
Power-up time	≤ 25 ms
Temperature coefficient	≤ 0.15 % FSR/10 K , measuring span ≤ 0.3 % FSR/10 K , zero point

Process conditions	
Process temperature	-40 … 100 °C -25 … 85 °C With NBR seal: -40 … 85 °C With EPDM seal: -20 … 85 °C With FKM seal:
Process pressure	Refer to section "Operating conditions"
Process connection	
Connection variants	Refer to section "Dimensional drawings"
Wetted parts material, process connection	AISI 316L (1.4404)
Wetted parts material, membrane	Ceramic, 96% AL2O3

Process connection	
Wetted parts material, gasket	NBR EPDM, optional FKM, optional, gaskets require a minimum ambient temperature of -20 °C and a minimum medium temperature of -25 °C

Ambient conditions	
Operating temperature range	-40 … 85 °C
Storage temperature range	-40 … 85 °C
Degree of protection (EN 60529)	IP 65 , with connector DIN EN 175301-803 A (DIN 43650 A), 4-pin IP 67 , with connector M12-A, 4-pin
Insulation resistance	> 100 MΩ 0 , 500 V DC
Insulation voltage	1 kV AC 0 , EN 50155
Shock and vibration tests (EN 61373:1999, 2010)	Category 2

Output signal	
Current output	4 … 20 mA , 2-wire
Voltage output	0 … 10 V 1 … 5 V
Load resistance	> 2 kΩ, with voltage output R ≤ (V DC - 10 V)/20 mA, with current output
Short circuit protection	Yes
Housing	
Style	Compact transmitter
Overall size	Refer to section "Dimensional drawings"
Material	AISI 304 (1.4301)

Technical data

Electrical connection	
Connector	DIN EN 175301-803 A (DIN 43650 A), 4-pin M12-A, 4-pin

Power supply	
Voltage supply range	10 … 30 V DC , with 4 … 20 mA output signal 15 … 30 V DC , with 0 … 10 V output signal 15 … 30 V DC , with 1 … 5 V output signal

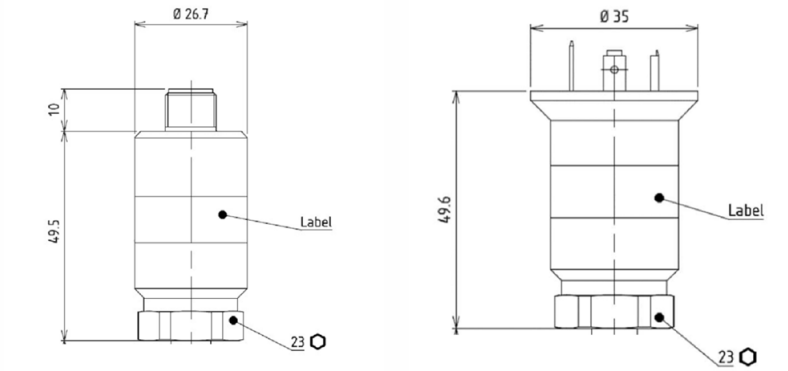
Compliance and approvals	
EMC	EN 50121-3-2
Railway applications	EN 50155
Fire protection	EN 45545-2

Operating conditions

Measuring range (bar)	Proof pressure (bar)	Burst pressure (bar)
0 … 1 0 … 1,6	4	6
0 … 2,5 0 … 4	10	20
0 … 6 0 … 10	20	35
0 … 16	40	60
0 … 25 0 … 40 0 … 50	100	140

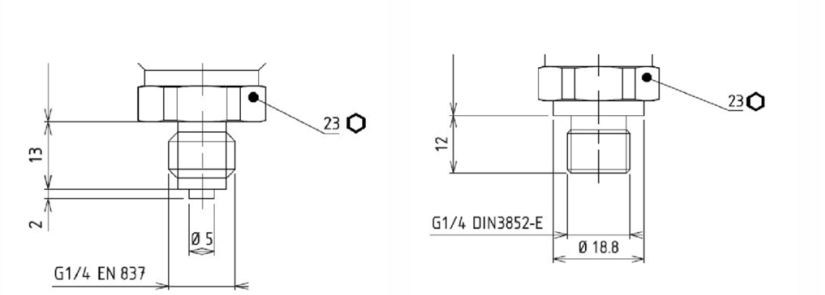
Dimensional drawings (mm)

Housing

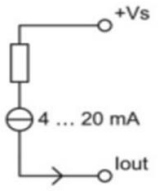
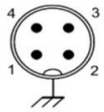
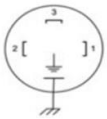
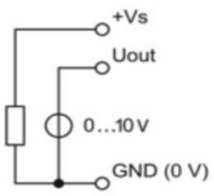
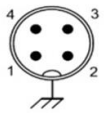
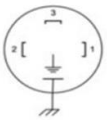


Dimensional drawings (mm)

Process connection



Electrical connection

Output type	Equivalent circuit	Electrical connection	Function	Pin assignment
4 … 20 mA (2-wire)			+Vs Iout Frame ground n.c.	1 3 Plug thread, 4 2
			+Vs Iout Frame ground n.c.	1 2 Grounding lug 3
0 … 10 V 1 … 5 V (3-wire)			+Vs Uout GND (0 V) Frame ground	1 2 3 Plug thread, 4
			+Vs Uout GND (0 V) Frame ground	1 2 3 Grounding lug

Product

pressure sensor PP10R PP10R

Housing material

SS 1.4301 AISI 304

Accuracy

±0.5 % FS

Pressure measurement Y91
Intrinsicallysafepressuretransmitterforprocessandenergyindustries

Overview

- Robust stainless steel housing
- Intrinsically safe version (LCIE 02 ATEX 6133X)
- Applications: Chemical, pneumatic, energy, industrial gas

Technical data

Performance characteristics	
Pressure type	Absolute Relative (gauged)
Compensated temperature range	-10 … 55 °C
Long term stability	0.2 % FSR/a
Max. measuring span	600 bar
Measuring range	-1 … 600 bar
Standard error of measurement (BFSL)	≤ ± 0.3 % FSR Including non-linearity, hysteresis and non-repeatability according BFSL ≤ ± 1 % FSR , for P ≤ 1 bar and P= 600 bar ≤ ± 1 % FSR , zero point error ≤ ± 1 % FSR , span error P > 1 Bar ≤ ± 2 % FSR , span error P ≤ 1 Bar
Min. measuring span	0.1 bar
Rise time (10 ... 90 %)	≤ 3 ms
Temperature coefficient	≤ ± 0.25 % FSR/10 K , zero point P > 1 bar ≤ ± 0.6 % FSR/10 K , zero point P ≤ 1 bar ≤ ± 0.15 % FSR/10 K , measuring range > 1 bar ≤ ± 0.3 % FSR/10 K , measuring range ≤ 1 bar

Process connection	
Wetted parts material, gasket	NBR CR, optional EPDM, optional EPDM O-rings are conform to 3-A Sanitary Standard 18-03 Class II, EPDM gaskets are conform to 3-A Sanitary Standard 18-03 Class I (8% milk fat max.) FKM, optional, gaskets require a minimum ambient temperature of -20 °C and a minimum medium temperature of -25 °C
Ambient conditions	
Operating temperature range	-25 … 70 °C
Storage temperature range	-40 … 85 °C
Degree of protection (EN 60529)	IP 65 IP 67
Shock (EN 60068-2-27)	25 falls from 1 m onto concrete floor
Vibration (sinusoidal) (EN 60068-2-6)	1.5 mm p-p (10 … 58 Hz), 20 g (58 Hz … 2 kHz)
Output signal	
Current output	4 … 20 mA
Voltage output	0 … 10 V 1 … 5 V

Process conditions	
Process temperature	-25 … 100 °C
Process pressure	Refer to section "Process conditions"
Process connection	
Connection variants	Refer to section "Dimensional drawings"
Wetted parts material, process connection	AISI 316L (1.4404)
Wetted parts material, membrane	Ceramic, 96% AL2O3

Load resistance	R = (Uver - 11 V)/20 mA, with current output > 2.5 kΩ, with voltage output > 1 kΩ, with voltage output (1...5V)
Insulation resistance	> 100 MΩ , 500 V DC
Housing	
Style	Compact transmitter
Overall size	Refer to section "Dimensional drawings"
Material	AISI 304 (1.4301)
Electrical connection	
Connector	DIN EN 175301-803 A (DIN 43650 A), 4-pin (standard) M12-A, 4-pin
Cable gland	PG7

Technical data

Electrical connection	
Cable outlet	1.5 m, 3-wire, shielded
Power supply	
Voltage supply range	11 … 28 V DC , with current output 14 … 28 V DC , with voltage output
ATEX I M1 Ex ia I Ma	
Please note	For the application in Ex zone you have to respect the conditions mentioned in the ATEX Type Examination Certificate (LCIE 02 ATEX 6133).You will find the relevant certificates and instructions at www.baumer.com
Maximum values for barrier selection, Ui	28 V
Maximum values for barrier selection, Ii	120 mA
Maximum values for barrier selection, Pi	800 mW
Internal capacitance, Ci	30 nF , 4 ... 20 mA 60 nF , 1 ... 5 V / 0 ... 10 V
Internal inductance, Li	0 µH

ATEX II 1 G Ex ia IIC T5 / T6 Ga	
Maximum values for barrier selection, Ii	120 mA
Maximum values for barrier selection, Pi	800 mW
Internal capacitance, Ci	30 nF , 4 ... 20 mA 60 nF , 1 ... 5 V / 0 ... 10 V
Internal inductance, Li	0 µH
ATEX II 1 D Ex ia IIIC T80°C / T105°C Da	
Please note	For the application in Ex zone you have to respect the conditions mentioned in the ATEX Type Examination Certificate (LCIE 02 ATEX 6133).You will find the relevant certificates and instructions at www.baumer.com
Maximum values for barrier selection, Ui	28 V
Maximum values for barrier selection, Ii	120 mA
Maximum values for barrier selection, Pi	800 mW

ATEX II 1 G Ex ia IIC T5 / T6 Ga	
Please note	For the application in Ex zone you have to respect the conditions mentioned in the ATEX Type Examination Certificate (LCIE 02 ATEX 6133).You will find the relevant certificates and instructions at www.baumer.com
Maximum values for barrier selection, Ui	28 V

Internal capacitance, Ci	30 nF , 4 ... 20 mA 60 nF , 1 ... 5 V / 0 ... 10 V
Internal inductance, Li	0 µH
Compliance and approvals	
EMC	EN 61000-6-2 EN 61000-6-3 EN 61326-1

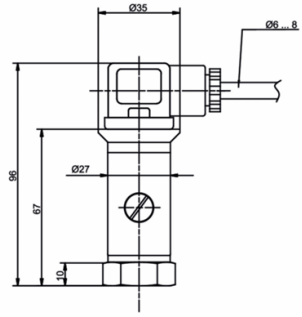
Operating conditions

Measuring range (bar)				Proof pressure (bar)	Burst Pressure (bar)
0.1	0.16			0.4	0.5
0.25	0.4	0.6		1	1.3
-1 … 0	-1 … 0,6	0 … 1	0 … 1,6	3	6
-1 … 1,5	0 … 2,5			4	7
-1 … 3	0 … 4			8	12
-1 … 5	0 … 6			12	18
-1 … 9	0 … 10			20	30
-1 … 15	0 … 16			32	48
-1 … 24	0 … 25			50	75
-1 … 39	0 … 40			80	120
	0 … 60			120	180
	0 … 100			200	300
	0 … 160			320	480
	0 … 250			500	480
	0 … 400			600	800
	0 … 600			800	1000

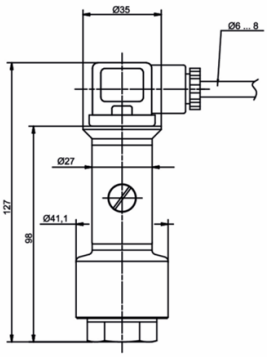
Dimensional drawings (mm)

Housing

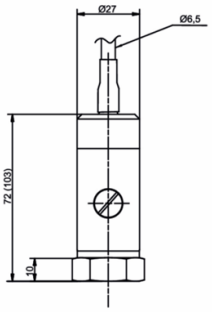
Standard (IP65)



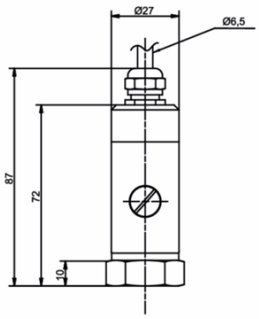
Standard 100 à 600 mbar (IP67)



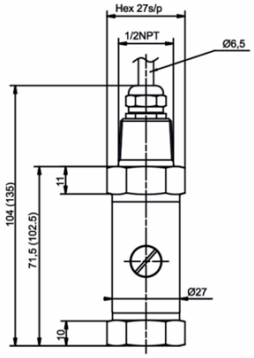
Option 2160 (IP65)



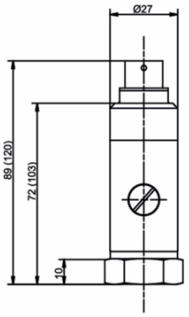
Option 2161 (IP67)



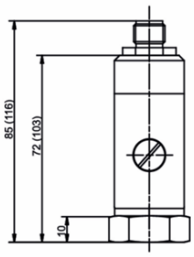
Option 2162 (IP67)



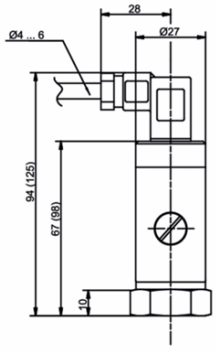
Option 2163 (IP67)



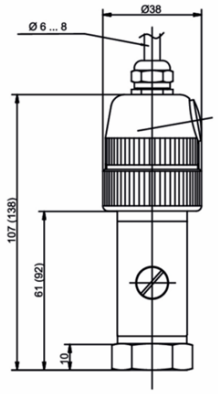
Option 2164 (IP65)



Option 2165 (IP65)

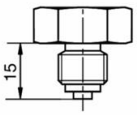


Option 2166 (IP67)

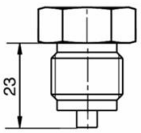


Dimensional drawings (mm)

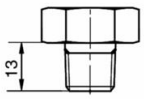
Process connection



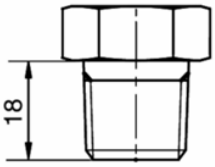
G30-02
G 1/4 B EN 837-1 (BCID: G30)



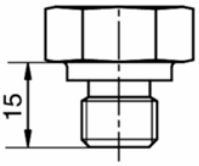
G31-3
G 1/2 B EN 837-1 (BCID: G31)



N01-5
1/4-18 NPT (BCID: N01)



N02-6
1/2-14 NPT (BCID: N02)



G50-06
G 1/4 A DIN 3852-E (BCID: G50)

Annexure 2

1. Data Acquisition system

SN	System Description	Value Range	
1.	Technical	Analog Channels	≥ 16 Channels
		Digital Channels	≥ 4 Channels
		Sampling Frequency	≥ 100 kHz
		OPC UA integration	Yes (with all interfaces)
		Memory	≥ 500 GB
		Connectivity	Simultaneous measurements on all channels Bluetooth, GSM, Wi-Fi, Modbus TCP/IP and RS485
		Operating power	Industry Standard 24V or 110V DC on-board power supply
2.	Temperature	0 – 65 degree C	
3.	Standards	a. EMC: EN/IEC 61000-6-4, EN 50121-3-2, ETSI EN 301 489-1, -17 b. Railway standards Compliant: with EN 50155:2017 and EN 50121-3-2 c. Vibration and shock: EN 61373 Cat II d. Salt mist test: 96 hours e. Fire & Smoke: EN 45545-2:2013 + A1:2015 f. Data Acquisition system shall be IP67 certified to complied with under the coach installation.	

2. Edge Device

SN	System Description	Value Range	
1.	Technical	Analog Channels	≥ 16 Channels
		Digital Channels	≥ 4 Channels
		Sampling Frequency	≥ 100 kHz
		OPC UA integration	Yes (with all interfaces)
		Memory	≥ 500 GB
		Connectivity	Simultaneous measurements on all channels Bluetooth, GSM, Wi-Fi, Modbus TCP/IP and RS485
		Operating power	Industry Standard 24V or 110V DC on-board power supply
2.	Features	a. Configuring the Edge device Wirelessly. The configuration shall be done by both IOS and Android mobile devices. For any troubleshooting shooting the same application shall be used. b. GSM, LTE, etc. shall be used for continuous data streaming to the cloud. c. Wi-Fi shall be used for continuous streaming to the cloud in case coach has its own internet-enabled Wi-Fi system. d. All the remote configuration shall be handled by Bluetooth, GSM & Wi-Fi. e. Edge device should accept industry standard protocols like MODBUS. This will be used for reading the sensor data from “third-party” devices whenever they are fitted on the existing system. Edge devices should be able to configure and transmit the field data from such devices. f. All the component like the GSM router, Wi-Fi Module, and GSM antenna should be inside the Edge device. Only the GPS module shall be installed outside the Edge device. g. The Edge device shall be IP67 certified to complied with under the coach installation.	
3.	Temperature	0 – 65 degree C	
4.	Standards	a. EMC: EN/IEC 61000-6-4, EN 50121-3-2, ETSI EN 301 489-1, -17 b. Railway standards Compliant: with EN 50155:2017 and EN 50121-3-2 c. Vibration and shock: EN 61373 Cat II d. Salt mist test: 96 hours e. Fire & Smoke: EN 45545-2:2013 + A1:2015	

ANNEXURE-III

Methods for Validation of Diagnostic and Prognostic Models:

1. Diagnostic Models: Key Metrics:

Confusion Matrix: A confusion matrix is a tool to visualize the performance of a diagnostic model. It shows the actual vs. predicted classifications.

- **True Positives (TP)**: Correctly predicted positive cases.
- **True Negatives (TN)**: Correctly predicted negative cases.
- **False Positives (FP)**: Incorrectly predicted positive cases (Type I error).
- **False Negatives (FN)**: Incorrectly predicted negative cases (Type II error).

a. Accuracy: Accuracy = (TP + TN) / (TP + TN + FP + FN) Measures the overall correctness of the model.

c. Precision: Precision==TP/FP+TP Measures the proportion of true positive results among all positive results.

d. Recall (Sensitivity): Recall=TP/FN+TP Measures the proportion of actual positives correctly identified.

e. F1 Score: F1 Score=2×(Precision*Recall)/(Precision+Recall) Harmonic mean of precision and recall, balancing both metrics.

f. Receiver Operating Characteristic (ROC) Curve and Area Under the Curve (AUC):

- ROC Curve: Plots true positive rate (TPR) against false positive rate (FPR).
- AUC: Measures the area under the ROC curve, indicating the model's ability to discriminate between positive and negative classes.

2. Prognostic Models:

a. Mean Absolute Error (MAE): Measures the average magnitude of errors in the predictions, without considering their direction.

b. Mean Squared Error (MSE): MSE= Measures the average squared difference between actual and predicted values.

c. Root Mean Squared Error (RMSE): RMSE= Provides a measure of the prediction error magnitude.

d. Mean Absolute Percentage Error (MAPE): MAPE=Expresses accuracy as a percentage of the error.

e. Prediction Interval Coverage Probability (PICP): PICP= Measures the proportion of actual values falling within a certain prediction interval.

f. Cumulative Relative Accuracy (CRA): CRA=Actual RUL Predicted RUL Evaluates how closely predicted remaining useful life (RUL) matches the actual RUL.

(FOR THE GUIDANCE OF THE CONTRACTOR)

Annexure-IV

1. Template for Guidance for Alarms Dashboard for the Loco Pilot, Guard, and Train Running Staff

This dashboard should focus on providing real-time alerts and critical information to the loco pilot, guard, and train running staff to ensure safe and efficient train operations. **This template is just for guidance however firms can improve it further.**

Sections

- **Real-Time Alerts**:
  - Visual and audible alerts for critical alarms (e.g., brake failure, assembly /bearings overheating, load limit exceed, air spring failure, etc).
  - Status indicators (red, yellow, green) for different systems (brakes, main assembly/sub-assembly/component, and other health monitoring items).
- **System Health**:
  - Key parameters (e.g., speed, brake pressure, bearing temperature, load condition in the wagon, etc).
  - Recent alerts and resolved issues.
- **Communication**:
  - Communication channel for direct contact with control office and maintenance staff.
  - Predefined messages for quick communication.

Example Layout

Section	Details
Real-Time Alerts	Overheated Bearing : RED - Brake Pressure Low: YELLOW
System Health	:Speed: 80 km/h - Brake Pressure: Normal - other monitoring system : Normal
Communication	: Message to Control: [Send Alert] - Quick Messages:[Predefined Options]

2. Alarms Dashboard for Control Office

Template Overview

This dashboard is designed for the control office to monitor alarms from multiple trains and respond to incidents promptly.

Sections

- **Train Overview**:
  - List of all trains with their current status and location.
  - Summary of active alarms for each train.
- **Alarm Details**:
  - Detailed information on active alarms (type, severity, timestamp).
  - Historical alarm data and trends.
- **Response Actions**:
  - Recommended actions for each alarm.
  - Communication tools to contact train crew.

Example Layout

Section	Details
Train Overview	- Train 101: [Active Alarms: 3] - Train 202: [Active Alarms: 0]
Alarm Details	- Train 101 -- Brake Failure: High Severity -- HVAC Issue: Medium Severity
Response Actions	- Train 101 -- Brake Failure: [Contact Loco Pilot] -- HVAC Issue: [Log Incident]

3. Integrated Dashboards for Alarms, Diagnosis, and Prognosis for Maintenance Depots/Sheds

Template Overview

This dashboard integrates alarms, diagnostic data, and prognostic information to support maintenance activities.

Sections

- **Current Alarms**:
  - List of active alarms with severity and affected components.
- **Diagnostic Data**:
  - Detailed diagnostic information for components (e.g., brakes, bearing ets).
  - Visual representation of component health (e.g., charts, graphs).
- **Prognostic Analysis**:
  - Predictions for component failures and maintenance needs.

- Remaining useful life estimates for critical components.

Example Layout

Section	Details
Current Alarms	- Bearing temperature very high : RED - Brake Wear: YELLOW
Diagnostic Data	- Bearing : Temperature: 90°C - Brakes: Wear Level: 80%
Prognostic Analysis	- Bearing failure Predicted in 1000 km - Brakes: Maintenance Needed in 500 km

4. Integrated Dashboard for All of the Above for RDSO Command Centre

Template Overview

This comprehensive dashboard integrates information from all other dashboards, providing a holistic view of the RDSO command center.

Sections

- **System-Wide Overview**:
  - Status summary of all trains, control offices, and maintenance depots.
  - Aggregated data on active alarms, system health, and maintenance needs.
- **Detailed Views**:
  - Drill-down capabilities to view details from each individual dashboard (train, control office, maintenance).
- **Analytics and Reports**:
  - Trends and analysis of alarm frequencies, maintenance actions, and system performance.
  - Customizable reports and KPI tracking.

Example Layout

Section	Details
System-Wide Overview	- Trains: [Active Alarms: 5] - Depots: [Maintenance Due: 3]
Detailed Views	- [View Train Alarms] - [View Control Office Data] - [View Maintenance Diagnostics]
Analytics and Reports	Alarm Trends: [Graph] - Maintenance Performance: [Report] - KPI Dashboard: [Customizable].

Annexure-V

Day-Wise Training Module for Railway Staff

Days 1-2: Introduction to RAMS and PHM

Day 1: Overview of RAMS and PHM

Introduction to RAMS

Importance of RAMS in railway rolling stock.

Key components: Reliability, Availability, Maintainability, and Safety.

Introduction to PHM

Importance of PHM in predictive maintenance.

Key components: Diagnostics, Prognostics, and Health Management.

Industry Case Studies

Examples of successful RAMS and PHM implementations in railway systems.

Day 2: Basics of Reliability Engineering and PHM

Reliability Engineering Concepts

Mean Time Between Failures (MTBF), Mean Time To Repair (MTTR), Availability.

Failure Modes, Effects, and Criticality Analysis (FMECA).

PHM Methodologies

Data-driven, model-based, and hybrid approaches for prognostics.

Practical Examples

Application of reliability and PHM in real-world scenarios.

Days 3-7: Training on RAMS and PHM Software

Day 3: Introduction to RAMS and PHM Software

Software Setup and Overview

Installation, basic navigation, and understanding of the interface.

Basic Features and Tools

Overview of tools available for RAMS and PHM analysis.

Day 4: Reliability Analysis Using Software

Reliability Block Diagrams (RBD)

Creating and analyzing RBDs.

Fault Tree Analysis (FTA)

Building fault trees and analyzing system reliability.

Software Exercises

Hands-on practice with sample data.

Day 5: PHM Software Modules

Diagnostics Module

Setting up diagnostics models for fault detection.

Prognostics Module

Developing prognostic models for predicting remaining useful life (RUL).

Case Study Analysis

Applying diagnostics and prognostics to real-world data.

Day 6: Advanced RAMS and PHM Software Features

Failure Modes, Effects, and Criticality Analysis (FMECA)

Performing FMECA using software tools.

Hazard and Risk Assessment

Creating hazard maps and conducting risk assessments.

Scenario Analysis

Analyzing different failure scenarios using the software.

Day 7: Practical Exercises and Review

Hands-On Session

Working on real-life examples and case studies.

Review and Discussion

Reviewing the week's learning and addressing queries.

Days 8-12: Digital Modeling of Rolling Stock

Day 8: Introduction to Digital Modeling

Basics of Digital Twin Technology

Overview of digital twin concepts and applications in railways.

Modeling Tools and Techniques

Introduction to software tools for creating digital models.

Day 9: Creating Basic Digital Models

Component-Level Modeling

Building digital models of individual rolling stock components.

Integration with Sensors

Linking digital models with sensor data for real-time monitoring.

Day 10: Advanced Digital Modeling

System-Level Modeling

Creating complex digital models that represent the entire rolling stock.

Simulations and Scenarios

Running simulations to predict performance under different conditions.

Day 11: Validation and Optimization of Digital Models

Model Validation Techniques

Ensuring digital models accurately represent the real-world system.

Optimization Strategies

Improving model accuracy and performance through optimization techniques.

Day 12: Practical Examples and Group Work

Hands-On Modeling Exercise

Participants create digital models of rolling stock.

Group Discussion

Sharing results and discussing challenges faced during modeling.

Days 13-14: Creation of Fault Trees, FMECAs, and Hazard Maps

Day 13: Fault Tree Analysis and FMECA

Introduction to Fault Trees

Creating fault trees to analyze potential failure points.

Performing FMECA

A step-by-step guide to conducting FMECA for rolling stock.

Day 14: Hazard Maps and Risk Assessment

Hazard Mapping Techniques

Creating visual hazard maps to identify high-risk areas.

Risk Assessment Methodologies

Conducting risk assessments based on FMEA/FMECA findings.

Group Exercise

Practical application of fault trees, FMECAs, and hazard maps.

Day 15: Data Acquisition and IT-Related Training

Introduction to Data Acquisition Systems

Data Collection Techniques

Overview of data acquisition hardware and software used in rolling stock.

Sensor Integration and Data Streaming

Setting up sensors and real-time data streaming.

Data Management and IT Infrastructure

Data Storage and Security

Best practices for managing and securing data.

IT Infrastructure Setup

Ensuring the IT infrastructure supports RAMS and PHM requirements.

Final Review and Group Project

Group Project

Participants work on a group project involving data acquisition and analysis.