Draft Functional Requirement Specifications (FRS) for
GLOBAL TENDER No: 2015/DEV.CELL/ICCI/1
March 2017

For Supply, Installation, Commissioning and Operation of
On Board Condition Monitoring Systems for
Indian Railway Rolling Stock
to
Specification Number: OBCMS/DCM/N/1, November 2016
Foreword:

1. This document consists of two parts:
   - **Part-I**
     Reasoned document for demanding the specific Functional Technical Requirements from the bidders.
   - **Part-II**
     Functional Technical Requirements (FTR) to which the equipment and services shall be procured.

2. The comments, if any, on these Functional Requirement Specifications (FRS) may be emailed to Director Mechanical Engineering (Development)/Railway Board upto mid night of 15.05.2017 at binay.jha@gov.in.

3. It is requested that comments may kindly be sent to Director Mechanical Engg. (Development)/Railway Board within the stipulated time. The responses received after above mentioned time shall not be entertained.
Part-I

Reasoned document for demanding
the specific Functional Technical Requirements
from the bidders.
Preamble:

1. In order to maintain transparency in Indian Railways’ need to demand certain functionality from the On-Board Condition Monitoring System while maintaining certain high level of baseline standards, this reasoned document is being put up for information of all concerned. The technology benchmarks to be followed in acquiring these systems have been laid down so as to guard against obsolesce. Indian Railways has, while deciding the technology, made sure that only the technology is being defined. No specific product which may fall under patent protection of a specific company has been chosen to be endorsed by Indian Railways since that would construe that such a specification would become biased by naming the product thereby defeating the very purpose of framing open and fair specifications.

2. These reasoned comments are based on the responses received from the various respondents to the EOI and the discussions of the offers received with the concerned authorities/officials.

3. For examining the responses received against the Expression of Interest (EOI) for purchasing the On-Board Condition Monitoring System, experts/officers were nominated at both Railway Board and at RDSO. Academic Expert too has been involved in examining the current practices, technology progression and available technologies to safeguard the interests of Indian Railways. This was duly approved by MRS (the then MM).

4. Further, in order to give a fair chance to all respondents, they were offered a chance to showcase their systems in presence of a number of senior officers at the Railway Board in “Live mode” via internet. This was held in February, 2016.

5. For the purpose of brevity, the following acronyms have been used:

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>WSN</td>
<td>Wireless Sensor Node</td>
</tr>
<tr>
<td>DC</td>
<td>Data Concentrator</td>
</tr>
<tr>
<td>EoI</td>
<td>Expression of Interest</td>
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<tr>
<td>IR</td>
<td>Indian Railways</td>
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<tr>
<td>RDSO</td>
<td>Research Designs and Standards Organization</td>
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</table>

6. As per the EoI, the On Board Condition Monitoring System for monitoring of vibrations and later to be extended to additional functional parameters which will be specified after the first phase is rolled out use the following major components:

6.2 Power source for the WSN.
6.3 Data Concentrator (DC) for collecting and pre-processing data being collected by various WSN.
6.4 Communication system between WSN and Data Concentrators (DC).
6.5 Communication system between Data Concentrators and Central processing ground stations.
6.6 Algorithms that analyse raw data to create actionable alerts.
Various vendors who responded to the EoI have given different solutions to achieve the objectives and the demands made by Indian Railways.

7. All the respondent firms were also invited to demonstrate their working systems. The live demonstration of various systems by each firm was done as per the following schedule:-

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of the Firm (M/s)</th>
<th>Date of Presentation</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>SKF India Ltd</td>
<td>23-02-2016 &amp; 19-04-2016</td>
</tr>
<tr>
<td>2</td>
<td>Medha Servo Drives Pvt. Ltd</td>
<td>23-02-2016</td>
</tr>
<tr>
<td>3</td>
<td>Apna Tech. &amp; Solutions Pvt. Ltd</td>
<td>23-02-2016</td>
</tr>
<tr>
<td>4</td>
<td>Amsted Rail Company Inc./ IONX</td>
<td>23-02-2016 (Through Webinar)</td>
</tr>
<tr>
<td>5</td>
<td>RSL Electronics Ltd</td>
<td>23-02-2016</td>
</tr>
<tr>
<td>6</td>
<td>Secure Rail India Pvt. Ltd</td>
<td>23-02-2016</td>
</tr>
<tr>
<td>7</td>
<td>Structural Solutions Pvt. Ltd</td>
<td>23-02-2016</td>
</tr>
<tr>
<td>8</td>
<td>IRD Mechanalysis Ltd</td>
<td>23-02-2016</td>
</tr>
<tr>
<td>9</td>
<td>RT Vision Technologies (p) Ltd</td>
<td>23-02-2016</td>
</tr>
<tr>
<td>10</td>
<td>Stone India Ltd</td>
<td>26-02-2016 (Tele-conference)</td>
</tr>
<tr>
<td>11</td>
<td>GE India Industrial Pvt. Ltd.</td>
<td>10-03-2016</td>
</tr>
</tbody>
</table>

- M/s ECM, Italy presented their system in AM(PU)’s chamber via video conferencing on 13-04-2016.
- M/s Amsted, USA presented their system on a later date via video conferencing on 23-02-2016
- M/s Star Navigation Systems presented their system in AM(PU)’s chamber on 13-04-2016.

Each firm’s personnel gave their presentation to a group of senior Railway Officials.

8. The objective of the "live presentation” exercise was to see if the vendors who showed interest in the EoI and submitted their responses have the necessary product as well as the technology running in any commercial railway system in the world to offer to Indian Railways. The aim, in short, was to see that Indian Railways should not be treated as an experimental lab or Guinea Pig by any firm to develop such technology and product.

9. Therefore, very fair opportunity was given to every respondent to present their product and to showcase the capabilities and limitations of their system.

10. The On-Board Condition Monitoring Systems for monitoring of vibrations has been envisaged to use same vibration sensor to be used for dual purpose – to monitor the health of the rolling stock/bearing and to monitor the state of track over which the vehicle is passing. The system uses the following major components:-
10.1 Wireless Sensor Node (WSN) that serve to provide signal for bearing as well as track health analysis from the same node.

10.2 Power source for the sensor nodes.

10.3 Data Concentrator (DC) for collecting and pre-processing data being collected by various WSN.

10.4 Communication system between WSN and Data Concentrators (DC)

10.5 Communication system between Data Concentrators and Central Processing ground stations.

10.6 Algorithms that analyze raw data to create actionable alerts.

11. Various vendors who responded to the EOI have given different solutions to achieve these objectives. While the standards and practices for communicating data between the sensors and data concentrators and between Data Concentrators and Ground control are fairly standard and established by industry norms, the major variation in the firms’ proposals was with respect to providing power to the Wireless Sensor Nodes and their ability to monitor the state of health of both track as well as bearings using the same WSN. Fitment methodology was another factor on which the firms had variety of solutions – some intrusive and some non-intrusive solutions.

12. While it is clear that all companies have capabilities to analyse data using their algorithms, it is clear that algorithms require continuous fine tuning and this can be done effectively only when the Sensor system is being used on a regular basis and real-time data is being processed. This is only possible if the system is being used by major users and actual user conditions are being used to fine tune the algorithms. Very evident example of algorithms acquiring highest levels of sophistications is GOOGLE SEARCH ENGINES. Comparisons between search results in first year of launch of Google Search and today would be completely different since based on usage and the clients’ demands, the search programs were improved and made faster and more efficient and accurate. This demonstrative of how algorithms require continuous and extensive usage for improvements.

13. Attached is a chart that shows the summary of response of all respondents. Based on the responses, the following key points emerge:

13.1 Besides the fact that a well tested and extensively used software algorithm is certainly likely to give more accurate and user-friendly results, the “Power Source” for WSN is clearly another qualitative differentiator. The following alternatives have been suggested as a “Power Source” by various firms:
- Batteries
- Bearing/Axle rotation being used to generate power.
- Energy Harvester
- Using the power from on-board source of the vehicle to power the Sensor Node.

14. A summary of the merits and de-merits of the various options of powering the sensor nodes is given below:

<table>
<thead>
<tr>
<th>Types of Power Source</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvesting from Bearing Rotation</td>
<td>Generates sufficient amount of power for continuous monitoring.</td>
<td>1) Major alteration required in fitting on existing bearing system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Invasive with regards to changes required in the bearing assembly. Each manufacturer of such energy source would have unique system hence no uniformity would be achieved causing major problem in interchangeability of bearings/ components.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3) Has moving parts inside the bearing hence there is an added risk that if the inner parts break/fail, whole bearing’s reliability becomes suspect and it becomes prone to catastrophic failure without giving indications.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4) Takes substantial time to install/inspect and repair when needed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5) There shall be connectors inside the bearing housing which are again possible points of failure.</td>
</tr>
<tr>
<td>Harvesting from axle rotation</td>
<td>Generates sufficient amount of power for continuous monitoring</td>
<td>1) This is still more of an R&amp;D project with the company and no railroad is using their system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Major changes required in bearing system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3) Invasive with regards to changes required in the bearing. Reach manufacturer of such energy source would have unique system hence no uniformity would be achieved causing major problem in interchangeability of bearings/ components.</td>
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<td></td>
<td></td>
<td>6) There shall be connectors inside the bearing housing which are again possible points of failure.</td>
</tr>
<tr>
<td>Batteries</td>
<td>Very good</td>
<td>1. Battery itself has too many possible modes of failure.</td>
</tr>
<tr>
<td>Quality batteries appear to be low initial cost solution for power generation to power the sensor.</td>
<td>that too when fitted in such critical application and when subjected to such harsh working environment.</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>2. Maintenance Costs in replacing batteries would a logistic problem.</td>
<td>2. May be the most initially expensive solution.</td>
<td></td>
</tr>
<tr>
<td>3. Once the WSN is opened for replacing batteries, sealing it back to Factory spec of IP7 requirements would require sanitized work area.</td>
<td>2. Volumes will bring eventual cost down and mitigate the initial high cost but</td>
<td></td>
</tr>
<tr>
<td>4. Disposal of replaced batteries would end up adding to the e-waste.</td>
<td>3. Life cycle cost shall become much lower.</td>
<td></td>
</tr>
<tr>
<td>5. Types of batteries to be used with WSN are generally termed as VERY HAZARDOUS. Disposal of such large volumes of these hazardous materials would be an environmental hazard.</td>
<td>Energy Harvesting</td>
<td></td>
</tr>
<tr>
<td>6. Only ONE railroad has shown confidence in battery powered WSN systems for Condition Monitoring.</td>
<td>Clean source of energy.</td>
<td></td>
</tr>
<tr>
<td>7. As battery life reaches its end, data integrity becomes a suspect due to end-of-life voltage-current characteristics.</td>
<td>No replacement of energy source.</td>
<td></td>
</tr>
<tr>
<td>8. Calculations suggest that power requirement for efficient continuous monitoring is not possible using non-rechargeable batteries.</td>
<td>Tried and tested technology by major railroad.</td>
<td></td>
</tr>
<tr>
<td>9. Rechargeable batteries would require energy harvesting mechanism that would have to produce power greater than power required for continuous monitoring.</td>
<td>Sufficient amount of power generated to power WSN.</td>
<td></td>
</tr>
<tr>
<td>Energy Harvesting</td>
<td>Maintenance free</td>
<td></td>
</tr>
<tr>
<td>Does not need replacement till</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
end-of-life so all logistic problems of locating a dying energy source (such as a dying/dead battery) and replacing them are eliminated.

| Wired sensors using power from On Board DC power source | Huge amount of power available on tap. | 1. Very invasive.  
2. Limited to passenger coaches and locomotives. It has been generally seen that wired connections especially below the under-frame are prone to breakage and damage due to ballast hit/harsh environment and vandalism.  
3. Cannot be proliferated to freight wagons. |

Indian Railways needs to look at the operational aspects too while implementing On-Board Condition Monitoring System. These operational aspects are discussed below:

14.1 Using Batteries to power WSN: Presuming that 2,50,000 wagons, 50,000 coaches and 10,000 locomotives are fitted with one battery powered sensor on each axle box, a total of 3,10,000 vehicles will be fitted with 25,00,000 sensors that have at least one battery in each sensor. Even with the state of the art batteries on date, average battery life in such harsh environment shall be appx. 5 years. Therefore, every year, Indian Railways will need to keep track of all these 25,00,000 batteries at ALL TIMES. The average replacement requirement of the batteries will be 25,00,000 ÷ 5 = 5,00,000 batteries every year in LOCATIONS ALL OVER THE COUNTRY. This is an impossible task. Further, these spent batteries will be hazardous waste so the same will have to be disposed of in an expensive manner ensuring that they don’t cause environmental pollution. **Hence as conscious decision has been taken that using batteries to power the sensor nodes cannot be accepted by Indian Railways.**

14.2 Axle rotation/Bearing rotation powered energy generation: Axle/Bearing rotation powered systems necessitate that the bearing, including the housing needs to be modified. An arrangement has to be made inside the bearing housing by adding a magnetic generator mechanism with gears, magnets, wires etc. to generate energy from rotation of the axle/bearing race. Internal structures and components of bearing are very critical components. **All along, Indian Railways is moving in the direction of keeping axle bearings as sealed entity with very rugged and as few components inside it as possible so**
as to reduce the chances of failure (more the number of components inside – more the chances of one of the components failing resulting in complete failure of the bearing).

Furthermore, each bearing manufacturer will have his own design of energy generator inside the bearing housing and such a system will be proprietary to each company since performance issues of the bearing itself will get linked to the complete assembly. With more components inside the bearing, the points of failure will increase thereby decreasing the reliability of the bearing assembly as a whole. Presently, approximately 700-800 bearings are failing catastrophically on line. Since these bearings do not have any components inside them that go not belong to the bearing manufacturer, failure analysis is much more precise and ownership of setting right the failure is well defined. With third-part components inside the bearing, it will be impossible to fix responsibility for a bearing failure.

Servicing this power generating system inside the sealed axle-box will also necessitate setting up specialized maintenance centres within all the workshops and manpower would have to be trained to deal with the complete system as a whole. Therefore, a decision has been taken by the competent authorities that the no powering system shall be permitted in which the bearing needs to be opened/modified/retrofitted with power generation sub-system. Energy generation using axle rotation/bearing rotation also cannot be permitted since additional system to generate electrical energy only for powering a sensor cannot be permitted as it will increase monitoring and maintenance needs of the same.

14.3 Energy harvester based power source for powering sensors have been offered by one company (M/s Perpetuum UK) and is being developed by two more companies (M/s SKF and M/s IONX). These systems are self-contained within the sensor and are “fit-and-forget” systems as an integral part of the sensor itself. The life of the sensor along with the energy harvester is stated to be 20 years. Energy harvesters are not a new concept. Due to their rugged, maintenance-free nature and due to their long life, such energy harvester systems are being used by large number of industries including defence industry. The fact that M/s SKF and M/s IONX are developing their solutions on energy harvester powered systems is a testimony to the fact that whenever and wherever rugged and maintenance-free sensor systems are needed, energy harvesters are the choice of power source. Energy harvesters powered sensors are based on powering the sensor using energy harvested by converting mechanical vibrations or tapping ambient conditions to generate electrical power. There are number of methods to “harvest” mechanical vibrations or ambient energy to generate electrical energy. In view of the above operational advantages, it has been decided to agree to adopting energy harvester based technology for powering the sensor nodes. Therefore bidders shall not be permitted to offer systems that are powered by battery if these internal batteries do not have self-sustained charging system using sealed energy harvester system within the same enclosure as that of the
**sensor/data concentrator.** However, test regime to support the claim of life of such sealed sensor nodes incorporating energy harvester must be furnished by the bidder so that the claim can be verified by Indian Railways. The minimum life of such energy harvester based wireless sensors shall not be less than fifteen (15) years when they are offered to Indian Railways as a solution against the above bid.

### 14.4 Frequency of sampling rate of data for monitoring condition of bearings and track for actionable analysis:

There is a trade-off in designing a system of condition monitoring of bearings, including condition monitoring of track. The choice is between sampling at frequent closely-spaced intervals or at infrequent, widely spaced intervals (say a couple of times a day only). Continuous monitoring should detect a problem straight away but it usually very energy hungry and puts severe computational load on the processing system on the sensor board itself. As against this, data acquisition at widely-spaced intervals demands very little power from power source and puts very small demand on the computation system but has a very high probability of missing out on possible alarm-causing events. Periodic sampling at widely spaced intervals (say just a few times in a day) is cheaper, uses less energy, and allows time for data cleaning and filtering but a real problem will be diagnosed only during the next processing session. This may be acceptable only in some situations that change slowly such as cracks slowly developing in bridges. Therefore, as a trade-off it is essential to acquire data at sufficiently frequent interval so as to get “near-real-time” inputs of the condition of the component being monitored. E.g. if a train is travelling at say 110 km/h, sampling the data from sensor at say even once every hour would result in missing out the track vibration signature for a stretch of 110 kilometres – i.e. if any portion of track in between these two points 110 km apart happens to have a dangerous spot in between and which gave a vibration impulse to the sensor, it would be missed by the monitoring system due to large sampling interval. Therefore, a decision has been taken by the competent authorities that sampling of data shall be done by the sensor at short interval say every three (3) minutes or even less but not longer than five minutes spacing. Faster sampling rate shall be factored in in case other conditions of performance between two bids are found equal. Data may be held after sampling on board the sensor and may be transmitted in bursts so as not to miss out significant events and to preserve energy reserve on the sensor.

15. It is the intention of Indian Railways to place purchase order of such system on one primary firm and two developmental firms provided they all meet the performance criteria without diluting any performance demands as asked for by Indian Railways.

16. The entire system shall be of a single identical design including sensors and harvester etc for fitment on coaches, wagons and locomotives. No request to permit dissimilar systems for coach, wagon or locomotive should be made. The performance demands of the
system shall not be diluted even if the firms cite the reason that design of such systems especially power source is difficult for fitting on freight wagons.

17. Since Indian Railways wishes that for developing such a system, it should not be made the experimental laboratory/Guinea pig, the system offered by the bidder must be commercially operational for at least one year in at least two railway systems.

This current document is drafted based upon the Indian Railways’ Functional Requirement Specifications (FRS) and on the basis of the current technology available and keeping in view the progression of such technology in near future. Indian Railways’ decision is to leapfrog in terms of technology rather than move ahead in small incremental steps. This is the final version of the specifications and is being uploaded for information of all prospective respondents so that they can prepare their proposals for submission keeping in view the stringent and technologically demanding requirements of such a system. This system, in principle, has been showcased to Hon’ble Prime Minister of India and other senior policymakers during Rail Shivir on 20th Nov, 2016. This system shall be the backbone for bringing paradigm shift in monitoring and maintenance methodology and operation of IR’s rolling stock. Notice for Bid Invitation shall be published shortly.
Part-II

Functional Technical Requirements (FTR)

to which the equipment and services shall be procured.
A. Preamble:

Indian Railways wishes to install railway vehicle mounted, ‘On Board Rolling Stock Condition Monitoring System’ that shall monitor the health and safety of key components of the coaches, freight cars, locomotives and rail track from the point of view of component health and its safety. Such a system would finally result in improved safety, improved reliability, higher utilization, increased up-time and reduced operation cost of the railway assets by enabling Predictive Maintenance and reduction in sudden catastrophic failures of these assets.

B. Broad Functional Requirements:

The ‘On Board Condition Monitoring System of Rolling Stock’ will enable Predictive Maintenance of coaches, wagons, locomotives and track by meeting the following functionalities:

a. Improving the reliability and safety by early warning of distress in or impending failures in wheels and wheel bearings using the vibration signature of the sensors that are strategically placed on the axlebox. To also do track condition monitoring using the same sensor(s) to indicate deterioration in the health of tracks.

b. Improvement in reliability of these assets by detecting early signs of deterioration in wheels, wheel bearings and track condition thus providing ample time for planning preventive and predictive maintenance and avoiding sudden breakdowns in service.

c. Enabling scientific decision-making for maintenance of assets based on accurate deterioration trending and quantified indices of state of health of these assets so as to plan condition-based maintenance rather than time-based maintenance.

d. It should be possible to Install On Board Condition Monitoring System on Rolling Stock on “in service” trains/coaches/wagons/locomotives within normal scheduled maintenance time when the rolling stock comes for routine inspection and maintenance usually at the end of the trip This is needed to reduce cost of installation, increased asset availability and prevention of train service disruption while reaping benefits of such predictive maintenance systems.

e. The proposed system should be capable of being used with existing roller bearings without having to make any structural modifications in the roller bearings or any major intrusive modification in the bearing/bogie frame.

f. Easy operation of the On Board Rolling Stock Condition Monitoring System by simple, automatically generated and actionable alerts.

System should be “future proof” to the extent that any change in communication technology and sensor electronics should not degrade its performance nor should necessitate that Indian Railways is compelled to change the purchased system to reap its intended benefits.

18. Key Requirements:

18.1 The standards for compliance are as specified in Annexure–1.

18.2 Vendors Qualification:
Following experience of the original system manufacturer or the Lead Technical firm in case the bid is submitted by a JV of firms in which the technology and the systems shall be under exclusive ownership of one single firm, shall be the minimum acceptable experience for the respondents to qualify them for taking part in the bidding process when request for proposal is called for:

a. Installation of at-least 5,000 wireless sensors on trains across different types of Coaches or freight cars. These sensors must have run in the field for at least 2 (two) years.

b. Experience of over 1,000,000,000 sensor-kilometres of accumulated service operation of wireless (non-battery) sensor nodes.

c. Submit documentary evidence to Indian Railways showing how asset maintenance costs have been reduced by their customers by deploying the system that they propose to supply.

d. Names of at least two customers along with their contact details who shall supply testimonials as asked for in (a), (b) and (c) above.

e. Proof of demonstration of successful detection of such damaged bearings which would otherwise have failed but have been caught by their system at least three months in advance of their failure.

f. The effectiveness of the wheel and bearing condition monitoring system shall be already proven in passenger coaching vehicle and locomotive/powered passenger stock. Since Indian Railways is not aware of any deployment of such systems on freight cars due to absence of reliable power source, same WSN should be capable of being deployed on freight vehicles without any change of configuration or change of functional parts so as to maintain universality in deployment across all types of stocks. Examples of successful wheel and bearing monitoring case studies wherein damage to bearing, wheel and track was successfully demonstrated well before occurrence of failure must be furnished with evidence of damages so detected, their documentation and field staff’s observations.

18.3 Deliverables expected from the System:

a. System shall be capable of operating effectively with 2G cellular data network coverage. System must be scalable to upgrade to 3G and 4G as and when needed and should choose the 2G/3G/4G networks automatically to ensure that the communication does not fail for any reason. Automatic switching between 2G/3G/4G should be done as a standard design of the communication system.

b. All data shall be captured and transmitted to a central server for inspection and analysis from the data concentrator. Transmission should be secure and encrypted. IR should be given the decryption methods and keys so that it is possible to decode and extract this data stream at the input to the analysis software for later use by Indian Railways for its own analysis.
c. Events that cause critical alert situation like impending failure should be dealt with differently. Such alerts should also be conveyed to central monitoring systems on an urgent, escalated-priority basis overriding normal communication methodology for flagging them for taking urgent action.

d. Vibration data shall be captured at every 3 (three) minutes or lesser. If required, it should be held in buffer on board the WSN/Data concentrator and then transmitted to a central database for processing, analysis and alert generation when the train is in normal service (at speeds over 25 Km/h) and as soon as it comes into cellular data coverage. In the event of cellular network not being available, the data shall be held for the entire required time until cellular network coverage becomes available and then data must be transmitted at the earliest. The data holding buffer must be designed accordingly.

e. The condition monitoring system shall not be specific to any particular bearing type or to any specific bearing supplier but should function with multiple types of bearings that are running on Indian Railways.

f. Respondent must specify the accuracy of their system on overall basis with reference to False–Positive and False–Negative alarm performance. Methodology of verifying the stated accuracy including the test regime to be followed to substantiate their claim must be specified. Indian Railways shall, while calling for technical and commercial bids, take into consideration these details furnished by the vendors. In absence of any numbers given by the respondents, Indian Railways shall set its own values based on its experience of similar equipment running in the field in India. Not more than 5% false positive shall be accepted by Indian Railways.

g. Vibration shall be measured and transmitted when train is operating in normal service (speed greater than 25 Km/h) and shall effectively work at speed upto 200km/h.

h. The system shall be capable of measuring, analysing and transmitting an alert in the event of detecting a high-risk occurrence pointing to an impending failure within typically three minutes and maximum ten minutes with appropriate 2G/3G/4G data connectivity. Time stamp and GPS location stamp of the system shall be used to report such events. Faster response times shall be preferred.

i. The condition monitoring software algorithm should also report the state of the health of the bearing, wheels and the track on discreet band zone – “Green Zone” for unconditionally safe to run, “Yellow Zone” - for beginning of noticeable deterioration and “Red Zone” - for indication to pull out the asset as soon as possible since it is reaching an impending failure stage.

j. The “condition band” (Green band, Yellow band and red band as mentioned in i. above shall, after appropriate configuration and calibration, enable the operator to distinguish between bearings/wheels and track with none or low level of rate of degradation, those that require to be kept sight of for further deterioration and finally
those requiring prompt attention to allow continued reliable operation of the train without a line-failure of the asset.

k. Besides the above mentioned “Zone Bands”, all parameters of the all assets should be possible to be plotted and trended over time/distance to identify the deterioration rate/trend. This should enable prioritisation of maintenance activities, thus enabling reducing damage to track and maximising useful wheel life.

l. The wheel condition monitoring system must be able to enable the operator to detect defects arising of Rolling contact fatigue like wheel shelling, wheel flats, etc.

m. In the event of sensor damage, a warning shall be generated to the control center to enable safe replacement of the sensor at the next maintenance location. The control room/system should have a mechanism to flag and display such defective sensor/data concentrator continuously to the personnel manning such terminals until the same is/are repaired/replaced.

n. Alert levels shall be configurable and set by the operator to enable simple, actionable responses. However, the vendor shall take the responsibility of identifying the values and setting the limits and alarm thresholds in consultation with Indian Railways. A time period of two months shall be given to the supplier to understand the Indian Railways operations and maintenance scenario and practices for setting such thresholds. The supplier shall be obligated to assist Indian Railways personnel in understanding the logics of the thresholds so set by him – to the full satisfaction of the Indian Railways personnel. A maximum period of six months from the date of installation on the last vehicle of all the purchased units shall be permitted to the supplier to do any fine-tuning of their system algorithms.

o. A system of cellular text alerts and acknowledgements to nominated maintenance personnel of Indian Railways shall be designed with necessary checks and compliances. Such a system should be completely automated with provisions to escalate level of attention in case the nominated personnel do not acknowledge the relevant text.

p. The training materials and documentation for the system shall include historical examples of bearing, wheel and track defects that have been monitored successfully, with a correlation between monitored degradation, action taken by operator and parameter levels on return to normal after maintenance.

q. All sensor data shall be time, date and location stamped. Data location shall be typically accurate to ±10m or better. Date and Time stamp shall be taken from the GPS system only.

r. The allocation of sensor nodes to a data concentrator and train will be easily configured either through the terminal input of the data concentrator using non-contact programming device (Bluetooth, NFC, Zigbee, etc.) or by remote connection with the user website.
s. The only configuration required for sensor nodes shall be the sensor node serial number with railway coach/wagon/locomotive number.

t. Decryption keys shall be provided wherever necessary to use the incoming data to the analytics program. Proprietary communication protocols or data formats/information interchange formats used by the system when interfacing during system integration with other sensors or while scaling up the deployment should be shared with Indian Railways with the express permission that the same can be used by Indian Railways for its own use without any restrictions.

u. IR should also be able to extract the data in usable format that is being sent between WSN and data concentrator and data concentrator and analytics program.

19. EQUIPMENT AND SYSTEMS:

For the purpose of this work, the system as asked for by Indian Railways is assumed to consist of:

i) Sensor(s) fitted on the axlebox/axlebox-cover with minimally intrusive fitment so as to capture the temperature of the axle box and the vibrations generated by axle bearings and those generated by wheel and track.

ii) Data concentrator – an electronic unit that is used to collect data from the sensors and transmit it to the control room using over the air data transmission method.

iii) Central collection and data processing centre for collection and analysis of data and for communicating the various alarms or maintenance messages to the concerned railway personnel on an automatic basis.

For the purpose of calculation and scoping of this document, it is assumed that for monitoring each axle-box one sensor each shall be fitted as near to the axle box as per firm’s design plan so as to capture the most accurate data required for making alert” decisions, i.e. two sensors for each wheel-set. Indian Railways Locomotive is a six-axle vehicle and the coach and freight cars are four axle vehicles at present.

19.1 Specifications & design of critical components shall also be approved by Ministry of Railways through its approved agency before they are fitted. Sensors and systems shall be as per existing standards for compliance for fitment on Railways coaches, wagons and locomotives. Notwithstanding any such approval, the respondents shall stand fully responsible in respect of design, manufacture and serviceability of the complete system. The respondents shall also be responsible for ensuring that the systems so fitted shall not affect the safety of the other railway equipment.

19.2 Certain number of units of the system shall be subjected to extreme limit of stress testing to the point of their failure so as to investigate the design margin available in the system before failure. Such units shall not be counted towards the number of bearings supplied but shall be part of product acceptance test by Indian Railways.
19.3 Firm shall also submit the Laboratory Test regime to test the sensors and data concentrator to evaluate the claims made by the firm towards the functionality and life expectancy claimed out of the equipment proposed to be supplied. These tests should also include accelerated ageing test wherever applicable wherever any particular component’s life is claimed to be more than the warranty period of the equipment.

19.4 During the currency of contract, after the basic system is proven, IR desires that certain additional parameters should also to be monitored since the basic backbone system of data collection, data analysis and monitoring shall already be in place. List of such additional parameters is enclosed in Annexure-1. The respondents shall develop all interfaces required to integrate such additional sensors into the “On Board Rolling Stock Condition Monitoring System” without having to change the basic architecture of the system already approved and installed on IR’s rolling stock. The cost and transfer the know-how to IR upon completion of the interface development shall be borne by the supplier of the main system.

19.5 For the future, when the Bids shall be called, they shall be based on “Two Packet System” Consisting of “Technical Offer” and “Commercial Offer”. Technical offer shall be evaluated first and the commercial offer shall not be opened or given any cognizance if the bidder fails to meet the technical requirement in their technical offer.

19.6 The indigenization plan for the “On Board Rolling Stock Condition Monitoring System” System offered against this tender should be submitted along with the technical bid. Indian Railways insists that at least 75% by cost of 25% of the supplies of the total quantity ordered on the firm should be either made in India within two years of initial supplies. This is to ensure that indigenization is taken seriously and completely aligned with the MAKE IN INDIA program of the government.

19.7 Indian Railways reserve the right to cancel the tender at any stage without assigning any reason therefor.

20. Following information must be furnished while submitting the response to this document: -

i) Any “Must-change” items to keep the system running and the periodicity of changing such must-change” items.

ii) The quantum of false alarms – both false positive and false negative must be declared at Technical Bid stage itself. False positive alarms shall not exceed 5%. Non-adherence to this shall be viewed seriously and shall result in severe financial penalty besides making the supplier of such equipment ineligible to participate in any tender of Indian Railways for purchasing equipment/sensor/system to monitor health of any rolling stock component or its systems/sub-systems, for a period of ten years subsequent to detection of such violation.
iii) The respondents must specify the “Up-time” of their system while submitting their bids. Any non-availability of their system, below their specified “Up-time” shall incur penalty. Quantum of penalty shall be advised at the time of framing the final specifications. Penalty shall be telescopic in nature. The minimum acceptable up-time for the sensors and data concentrator and data capturing and analysis systems including control room equipment shall be 98% not counting communication failure attributable to equipment/systems that are not owned by the successful supplier(s).

21. WARRANTY:

21.1 The respondent will provide warranty at the nominated maintenance depots for 39 months from the date of supply or 36 months from date of commissioning, whichever is earlier. During warranty, the respondents shall rectify the defects, if any, in the “On Board Rolling Stock Condition Monitoring System” system by replacing components as necessary at his cost.

21.2 If the warranty support is not provided within 7 (seven) days of notice demanding the same, Indian Railways shall levy appropriate penalties for non-functioning of the system. For this purpose, even if a sub-assembly within a complete unit (one coach/wagon/locomotive) is not working, the entire coach, wagon or locomotive system shall be deemed to be non-functional. Rate of penalty shall be calculated and notified at the time of calling for Request for Proposals. The rate of penalty shall be telescopic in nature so as to discourage non-compliance for long duration.

21.3 Respondent shall also undertake to ensure availability of all requisite spare parts for a minimum period of 15 years after purchase from the date of Letter of Acceptance of the offer when Technical and Commercial Bids are called for. In case any specific spare part is not available at a later date for whatever reason, an equivalent or superior spare part that performs all the functions of the original spare part can be accepted subject to preapproval of the same by RDSO. In making such substitution of spares, which should have minimum impact on the existing architecture/software/layouts etc. The expenditure in modifying the system/sub-system/architecture shall be borne by the suppliers.

21.4 The respondent shall give an undertaking that should there be any need for modification arising out of field trials or during the currency of the contract – as per the deliverable functional capability promised by the respondent, it will be carried out by the respondent without any cost to the Indian Railways.

22. System Configuration:

22.1 The ‘Rolling Stock and Track Condition Monitoring System’ shall have the following elements:
- Sensor module (Sensor Node).
- Communications network.
- Analysis Software.
The bidders shall not be permitted to offer sensor systems that are powered by battery alone if their internal batteries do not have self-sustained charging systems using sealed energy harvester within the same enclosure as that of the sensor/data concentrator. The Ingress Protection rating requirement shall apply to the complete unit. Indian Railways shall not permit replacement of the internal battery for 15 years (minimum life of such sealed sensors).

Bidders are required to offer sealed sensors and data concentrators with a minimum life of 15 (fifteen) years.

The order for purchase, installation commissioning, monitoring and generation of alerts using the On-Board Condition Monitoring Systems shall be placed on one primary firm and two developmental firms. There shall be no dilution in technical standards and requirements for supplying such equipment by the developmental firms.

The offered monitoring systems should be similar to commercially running On-Board Condition Monitoring Systems in at least two railway systems in the world for a continuous period of one year.

The accelerated aging test for such energy harvester based sensor so developed by these firms shall have to be submitted along with the technical bid. Indian Railways may conduct its accelerated aging tests even at a later date after supply and if the equipment fails to qualify in such test, the firm shall be penalized. Non-adherence to this shall be viewed seriously and shall result in severe financial penalty besides making the supplier of such equipment ineligible to participate in any tender of Indian Railways for purchasing equipment/sensor/system to monitor health of any rolling stock component or its systems/sub-systems, for a period of ten years subsequent to detection of such violation. Permission to fit harvester based sensors and data concentrator shall be given only after necessary tests to ascertain the claimed longevity of the sensor and data concentrator have been successfully carried out by Indian Railway to its full satisfaction.

Since the On-Board Condition Monitoring Systems shall have to be fitted on the entire fleet of Indian Railways, bids shall be called in the next phase in which IR is also exploring possibilities of service based payment system. Firm shall have to bear the entire cost of fitment of sensors and allied hardware, creation of back end IT systems for analysis and monitoring, system of generation of alerts and passing on the same to designated officials of Indian Railways. Payment to the supplier shall be made based on the basis of functioning of the system by way of transmitting data to the control centres and correct generation of and transmission of maintenance and other alerts. As a general guide for such a model, a period of 24 hours shall be reckoned as the unit for making payment per day. Any sensor system on vehicle that does not transmit its data for a period of six hours within 24 hours of the day shall
be deemed to be defective and payment for that vehicle shall not be made even if only one sensor out of all the fitted ones is defective or any small defect of any nature including damage caused by track ballast hit, etc. is there in the system. The automatic computer generated log of the functioning of the system shall be used to determine such inoperative vehicles. However, the final call shall be taken at a later date.

27. Sensor Node:

27.1 The wireless sensor node shall contain sensor for vibration and temperature. A single sensor node shall be capable of monitoring condition data from the track, wheel and bearing.

27.2 Sensor node shall be contained in a single robust housing with no external electrical wiring or connections (for sensors powering or communication purposes). This is essential to prevent failure of the system due to damage to such cables or connectors due to factors like ballast hit, vandalism, etc and to ensure fail-safe operation.

27.3 The sensor node should be deployed on or close to the axle box assembly. The fitment arrangement shall first have to be preapproved by the firm from nominated agency of Indian Railways before commencing supplies.

27.3.1 Each sensor node shall have a unique electronic identification number, accessible from the web/NFC/non-contact reader and should be clearly marked on the sensor at the time of fitment.

27.3.2 Sensor node shall be sealed to IP67 standard.

27.3.3 Sensor node housing shall be suitably treated to protect against corrosion.

27.3.4 The WSN and data concentrator shall operate satisfactorily over the range of specified in the operating environment standards mentioned elsewhere in this document.

27.3.5 In order to maintain standardization of equipment, the sensor nodes to be fitted on Coach, freight wagon and locomotives shall be of the same design.

28. On-vehicle Communications Hub (or Data Concentrator):

The Data Concentrator shall incorporate a GSM communication system and GPS location device.

i) The data concentrator shall have an IP 67 rating.

ii) The data transmitted from the data concentrator to the remote storage and processing centre shall be encrypted.

iii) The SIM(s) for cellular communication should be hardwired in the data concentrator itself.

iv) The data concentrator shall comply with all relevant standards as mentioned elsewhere in this document.

29. Software and Algorithms:

i) The data analysis software shall analyse the received sensor data and produce simple actionable alerts for maintenance staff.
ii) The alerts and condition information must be generated automatically without the need for operator intervention.

30. **Track Monitoring System Requirements**

i) The system shall be capable of monitoring the track condition not only for the level of shock and vibration but also the change of these levels with time so as to identify the deterioration trend.

ii) Information shall be presented from management perspective on a map making use of the GPS coordinates of the data so captured to enable maintenance action.

iii) Time based trend shall also be available to be viewed for analysing the level and rate of degradation.

31. **Installation**

i) Sensor node shall typically be installed in less than one man-hour under normal conditions and the required special (proprietary) tooling will be supplied to all depots and maintenance sheds/workshops of the Indian Railways.

ii) Sensor node shall be capable of being fitted to the existing in-service axle bearing assemblies at any time in the lifecycle of the bearing.

iii) Sensor node shall be capable of being fitted to both legacy and **new rolling stock** without the need for buying special bearings or special bearing housings/parts. Minor non-structural modification that does not necessitate removal of bearing cover or opening of bearing can only be permitted.

iv) Sensor node fitment shall not require any change to the existing bearings. The sensor nodes fitment shall be non-intrusive i.e. no requirement to modify the bearing, bearing housing or the bearing cap/casing.

v) Necessary anti-pilferage measures as per international norms shall be built into the installation so as to reduce the danger of theft or vandalism. Indian Railways shall take all necessary precautions to prevent vandalism but Indian Railways cannot be held accountable for any vandalism etc.

vi) **Configuration Diagnostics:** A suitable display and log shall be provided to clearly show the list and health of all sensor nodes attached to each data concentrator. Health check of system shall be done once every 24 hours and log of such a check must be maintained at the data processing centre for later scrutiny if required.

vii) The replacement of any defective WSN or data concentrator shall be possible to be done in less than 30 minutes.

32. **Communications:**

i) Communications to and from the WSN and data concentrator shall be wireless.

ii) The wireless communication from the sensors shall be free from interference by passenger communication systems such as Wi-Fi, Bluetooth and cellular radio, etc.

33. **Front-end presentation at the control room:**
The information for monitored rail assets with sensors shall include but not be limited to:

1. Location (shown on a map and available as a downloaded data file).
2. Speed of the vehicle.
3. Direction of travel of the vehicle.
4. State of health of the monitored asset viz. bearing, wheel and track.
5. Necessary APIs (Application Program Interface) with for this, along with the mapping software, should be developed by the supplier of the system – including obtaining any authorization for use of Geo-mapping data and software. No fees shall be paid by Indian Railways for use of such third party resources like maps, etc.
6. The website shall be hosted on a non-proprietary cloud computing system with scalability, and geographical resilience with adequate redundancy and with mirrored redundant servers at each geographical location. The cloud platform for this purpose shall be a secure and reputed one. The software shall at a later date be required to be shifted onto India-based Cloud services of choice that shall be jointly decided between the supplier and Indian Railways. Cost of shifting over to Cloud in India shall be borne by the supplier of the equipment.
7. The User interface shall have to be preapproved by Indian Railways before the same is deployed. Any changes to firm’s own dashboard shall have to be done by the firm at its own cost to the satisfaction of Indian Railways. The website shall have multi-level query menu as per the demands of Organizational hierarchy – relevant to that particular administrative level of person logging in.

34. Access to Data and Alerts:

34.1 Condition Monitoring information shall be securely accessible on computer, tablet or smartphone from anywhere with broadband internet access.

34.2 Access to the information shall be security protected to a recognised industry standard and shall be of hierarchical in nature depending on the administrative position/privilege of the accessing client.

34.3 The software shall escalate the urgent alerts to successive end users in the event of acknowledge of the alert not being confirmed by its first intended recipient.

34.4 An audit trail shall be available to monitor and record website activity as well as data concentrator logs.

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ANNEXURE - 1

The following standards/equivalent standards or their latest versions shall govern the specifications to which the equipment and systems shall comply with. Whenever there is any ambiguity regarding interpretation of standards, procedures and norms, the stricter of the conflicting norms shall be applicable.

Following standards shall apply as appropriate to the various components, subassemblies and subsystems/systems:

- I. AAR-S-5702 : for testing for effect of working environment conditions.
- II. CMMI-SVC : for service provision
- III. IEC 60571 : for railroad electronics
- IV. IS 2500 : for sampling plans
- V. ISO27001 : for information security management systems
- VI. ISO 9001 : for Quality Management System
- VII. ISO 9421 : guidelines for user interface development
- VIII. NMEA 2000 (IEC61162-3) : for sharing of GPS Data
- IX. TIA-942 : for server uptime
- X. UL60950 : for safety of mains powered equipment.


MECHANICAL STANDARDS:
Bogie mounted equipment must conform to
BS 7608:2014 (fatigue)
EN 13749:2011

Bogie and coach mounted equipment must conform to:
EN 61373:2010 (shock and vibration tests)
EN 12663 (2010) (equipment mounted to vehicle bodies)
EN 45545 (2013) (fire precautions)

ELECTRICAL STANDARDS
EN 62311 and EN 62479 (exposure to EMI)
EN 50121 (electromagnetic compatibility)
R&TTE directive 1999/5/EC
EN 301 489

Power supply: EN 50155 and EN 50121

ENVIRONMENTAL STANDARDS:
EN 50125-1
EN 60529
GENERAL:

- **EN 50126** (Railway Applications - The Specification and Demonstration of Reliability, Availability, maintainability and Safety (RAMS)).

- Equipment to be designed and manufactured under **ISO 9001**.

- **NEMA-3** Compliant enclosure unit.

- Indian Railways Standard (IRS) General Conditions of Contract (GCC) shall prevail while doing interpretation of the various financial, operative and purchase conditions in executing the above-mentioned work.

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This current document is an Expression of Interest (EoI) published by the Government of India, Ministry of Railways to solicit and examine the response of the firms/companies/entities that are supplying or capable of supplying the Goods and Services as per the requirements mentioned in this document. The Government of India, Ministry of Railways reserves the right to accept or reject any and all of the offers or proposals submitted in response to this EoI document.

The Indian Railways, based on the response submitted by the respondents in response to this document, will proceed to finalize the specifications of the Goods and Services on which the EoI is based. After examining the response received in response to this EoI document, the Indian Railways will determine the technical and commercial bids to be issued and will issue them authority to contact the Chief Mechanical Engineer, Northern Railway for necessary discussions.

The timelines and the quantity of units mentioned in this document are subject to change and shall be finalized after discussing the requirements with the Government of India, Ministry of Railways. The decision of the Ministry of Railways, Government of India, is final while considering the bids.

The Indian Railways solicits response from interested Indian and foreign companies/entities who are technically and commercially capable of supplying the Goods and Services as per the requirements mentioned in this document. The respondents are required to give an undertaking to express their willingness to enter into a comprehensive Annual Maintenance and Operation Contract (AMOC) with Indian Railways, based on the response submitted by the respondents in response to this document.

The Indian Railways reserve the right to enter into AMOC by entering into a comprehensive Annual Maintenance and Operation Contract (AMOC) with any Indian or foreign contractor beyond the period of warranty. Comprehensive Warranty of the entire system shall be for a period of five years and shall be renewed in time slabs of five years subsequently as per operational exigencies, technological change, IR’s experience and administrative requirement of Indian Railways.

The respondents are required to indicate the GSN (Goods and Services Name) as Rolling Stock Condition Monitoring System or On Board Rolling Stock Condition Monitoring System or On Board Rolling Stock Condition Monitoring System, or any other technology that may be adopted by Indian Railways.

The Indian Railways reserve rights to change the terms and conditions and/or technical, commercial, or eligibility criteria of this document or to extend the deadline for submitting the responses.

The respondents are also required to submit a detailed technical proposal for the Goods and Services as per the requirements mentioned in this document. The responses will be evaluated based on the technical and commercial merits.

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The Indian Railways reserve the right to reject any and all of the offers or proposals submitted in response to this EoI document.

The Indian Railways reserve the right to accept or reject any and all of the offers or proposals submitted in response to this EoI document.
To facilitate the supplier maintaining and operating the “On Board Rolling Stock Condition Monitoring System” to have a breadth of India. The System should be Maintenance less or Maintenance free system, as much as possible. Considering any parts or any subassemblies that at about 5 to 10 years in India, India, and local manufacturing and local manufacturing is expected.

4.2 Within 2 (two) months of the approval by Indian Railways, 140 numbers of "On Board Rolling Stock Condition Monitoring Systems" for the purpose of this work, the systems as asked for by Indian Railways is assumed to consist of:

(ii) Data concentrator – an electronic unit that is used to collect data from the sensors and transmit it to the control room. The Sensors or the data concentrator shall have “in-built intelligence” to raise alarms on the vehicle itself in case the signals generated by the sensors indicate impending failure of the component.

4.3 After successful fitment & commissioning of the systems as mentioned in para 4.2 above, the supplier will be given a clearance by Indian Railways for fitment as per the contract. The firm shall make supplies of 6800 units in the first phase to IR within 2 (two) months of placement of the order, drawings and specifications indicating functional and technical details of the system shall be submitted by the firm to Railway Board for approval. The fitment drawings shall clearly indicate not only the dimensions and details critical to fitment of individual type of coaches/wagons/locomotives but also technical requirements.

4.4 After successful fitment & commissioning of the systems as mentioned in para 4.3 above, the supplier will be given a clearance by Indian Railways for fitment as per the contract. The firm shall make supplies of 6800 units in the first phase to IR within 2 (two) months of placement of the order, drawings and specifications indicating functional and technical details of the system shall be submitted by the firm to Railway Board for approval. The fitment drawings shall clearly indicate not only the dimensions and details critical to fitment of individual type of coaches/wagons/locomotives but also technical requirements. The system should be Maintenance free as far as possible. Considering any parts or any subassemblies that at about 5 to 10 years in India, India, and local manufacturing and local manufacturing is expected.


data concentrator shall have “in-built intelligence” to raise alarms on the vehicle itself in case the signals generated by the sensors indicate impending failure of the component.

The Sensors or the data concentrator shall have “in-built intelligence” to raise alarms on the vehicle itself in case the signals generated by the sensors indicate impending failure of the component.

2. This type of plan is closely guarded secret from major Japanese and Korean companies. This is done for Indian Companies desiring to Develop this system in India and should be given extra time to develop and implement.
Once the proving trials with 6800 units of the above is completed for a duration of six months to the satisfaction of Indian Railways as per stipulations and technical requirements spelt out in the Draft Schedule of Technical Requirement, the... system is accepted and jointly signed by the firm supplying and operating the systems and Indian Railways.

4.5 After the proving trials are completed in para 4.5 above, permission shall be granted to the firm for supplying, installing and operating the... the same system.

4.6 The respondents shall develop all interfaces required of the... parameter on the coach, wagon and locomotive sub-assemblies and structures, as enclosed at Annexure-1, at their cost and transfer the know-how to IR upon completion of the interface development. Compliance to Technical Requirement Appendix-9.

4.7 Clause Wise Schedule of Technical Requirement Appendix-9)

5.1 The respondents should submit their comments and compliance to the specifications in all respects and not in abstract or cryptic manner. If... Safety, Promoters of India.

5.2 The indigenization plan for the... System offered against this tender should be... within 1 years from Trial completion maybe barred for Indian Companies desiring to Develop this system in India and should be given extra time to develop and implement.

5.3 All inquiries related to the specifications are handled on receipt to the... Two Packet System consisting of "Commercial System" and "Commercial Offer". The two offers shall be enclosed and sealed in individual envelopes superscribed "Technical Bid for On Board Rolling Stock Condition Monitoring System" respectively.

5.4 BIDS FROM RESPONDENTS, WHO HAVE NOT PURCHASED THE BID DOCUMENTS THEMSELVES, BIDS NOT ACCOMPANIED BY BID GUARANTEE AND BIDS FROM AGENTS WITHOUT LETTER OF AUTHORITY FROM THE MANUFACTURERS ARE LIABLE TO BE SUMMARILY REJECTED. BIDS NOT ACCOMPANIED OR SIGNED BID GUARANTY SHALL BE SUMMARILY REJECTED.

5.5 When Notice inviting tender is published and bids are called, the respondents must clearly indicate in the offer various costs under the following heads for commercial evaluation of the tender:

5.6 Indian Railways reserve the right to cancel the Expression of Interest or the tender at any stage without assigning any reason.

5.7 The respondents are hereby advised to study the existing coach, wagon and locomotive design thoroughly and also the Indian Railway’s track structure including its layout in their own interest before submitting their proposal. Any Vendor/Group/Companies not agreeing to local Manufacturing within 1 years from Trial completion maybe barred for Indian Companies desiring to Develop this system in India and should be given extra time to develop and implement.
1. The Unit Cost of the "Behavioral Rolling Stock Condition Monitoring System" for each coach, wagon and locomotive - including installation and commissioning.

2. List of standard procured items and individual prices thereof taken at period during warranty period of three years and post warranty period of seven years thereafter.

3. Annual operational (day to day) and maintenance cost (AMOC) of the Ground Support Facilities respectively during warranty and post warranty period.

4. The feasibility of the product has been scrutinized by the Indian Railways depending upon the finalization of the technology to be adopted.

5. Any “Must-change” items to keep the system running and the periodicity of changing such must-change items. No comments

6. The respondents must specify the “Up-time” of their system. Any non-availability of their system, below their specified “Up-time” shall incur penalties for non-functioning of the system. For this purpose, even if a sub-assembly within a complete unit (one item in a complete unit) is not available as such, it shall be acceptable as long as the complete unit is available as such.

7. Respondent shall also undertake to ensure availability of all requisite spare parts for a minimum period of 15 years after purchase from the date of Letter of Acceptance of the offer when Technical and Commercial Bids are called for.

8. Contractor will also have to give a Performance Guarantee Bond equivalent to 10% of the cost of AMOC at the time of entering into to AMOC.

9. Other General Conditions and stipulations contained in the bid documents followed by Indian Railways when the Bids for purchase of the equipment are called for.
If and when sales tax on order (if placed) becomes payable under law, such payments when made will not be on contractor's account. The Ministry of Railways (Railway Board) will not, however, be responsible for the payment of sales tax paid by the contractor under misapprehension of law.

Firms may indicate the rate at which they are capable of supplying the equipment to Indian Railways. If the progress of manufacture and supply or performance of the material and/or stores during inspection and tests is not considered satisfactory, the Purchaser may, at his option, cancel or modify any order in respect of the material, without any claim for compensation by the contractor, either cancel the order altogether or modify the quantity ordered.

The user interface for using the "On Board Rolling Stock Condition Monitoring System" should be developed by the supplier to the satisfaction of Indian Railways. The supplier shall do necessary customization in the user interface to meet the requirements of Indian Railways at the cost of supplier. This exercise shall be done to mutually acceptable demands from users.
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<td>The 'On Board Condition Monitoring System of Rolling Stock' will enable Predictive Maintenance of coaches, wagons, locomotives and track by meeting the following functionalities:</td>
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<td>a. Improving in reliability of these assets by detecting early signs of deterioration in wheels, wheel bearings and track condition.</td>
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<td>b. Improvement in reliability of these assets by detecting early signs of cracks, alignment, bearings, suspension etc will always reflect in its frequency analysis. Also it is necessary to CORRELATE the frequency analysis to actual situation and other monitoring at different situations and frequencies.</td>
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<td>c. Improving in reliability of these assets by detecting early signs of deterioration in wheels, wheel bearings, track condition.</td>
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<td>d. Reducing maintenance cost of the railway assets by (i) identifying unnecessary maintenance regimes (ii) reduced replacement of &quot;still serviceable&quot; components and (iii) more efficient deployment of maintenance resources.</td>
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<td>e. Ability to Install On Board Condition Monitoring System by simple, automatically generated and actionable alerts.</td>
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<td>f. The proposed system should be capable of coping with vast scale models of varying size and varying systems on board the train packages without affecting due to being robust in scalability to the scale.</td>
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<td>g. Simple and easy operation of the On Board Rolling Stock Condition Monitoring System by simple, automatically generated, actionable alerts.</td>
<td>IONX Complies</td>
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<td>h. Options to enhance the functionality and capability of this system in the future without requiring major replacement of the existing equipment monitoring system.</td>
<td>IONX Complies</td>
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<td>B. Key Requirements</td>
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<td>1. Vendors Qualification: The vendors must be ISO:9001 certified and should have proven experience of delivering these systems in large volume to the rail industry.</td>
<td>IONX Complies Noted and Complied ISO Certified ISO9001:2008</td>
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<td>2. Monitoring the health of the railway assets by 24x7 monitoring of sensors such as temperature sensors etc.</td>
<td>IONX Complies</td>
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<td>3. The proposed system should be capable of coping with vast scale models of varying size and varying systems on board the train packages without affecting due to being robust in scalability to the scale.</td>
<td>IONX Complies</td>
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<td>4. The proposed system should be capable of coping with vast scale models of varying size and varying systems on board the train packages without affecting due to being robust in scalability to the scale.</td>
<td>IONX Complies</td>
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<td>5. The proposed system should be capable of coping with vast scale models of varying size and varying systems on board the train packages without affecting due to being robust in scalability to the scale.</td>
<td>IONX Complies</td>
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<td>6. The proposed system should be capable of coping with vast scale models of varying size and varying systems on board the train packages without affecting due to being robust in scalability to the scale.</td>
<td>IONX Complies</td>
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<td>7. The proposed system should be capable of coping with vast scale models of varying size and varying systems on board the train packages without affecting due to being robust in scalability to the scale.</td>
<td>IONX Complies</td>
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<td>8. The proposed system should be capable of coping with vast scale models of varying size and varying systems on board the train packages without affecting due to being robust in scalability to the scale.</td>
<td>IONX Complies</td>
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</table>
Complies. (1) This limits number of Vendors to a great extent. Furthermore, such organisations may not give best possible solutions considering safety aspects from a much bigger macro-level scenario.

No comments No comments No comments No comments. No comments. No comments. SKF has wide experience in wired vibration sensor technology and analysis. SKF has the remote diagnostic centres across the globe. SKF has completed approximately 1 lakh installations of rolling stock on-board equipment and sensor technology. The installation was of rolling stock in 8 Years. SKF has more than one billion operational Kilometers experience for rolling stock on-board equipment and sensor technology.

2. Deliverables expected from the System:

2.1. System shall be capable of operating effectively with 2G cellular data network coverage. System must be scalable to upgrade to 3G and 4G as and when needed in future without having to replace the complete data concentrator.


2.2. Algorithm for Actionable alert are available, transmitting these alerts via appropriate wireless protocol without GSMA or CDMA is No longer required. These alerts are to be forwarded to the customer, to avoid huge data streaming hence reduces NO. Time interval for data capture will not be required to be done every 5 minutes for this condition.

SKF Complies. Noted and complied. Smart sensor is incorporated. 2G and 3G capabilities. Complies. No comments. Complies. No comments. Complied. However SKF focus is to provide valid data to the customer, to avoid huge data streaming hence reduces NO. Time interval for data capture will not be required to be done every 5 minutes for this condition.

2.3. SVT has the capability to transmit Vibration sensor data, fast or slow depending on the system requirements. For this system the SVT should be able to transmit sensor data continuously at a rate of one measurement per second. The SVT should be able to transmit data continuously for the duration of the test. The SVT should be able to transmit data continuously for the duration of the test.

IONX Complies. Smart sensor is incorporated. 2G and 3G capabilities. Complies. No comments. Complies. No comments. Complied. However IONX is working on an energy harvesting project that will be deployed to extend sensor life.

3. Detailed Evaluation:

3.1. The effectiveness of the wheel and bearing condition monitoring system can be demonstrated to Indian Railways how costs have been reduced with its technology collaborators, has wide experience and ample of expertise for rolling stock and industrial ex.

IONX Complies. IONX recommends reporting deteriorated bearing health in Km. of service not month of service. IONX has found that to reduce maintenance costs, it is necessary to have separate systems for auxiliary, track and other monitoring as it has different vibration algorithms and frequencies.

3.2. The primary focus of INOX is on monitoring freight wagon however its core methods can be applied to passenger coaches or other assets in the Indian railway fleet. Likely differences between freight wagon and coaches will be found in the installation of the device deployment/ However the principle for freight will be the same as for passenger coaches.

IONX Complies. IONX recommends partial application of the IONX Edge platform to indicate the location of the sensors. The edge platform will be able to perform concentration for these systems. However IONX is working on an energy harvesting project that will be deployed to extend sensor life.

3.3. For the requirements of 100000000 meter trolley, of accumulative service operation of wireless (non-battery) sensor nodes.

IONX Complies. IONX recommends partially on-vehicle data processing and concentration from the data concentrator. It should be possible to decode and extract the data stream of the analysis performed on the system by Indian Railways for its own analysis.

IONX Complies. IONX recommends partially on-vehicle data processing and concentration from the data concentrator. It should be possible to decode and extract the data stream of the analysis performed on the system by Indian Railways for its own analysis.

3.4. A testbed must be ready for testing with full power roll test load. The testbed must be ready for testing with full power roll test load.

IONX Complies. IONX recommends partially on-vehicle data processing and concentration from the data concentrator. It should be possible to decode and extract the data stream of the analysis performed on the system by Indian Railways for its own analysis.

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IONX Complies. IONX recommends partially on-vehicle data processing and concentration from the data concentrator. It should be possible to decode and extract the data stream of the analysis performed on the system by Indian Railways for its own analysis.

IONX Complies. IONX recommends partially on-vehicle data processing and concentration from the data concentrator. It should be possible to decode and extract the data stream of the analysis performed on the system by Indian Railways for its own analysis.
IONX sensors work with standard components that can be found in Industry standards and are compliant with various Railways of different countries. The systems can be deployed on different types of rolling stock, including high-speed trains and conventional railcars. The sensor array can be configured to detect a wide range of defects, including those caused by bearing failures, wheel cracks, and other wear and tear issues. The systems are designed to work with the current infrastructure and do not require significant modifications to existing systems. The sensors can be easily deployed and removed without the need for permanent installations.

2.1. The bearing condition scale shall, after appropriate configuration and adjustment, enable the operator to detect defects arising from rolling contact fatigue like wheel cracks, wheel flats, and wheel disc cracks, etc. The system shall consist of a sensor array that can be placed on the wheels, axles, or other critical components of the vehicle. The system shall be able to detect the onset of wear and tear and provide real-time monitoring of the condition of the bearings.

2.2. The training materials and documentation for the system shall include historical examples of bearing, wheel, and track defects that have been monitored successfully, with a correlation between monitored degradation, action taken by the operator, and the condition of the vehicle. The documentation shall be provided in a format that is easy to access and understand, and shall include guidelines for the use of the system.

2.3. The sensor data shall be configured and set up in the system to enable simple, actionable responses. However, the vendor shall take responsibility for identifying the optimal settings for the sensors and the thresholds for alert generation. A fine-tuning of settings may be permitted to the supplier to optimize the performance of the system.

2.4. The bearing condition scale shall be configured to detect defects arising from rolling contact fatigue like wheel cracks, wheel flats, and wheel disc cracks, etc. The system shall consist of a sensor array that can be placed on the wheels, axles, or other critical components of the vehicle. The system shall be able to detect the onset of wear and tear and provide real-time monitoring of the condition of the bearings.

2.5. The training materials and documentation for the system shall include historical examples of bearing, wheel, and track defects that have been monitored successfully, with a correlation between monitored degradation, action taken by the operator, and the condition of the vehicle. The documentation shall be provided in a format that is easy to access and understand, and shall include guidelines for the use of the system.

2.6. The system shall have proven capability of detecting bearing damage occurring within the system (hardware + Sensors + Software alerts), should the on-board software in the system be any reasonable basis for detecting such damage. The system shall be able to detect the onset of wear and tear and provide real-time monitoring of the condition of the bearings.

2.7. The condition monitoring software algorithm shall be configured to detect the onset of wear and tear, and to alert the operator to any changes in the condition of the bearings. The algorithm shall be able to detect the onset of wear and tear and provide real-time monitoring of the condition of the bearings.

2.8. The system shall be configured to detect defects arising from rolling contact fatigue like wheel cracks, wheel flats, and wheel disc cracks, etc. The system shall consist of a sensor array that can be placed on the wheels, axles, or other critical components of the vehicle. The system shall be able to detect the onset of wear and tear and provide real-time monitoring of the condition of the bearings.

2.9. The training materials and documentation for the system shall include historical examples of bearing, wheel, and track defects that have been monitored successfully, with a correlation between monitored degradation, action taken by the operator, and the condition of the vehicle. The documentation shall be provided in a format that is easy to access and understand, and shall include guidelines for the use of the system.

2.10. A data concentrator shall be used to collect information from all the vehicles (cars, coaches, wagons, locomotives). Each data concentrator shall be capable of monitoring data from at least four vehicles – two in its front and two on its rear. The data concentrator shall be able to collect and process data from the sensors in real-time, and to provide alerts to the operator when necessary.

2.11. The system shall have proven capability of detecting bearing damage occurring within the system (hardware + Sensors + Software alerts), should the on-board software in the system be any reasonable basis for detecting such damage. The system shall be able to detect the onset of wear and tear and provide real-time monitoring of the condition of the bearings.

2.12. The system shall have proven capability of detecting bearing damage occurring within the system (hardware + Sensors + Software alerts), should the on-board software in the system be any reasonable basis for detecting such damage. The system shall be able to detect the onset of wear and tear and provide real-time monitoring of the condition of the bearings.

2.13. The system shall have proven capability of detecting bearing damage occurring within the system (hardware + Sensors + Software alerts), should the on-board software in the system be any reasonable basis for detecting such damage. The system shall be able to detect the onset of wear and tear and provide real-time monitoring of the condition of the bearings.

2.14. The bearing condition scale shall, after appropriate configuration and adjustment, enable the operator to detect defects arising from rolling contact fatigue like wheel cracks, wheel flats, and wheel disc cracks, etc. The system shall consist of a sensor array that can be placed on the wheels, axles, or other critical components of the vehicle. The system shall be able to detect the onset of wear and tear and provide real-time monitoring of the condition of the bearings.

2.15. Besides the above mentioned “Zone Bands”, all parameters of the all assets should be possible to be plotted and trended over time/distance to identify the deterioration rate/trend. This should enable prioritisation of maintenance activities, thus enabling reducing damage to track and reducing overall costs.

2.16. The training materials and documentation for the system shall include historical examples of bearing, wheel, and track defects that have been monitored successfully, with a correlation between monitored degradation, action taken by the operator, and the condition of the vehicle. The documentation shall be provided in a format that is easy to access and understand, and shall include guidelines for the use of the system.

2.17. In the event of sensor damage a warning shall be generated to enable the operator to detect defects arising from rolling contact fatigue like wheel cracks, wheel flats, and wheel disc cracks, etc. The system shall consist of a sensor array that can be placed on the wheels, axles, or other critical components of the vehicle. The system shall be able to detect the onset of wear and tear and provide real-time monitoring of the condition of the bearings.

2.18. Alert levels shall be configurable and set by the operator to enable simple, actionable responses. However, the vendor shall take responsibility of identifying the optimal settings for the sensors and the thresholds for alert generation. A fine-tuning of settings may be permitted to the supplier to optimize the performance of the system.

2.19. A system of email alerts and acknowledgements shall be available to communicate with the operator to detect defects arising from rolling contact fatigue like wheel cracks, wheel flats, and wheel disc cracks, etc. The system shall consist of a sensor array that can be placed on the wheels, axles, or other critical components of the vehicle. The system shall be able to detect the onset of wear and tear and provide real-time monitoring of the condition of the bearings.

2.20. The training materials and documentation for the system shall include historical examples of bearing, wheel, and track defects that have been monitored successfully, with a correlation between monitored degradation, action taken by the operator, and the condition of the vehicle. The documentation shall be provided in a format that is easy to access and understand, and shall include guidelines for the use of the system.

2.21. The sensor data shall be configured and set up in the system to enable simple, actionable responses. However, the vendor shall take responsibility of identifying the optimal settings for the sensors and the thresholds for alert generation. A fine-tuning of settings may be permitted to the supplier to optimize the performance of the system.

2.22. The training materials and documentation for the system shall include historical examples of bearing, wheel, and track defects that have been monitored successfully, with a correlation between monitored degradation, action taken by the operator, and the condition of the vehicle. The documentation shall be provided in a format that is easy to access and understand, and shall include guidelines for the use of the system.

2.23. The sensor data shall be configured and set up in the system to enable simple, actionable responses. However, the vendor shall take responsibility of identifying the optimal settings for the sensors and the thresholds for alert generation. A fine-tuning of settings may be permitted to the supplier to optimize the performance of the system.

2.24. The training materials and documentation for the system shall include historical examples of bearing, wheel, and track defects that have been monitored successfully, with a correlation between monitored degradation, action taken by the operator, and the condition of the vehicle. The documentation shall be provided in a format that is easy to access and understand, and shall include guidelines for the use of the system.
The selection of sensor nodes is a critical component in the overall system design. The system must be configured to ensure compatibility with various data concentrators and programming systems. The selection and configuration of the system are essential for ensuring reliability, availability, maintainability, and safety (RAMS).

2.23 The only configuration required for sensor nodes shall be the sensor node serial number with railway coach/wagon/locomotive number.

3. System Configuration:

3.4 Analysis Software. IONX complies. No comments. Partially complies. No comments. Complies. Only mentioned about sensor node serial number. Housing is IP 65, IP 67 etc.

4. Sensing Technologies:

4.1 The sensor node shall include sensors for both temperature and vibration monitoring. A single sensor node shall be capable of monitoring condition data from the track, wheel and bearing (to the axle box assembly) as well as data from the transponder. The sensor node shall be mounted close to the axle box by the suitable clamping in a custom made rugged enclosure and of IP68 grade to work in harsh and rugged environment.

4.4.2 Lower limit of detection 0.025 'g' RMS IONX does not comply. IONX recommends to mount the sensor directly on the axle box using the bolts for the cover. Sensor should be placed close to loaded zone of bearing (within 10 to 2 O’Clock position).

4.4.5 Sampling Data rate of at least 1000Hz IONX complies. Noted. Complies. No comments. Continuous (32 hz to 1,000,000 hz). Sampling frequency: 1000Hz. It is not enough. Fourier transform is limited up to a certain frequency. Continuous 32Hz to 1,000,000 Hz. Continuous (32 hz to 1,000,000 hz)....


8. Sensor Compatibility:

1. The only standard required for sensor nodes shall be the sensor node serial number with railway coach/wagon/locomotive number. The sensor node shall be configured to ensure compatibility with various data concentrators and programming systems. The selection and configuration of the system are essential for ensuring reliability, availability, maintainability, and safety (RAMS).
4.4.18. Sensor node housing shall be surface treated to protect against corrosion.

4.4.19. The bogie mounted sensor nodes mounted on the trains shall operate satisfactorily over the range of -10°C to +85°C.

4.4.20. Sensor node shall either communicate on an unlicensed frequency, or in a frequency separate from other train systems.

5. On Train Communications Hub (or Data Concentrator):

5.1. The Data Concentrator shall incorporate a GPS location device. IONX complies in that the device is designed to wirelessly transmit information so the ports are internal to the data concentrator. In future models the ports can be made external if this is important to Indian Railway requirements.

5.2. A single data concentrator shall be capable of receiving sensor data for backup or as a main source of power along with energy harvesting facilities available. Other specification not mentioned.

5.3. The data concentrator shall be powered by Industry Standard 24V or 48V and shall have a continuous output power of 100W. The sensor node shall have a continuous output power of 20W. The data concentrator shall be able to communicate with Industry Standard 24V and 48V systems.

5.4. The data concentrator shall have one RS232/RS485 and one USB port. IONX complies in that the device is designed to wirelessly transmit information so the ports are internal to the data concentrator. In future models the ports can be made external if this is important to Indian Railway requirements.

5.5. Continuous data streaming output that is compatible with alternative communication interfaces. IONX recommends using a digital enabled SIM card to connect the data concentrator to OBCMS central server. This allows data concentrator to transfer data to server and to receive configuration commands from the central server. Indian railways do not support dedicated circuits and few railroads do not allow internet access.

5.5.1. Power indicator. IONX complies in that the device is designed to wirelessly transmit information so the ports are internal to the data concentrator. In future models the ports can be made external if this is important to Indian Railway requirements.

5.5.2. Battery status. IONX complies in that the device is designed to wirelessly transmit information so the ports are internal to the data concentrator. In future models the ports can be made external if this is important to Indian Railway requirements.

5.5.3. Activity ("Awake/Asleep"). IONX complies in that the device is designed to wirelessly transmit information so the ports are internal to the data concentrator. In future models the ports can be made external if this is important to Indian Railway requirements.
| 5.10.4 | GSM/GPRS connection. IONX does not comply because Noted Complies No comments No comments No comments. Eliminates redundant hardware elements such as GPS, GPRS modules. |
| 6. | A set of indicators showing mobile data connection health and signal strength. IONX Complies Noted No comments No comments No comments. Complies. No comments Complied, smart sensor Complies. No comments |
| 9. | Track Monitoring System Requirements IONX Complies. (A research programme in place for track monitoring with preliminary algorithms based on field data) Information on shock and impact the level of shock and vibration but also the change of these levels with time so as to identify the deterioration trend. |
| 9. | Track Monitoring System Requirements | IONX Complies Noted Complies No comments No comments No comments. Complies. No comments Noted and Complied Complies. No comments. Complies. No comments |
| 9. | Track Monitoring System Requirements | IONX Complies Noted Complies No comments No comments No comments. Complies. No comments Noted and Complied Complies. No comments. Complies. No comments |
| 9. | Track Monitoring System Requirements | IONX Complies Noted Complies No comments No comments No comments. Complies. No comments Noted and Complied Complies. No comments. Complies. No comments |

**Table:**

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<tr>
<th>Requirement</th>
<th>IONX Complies</th>
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<tr>
<td>5.10.4 GSM/GPRS connection</td>
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<td>No comments</td>
<td>No comments</td>
<td>GSM/GPRS module has no approval on reach and every OPEX service will be provided by OPEX</td>
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<td>6. A set of indicators showing mobile data connection health and signal strength at point of reception</td>
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<td>7. Software and Algorithms</td>
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<td>9. Track Monitoring System Requirements</td>
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<td>Complies</td>
<td>No comments</td>
<td>No comments</td>
<td>Complied, smart sensor</td>
<td>Complies</td>
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</table>
iv. The resolution shall depend on the number of wheels monitored and the frequency of service but shall be capable of daily updates subject to train passage frequency.

v. The system shall provide the capability of viewing the vibration data as a function of time and as a function of distance so that the customer can see where the damage is and how it is evolving with time.

vi. The system shall be capable of accurately identifying which of the two service axle bearing assemblies at any time in the lifecycle of the bearing.

vii. Necessary anti-pilferage measures as per international norms shall be built into the installation so as to reduce the danger of theft or vandalism.

viii. Data concentrator should be designed as vandal proof to international standards and should be mounted on freight cars in a position ensured.

a. Sensor node shall comply with the following specifications for resistance to vibration and shock (both as applied to equipment mounted above and below rail level as well as applied to equipment mounted between rail levels).

   - Sensor node shall comply with IP68 specifications. IONX Complies Noted Complies No comments Not Complies, But IP 67 Mentioned.
   - Sensor node shall comply with the following test specifications for resistance to vibration and shock (both as applied to equipment mounted above and below rail level as well as applied to equipment mounted between rail levels).
     - GM/RT 2100 IONX tests to AAR S5702 standard and will test to this standard too
     - EN61373:2010 as applied to equipment mounted above and below rail level
     - EN50125-1:1999 (or the latest edition where applicable)

b. Communications:

   - Data compression and filtering will be part of the “on train” processing.
     - Noise conditioning and filtering will be part of the “on train” processing.
     - Sensor information shall be available as simple coloured status diagrams, tables of numerical values indicating alert, equipment health and diagnostic information, and graphical display of historical condition information allowing comparison on all common Internet browsers.
<table>
<thead>
<tr>
<th>No</th>
<th>Description</th>
<th>Noted</th>
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<td>Condition as indicated by vibration (monitored axles must include accelerometers)</td>
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<td>6.</td>
<td>Necessity APIs (IONX will work with Indian Railway to meet this requirement)</td>
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<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
</tr>
<tr>
<td>7.</td>
<td>Website shall display the train sets with the correct</td>
<td>Noted</td>
<td>Complies</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
</tr>
<tr>
<td>8.</td>
<td>Access to Data and Alerts:</td>
<td>Noted</td>
<td>Complies</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
</tr>
<tr>
<td>9.</td>
<td>Email/SMS Text alerts shall be provided when problems arise (with provision to provide text alerts to cellular phones)</td>
<td>Noted</td>
<td>Complies</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
</tr>
<tr>
<td>10.</td>
<td>Safety in design of system:</td>
<td>Noted</td>
<td>Complies</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
</tr>
<tr>
<td>11.</td>
<td>Scalability and universality of the Onboard Monitoring System:</td>
<td>Noted</td>
<td>Complies</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
</tr>
<tr>
<td>12.</td>
<td>Data concentrator shall be modular and should be scalable to accept connection of additional sensors. For the protocol to be used for communication of the Data concentrator, kindly refer to clause 5.5.4. Apart from the hardware connectivity, software handshaking with sensors must also be ensured.</td>
<td>Noted</td>
<td>Complies</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
</tr>
<tr>
<td>13.</td>
<td>B) Temperature of internal air temperature is available (IONX can develop a water tank level monitoring sensor)</td>
<td>Noted</td>
<td>Complies</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
</tr>
<tr>
<td>14.</td>
<td>Additional input device in wireless fashion to the data concentrator</td>
<td>Noted</td>
<td>Complies</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
</tr>
<tr>
<td>15.</td>
<td>Additional input device in wireless fashion to the data concentrator</td>
<td>Noted</td>
<td>Complies</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
</tr>
<tr>
<td>16.</td>
<td>System shall be capable of being scaled-up in future, with simple addition of sensors by connecting them to data concentrator, to monitor the following parameters. The list of parameters is not exhaustive and is not limited to only the ones mentioned in Annexure - 1</td>
<td>Noted</td>
<td>Complies</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
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<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
</tr>
<tr>
<td>17.</td>
<td>ANNEXURE – 1</td>
<td>Noted</td>
<td>Complies</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
<td>No comments</td>
</tr>
</tbody>
</table>

**Notes:**
- “Noted” indicates that the requirement is noted but not necessarily met.
- “Complies” indicates that the requirement is met.
- “No comments” indicates that there are no comments on the requirement.
- “Pending” indicates that the requirement is pending.
- “No current available” indicates that the requirement is not currently available.

Please note that some requirements may have specific notes or additional details not shown in the table.
2. Additional parameters to be monitored in Freight Car (Wagon):

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Brake system's brake piston travel. IONX Complies by measuring piston</td>
<td>Approved and Implemented</td>
</tr>
<tr>
<td>force rather than piston travel.</td>
<td></td>
</tr>
<tr>
<td>b) Brake cylinder pressure. IONX has pressure sensor in development that</td>
<td>Approved and Implemented</td>
</tr>
<tr>
<td>will work for this application.</td>
<td></td>
</tr>
<tr>
<td>c) Brake pipe and feed pipe pressure. IONX has pressure sensor in</td>
<td>Approved and Implemented</td>
</tr>
<tr>
<td>development that will work for this application.</td>
<td></td>
</tr>
<tr>
<td>d) State of wagon – whether Empty or Loaded. IONX Complies</td>
<td>Approved and Implemented</td>
</tr>
<tr>
<td>e) Additional wheel damage differentiation such as flange wear, out-of-</td>
<td>Approved and Implemented</td>
</tr>
<tr>
<td>round, etc.</td>
<td></td>
</tr>
</tbody>
</table>

3. Additional parameters to be monitored in Locomotive:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Brake system's brake piston travel. IONX Complies by measuring piston</td>
<td>Approved and Implemented</td>
</tr>
<tr>
<td>force rather than piston travel.</td>
<td></td>
</tr>
<tr>
<td>b) Brake cylinder pressure. IONX has pressure sensor in development that</td>
<td>Approved and Implemented</td>
</tr>
<tr>
<td>will work for this application.</td>
<td></td>
</tr>
<tr>
<td>c) Brake pipe and feed pipe pressure. IONX has pressure sensor in</td>
<td>Approved and Implemented</td>
</tr>
<tr>
<td>development that will work for this application.</td>
<td></td>
</tr>
<tr>
<td>d) State of wagon – whether Empty or Loaded. IONX Complies</td>
<td>Approved and Implemented</td>
</tr>
<tr>
<td>e) Additional wheel damage differentiation such as flange wear, out-of-</td>
<td>Approved and Implemented</td>
</tr>
<tr>
<td>round, etc.</td>
<td></td>
</tr>
</tbody>
</table>