PART- 2
(Locomotive Management System and Server)
of
Technical Specification
of
Data Retrieval and Analytic System
for
Three Phase Electric Locomotives

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Technical Specification of Data Retrieval and Analytic System for Three Phase Electric Locomotives	PREP. & CHECKED BY SSE/D&D	D & D CENTRE CHITTARANJAN LOCOMOTIVE WORKS WEST BENGAL, INDIA NO: CLW/C-D&D/ES/3/0554, Part 2							
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Brief Description

This is a part of a four-part specification numbered 0 to 3 describing the requirements for setting up systems for Data retrieval and Analytics system for Three Phase Electric locomotives (DRAS).

FOREWORD

DRAS Enables remote monitoring of Electrical Locomotives. It creates a complete IT enabled ecosystem which provides a platform for remotely monitoring health and operational characteristics of electric locomotives.

It also enables monitoring of performance of crew and helps in identifying lapses. This will enable focused counselling and training of such crew, who are prone to unsafe working.

DRAS also monitors condition of locomotive and makes preventive and predictive maintenance of locomotives more effective. DRAS monitors shutting down of locomotives when idle for a long time and generates management information to ensure this.

The complete specification for DRAS is split over four parts numbered from 0 to 3. Together these parts specify the requirements for setting up the complete system.

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1. **Introduction**

   This document is part of set of documents specifying equipment and services for the deployment of DRAS. This document is one of the set of 4 (four) documents that together comprise of the complete specification for DRAS.

2. **Scope &Objective:**

   This document describes the requirements of locomotive management system (LMS) consisting of backend servers, databases, analysis programmes and internet portal based data presentation using the Situation Awareness Display System (SADS) concept. This document defines the requirements for setting up, operate and maintain LMS and server mentioned in this part of specification at IR premises for implementation of DRAS.

3. **Abbreviations & Keywords:** Kindly refer to part 0 of the specification

4. **Keywords:** Kindly refer to part 0 of the specification

5. **Brief description of the system/equipment/components:**

   Locomotive Management System (LMS): LMS consists of service provision for the DRAS system that aims to provide services for the following: Logging, maintenance, analysis and presentation of data logged on the locomotive control computers and relayed to server for use by the operations and maintenance personnel of Indian Railways. This service provision shall require internet accessible server cluster, operational 24x7. This system shall collect the data transmitted by the locomotive ORMS, compile the same in suitable databases and also convert and maintain this database file (like NI-TDMS files). The data in databases shall be available over the internet through dynamic web pages. The TDMS files shall be provided via a FTP interface. This captured data shall be presented via web based applications for use by maintenance sheds and power control organization for management and maintenance planning of locomotives. Thus LMS and server is a service provision that shall provide following required services:

   5.1. Setting up, operation and maintenance of web portal running on servers based at an internet data centre for period of 5 years from the start of contract. The vendor shall also provide quote for 3 year AMC during tender. The required space and electricity shall be provided by contractor i.e. IR.

6. **General requirements**

   The following general conditions apply to all equipment that shall be supplied against this specification.

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6.1. Quality of equipment / software
- All equipment shall be from reputed manufacturers and shall be of good quality.
- All software shall be developed with proper documentation and be thoroughly tested before deployment.

6.2. Requirement for service provider
The LMS system with server shall be developed, deployed and maintained by IR through this part of specification.

6.3. Duration of contract
Since a considerable effort and experience are required for developing, testing and deployment, the duration of contract for setup, operate and maintain LMS and server shall for 5 years warranty with AMC for next 03 years.

6.4. End of life/termination of contract
The equipment / service provider shall handover the following at the time of:
- Source of all equipment and ordering specifications.
- All software source code and configuration files.
- Details of header files, libraries and compilers used for creation of software.
- Full rights to ownership of the code and details provided.

7. Functional Requirements:
The functional requirements of the LMS, server and the hardware configuration are described for each component in the following paragraphs:

7.1. Web portal for LMS
This web portal shall be hosted on clustered high availability servers located in an data centre and shall be available on the internet on a fixed IP address with a registered domain name. The web portal setup shall be compliant to TIA 942 Tier III or better.

7.1.1. Ownership of data All data collected on the internet portal servers shall be the property of the Indian Railways. The service provider shall seek written permission for using this data for any purpose other than that specified here.

7.1.2. Ownership of programmes and configuration files All application packages, configuration files etc. required for operation of the internet portal shall be the property of Indian Railways. The service provider shall provide fully documented

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source code for all proprietary applications developed by them for the implementation of features required on the web portals and its clients.

7.1.3. Selection of application packages It is suggested as a general guideline that the application packages that also have open source licensed copies be selected over proprietary packages. The preferred server software stack for web portal shall be based on open source technology using Linux, Apache, Phyton, MySQL and PHP. Other application software for data mining, presentation, security etc. shall also be selected similarly. The software shall be highly scalable to support growing number of locomotives and clients. The service provider must propose with detailed justification the selection of software packages for the internet portal and obtain an approval for the same from CLW.

7.1.4. Selection of hardware platform: The service provider shall select a suitable hardware platform for creation of web portal. It is recommended to use scalable computing clusters for fault tolerance and expandability. The service provider must propose with detailed justification the selection of hardware for the internet portal and obtain an approval for the same from CLW.

7.2. Access to servers and security The following features shall be provided for securing and accessing the web portal and its servers:

7.2.1. Access to the servers through internet All access to the server shall be secure. A two factor authentication system shall be used for authentication and authorization. The server shall also have atleast three user categories i.e.
- o Normal Users: Able to access all reports and data but no changes are permitted
- o Power users: Able to access all reports and data and modify parameters and reporting modules.
- o Administrators: All functions of power users with additional ability to add/ delete users.

Super user accounts shall be retained by the service provider for the system maintenance

7.2.2. Physical security of server and data The vendor shall ensure that servers are physically protected from unauthorised access. The server shall be secured with biometric security and all physical access shall be logged. There shall be adequate provisions to ensure that data available on the server is available only to authorised personnel and the access by all shall be logged for traceability.

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7.3. **Reception conversion, storage and management of ORMS data** The servers shall be capable of receiving the data transmitted by the locomotive ORMS. The server systems shall be capable simultaneous reception of locomotive data and meet the performance metrics for the same. The data received from the locomotives shall be checked and then converted and stored in two different formats:

7.3.1. **Data on RDBMS Server** The data shall be stored on RDBMS. The data on the RDBMS server shall be available through ODBC interface and also via predefined dynamic web pages.

7.3.2. **Data stored in NI TDMS format** The data shall be converted and stored as National Instruments TDMS (Technical Data Management Streaming) file format. These files shall be prepared on per locomotive per day basis i.e. for a given locomotive number; one file shall be kept for each day. A new file shall be opened when the locomotive is standstill. (Incase a locomotive is in motion at 00:00 HRS, data shall be recorded in the previous day's file till such time the locomotive comes to a stop.) These files shall be named as per the following naming template

File name template	NNNNN-YYYYMMDD.tdms
NNNNN	5 digit locomotive number
YYYY	Year in 4 digits
MM	Month of year in two digits
DD	Day of month in two digits

The TDMS files offer three levels of hierarchy – root, group and channel as shown in the figure alongside. The file format also allows the logged data to be stored alongwith the meta-data which can contain properties and names of data channels.   These features shall be used to document the captured data extensively and also to internally organize the file. The internal organization shall be as per the following overall plan:

- ○ Root property fields shall be used to store information like locomotive number and date, train details as entered by the crew.
- ○ All data channels shall be named with names / abbreviations that make the channel name unique and easy to understand.
- ○ The following top level groups shall be used to organize data channels
  - ■ **Traction Converter:** Shall contain all channels pertaining to the Traction systems.
  - ■ **Auxiliary Converter:** Shall contain all channels pertaining to the Auxiliary systems.
  - ■ **Hotel Load Converter:** Shall contain all channels pertaining to the HOG systems.

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- **Pneumatic system**: Shall contain data related to compressors and pneumatic brake equipment.
- **Low Voltage Electrics**: All parameters of equipment associated with low voltages on board.
- **High Voltage Electrics**: Parameters of equipment in the high voltage equipment.
- **Vehicle Control Unit**: Parameters related to whole locomotive like speed, TM speed, vehicle speed etc.
- **General / Misc Parameters**: Parameters that could not be included under the other groupings.
- **Data Pack**: This group shall contain the data captured for the different data packs i.e. Event Recorder Data Pack, Steady State Data Pack, Cumulative Data Pack and Fault data pack

All the TDMS format files generated shall be stored in folders by locomotive number. These files shall be available for download via FTP.

7.3.3. Retention period of data Data shall be stored for a period of four and half years for each locomotive. Older data shall be archived for a period of six months and if no request is received this shall be automatically purged without any further confirmation. The data shall be moved from active to archive and purging of archive shall be done once a month on fixed date. It is estimated with prospective ORMS vendors that a three-phase locomotive (ORMS) will generate around 40MB of data per day to be stored in server. Presently there are more than 7000 Three Phase electric locomotives in service. In next two years 3000 additional three phase electric locos are going to be added in service. Hence server shall have capacity to handle data of 10,000 Locos. Further provisions shall be provided in the server so that capacity can be augmented in future to cover more number of locos in later stage.

7.4. Analysis and presentation of data acquired The server shall have predefined queries for analysis of the logged data. The server shall also support user defined queries with options to save the same as pre-defined queries. The results of the queries shall be published on the website in a tabular format, graphs and also links shall be provided to download the data into a MS Excel readable file. The data shall be presented to the users in the form of reports and data visualization in charts and graphs.

7.4.1. Reports

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7.4.1.1. Canned reports The portal shall have canned (predefined) reports that can be accessed by the users on demand. These reports shall be displayed in a separate new window and options for printing, emailing and exporting (to MS Excel readable file) the same shall be provided. The following canned reports shall be provided

● Electric/Diesel Shed MIS Report
● Divisional Power Control MIS Report
● Zonal Power Control MIS Report
● The data and the format for presentation of these reports shall be jointly fixed by CLW and the service provider.

7.4.1.2. User defined reports The portal shall have options for users to create their own reports. It shall be possible to save these visualizations as canned reports in the user's login.

7.4.2. Data visualization The portal shall offer feature of data visualization. This feature shall provide the users with the ability to select data in a SELECT query and display the same in two different modes for visualization i.e. time trend visualization and aggregate data visualization. The Three modes of data visualization are detailed below.

7.4.2.1. Time trend visualization This feature shall allow the user to select upto six channels of data which shall be presented as a time trend graph. It shall be possible to fix Lower Control Limit (LCL) and Upper Control Limit (UCL) on any one parameter out of fifteen and the software shall indicate areas for where the given parameter falls out of these limits. The remaining fifteen time trends shall also be indicated in this graph using suitable scale. It shall be possible to download the selected data in MS Excel readable file for offline data analysis. It shall be possible to save these visualizations as canned visualization in the user's login.

7.4.2.2. Visualization of trends with selection of independent parameter The system shall also have the provision to permit users to design their own custom visualization. It shall be possible to save these custom reports as canned reports for repeated use The feature shall permit selecting upto six parameters together for creation of data table and graphs. It shall also have feature permitting selection of any logged parameter as the independent parameter on the X axis. It shall be possible to download data into an MS Excel readable file.

7.4.2.3. Aggregate data visualization This feature shall allow the user to select upto two channels of data which shall be presented as aggregate data charts like

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scatter plot, population distribution, Pareto chart. It shall be possible to download the selected data in MS Excel readable file for offline data analysis. It shall be possible to save these visualizations as canned visualization in the user's login.

7.4.3. **Canned visualizations** Time trends of parameters as defined below shall be provided as canned visualization i.e. visualization that are ready to use at a press of a button. These graphs shall contain the data table and graphs depicting the time trend. The time period for displaying the trends shall normally be two months however the user shall have the option for changing the same. These trends shall be displayed for the parameters recorded by system. eg.

- Converter parameters
    - Traction Converter Parameters
    - Auxiliary Converter Parameters
    - Hotel Load Converter Parameters
    - Transformer Oil pressure and temperature.
    - Coolant pressure and temperature.
    - Air pressure of Auxiliary blower machines like TMB, OCB and MRB.
- Electrical Parameters
    - VCB and panto status with pressure values
    - Throttle handle position, Line & drive side voltage & current with temperature and firing signal values.
    - Low Voltage Electrical parameters
    - High Voltage Electrical parameters
    - Filter Circuit Electrical Parameters
    - Battery voltage while charging and also while when not charging
    - Max differential current recorded between all traction motors. (Max of all samples aggregated to one reading per hour)
    - Fire detection Unit, Flasher light, Cab AC status
- Pneumatic Parameters
    - Pneumatic parameters comprising MR, BP, BC, AFI and FP pressure
    - Compressor and Unloader load / unload events with time duration
- Journal of data pack occurrences along with the option to download the relevant data pack
- Any other parameters which will be mutually decided between IR and Vendor

7.4.4. **Presentation of data** Information shall be presented by the data centre servers over the internet using the concept of Situation Aware Display System (SADS). The basic underlying concept shall be: "Overview first, zoom and filter, then

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details on demand." The SADS requirements are detailed in another part of this specification. The data centre servers must ensure that the information is generated and presented as required by the SADS clients.

7.5. Geo-fencing The LMS provider shall develop suitable applications and create databases to correctly identify the location of the locomotives. These applications shall be based on the concept of geo-fencing. The following shall be identifiable entities provided in under geo-fencing

- Railway Divisional boundaries
- Railway Zonal Boundaries
- Electric/Diesel Shed Boundaries
- Every railway station

The geo-fencing application and its information store shall be developed in such a manner that it shall be possible to continually refine and add further details in future. In order to kick start the system the geo-fencing application system shall be developed in the sequence given above.

7.6. Scalability requirement The servers shall be designed for expandability. Basically it is seen that the data for each loco comprises of Approximately 40 MB for one day at @ sample rate of 1 secs. Thus, in initial phase 10,000 locos is planned which will increase in phase manner. Thus the scope of supply for server should be kept in such a way that minimum four and half year data is archived. Also, the server should have the facility of extendibility which can be enhanced in future and for this purpose Solid state device would be preferred.

7.7. Alerts Generation: On LMS web portal, provision of alter configuration shall be provided. The user shall be able to select the loco parameters, system and subsystem and thereafter able to set a alert criteria. On occurrence of set criteria alters shall be generated on LMS and suitable SMS and/or email shall be sent to predefined phone numbers and email IDs. Option shall be given for entering phone numbers and email IDs during creation of alerts. Details scheme shall be submitted to CLW during design approval stage.

7.8. Artificial intelligence (AI) and Machine Learning (ML) : One of the major objective of DRAS system is to set up IT enabled system that can cater requirement of preventive and predictive maintenance of locomotives to make locomotive more robust and reliable. For this the data collected through DRAS system shall be gone though health monitoring, data analytics and other algorithms, AI system and ML

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systems to predict failures of systems and sub-systems. All these algorithms, AI and ML algorithms shall be hosted via application running on server. The results, reports, customisable formats/reports will be made available to IR for their fleet management decisions. The vendor should keep this in consideration while deciding the requirement and capacity of server and LMS web portal. The LMS and server shall have adequate computation capacity to handle requirement of health monitoring, data analytics and other algorithms, AI system and ML. The required details shall be provided by vendor during design approval stage to CLW. The vendor may collaborate with experts available in this domain, but final responsibility of performance shall be on vendor taking the contract.

7.9. Technical support: Vendor should deploy two manpower trained to operate and maintain the LMS and server at desired location of IR where complete system shall setup for the duration of contract. In addition of above, The vendor shall also provide 24x7 technical support for maintenance and management of LMS systems and server for its healthy working through:
- o Telephone via a toll free number
- o Video conferencing
- o Email
- o Physical visits

The technical support shall have a documented and advertised issue tracking system (ITS) which shall be fully automated and shall log and issue tickets for issues reported through any of the media above.

The details of deployed manpower, their qualification, expertise and experience of handling such IT enabled system including but not limited to AI and ML shall be submitted to contractor in the tender document.

8. **Technical requirements**
   8.1. ISO 9001 Certificate The service provider must be certified to ISO 9001.
   8.2. ISO 27000 certificate The service provider shall be certified as conformant to **ISMS ISO27001**. The firm providing the service shall further ensure that the new facilities setup for handling the LMS shall be included in the scope of certification within 6 months from the date of setting up the services.
   8.3. CMMI Level 3 qualification Service provider for the services requirement described in this document shall be assessed to **CMMI Level 3** or better.
   8.4. Uptime requirements for internet portal The internet portal for LTMS shall be compliant to **TIA-942 Tier III or latest**.

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8.5. Guidelines for user interfaces The user interfaces shall be developed using the guidelines contained in **ISO 9421**.

8.6. Performance indices for service provision A separate list indicating the required performance indices for to be provided in this specification part 0. Payments shall be governed by performance.

8.7. Power supply All mains powered equipment shall be suitable to operate on Indian utility supply

9. **Applicable drawings**
   None

10. **Safety Requirements** The equipment / systems shall follow the following safety guidelines: All mains powered equipment shall be compliant to UL 60950 for electrical safety.

11. **Environmental / climatic requirements** All equipment (if any) supplied by the service provider, under the requirements mentioned in this document shall be suitable for use in non-air-conditioned office spaces

12. **Referred standards** Kindly refer part 0 of the specification.

13. **Maintenance and diagnostic aid** The service provider shall explicit document and requirements and function of the any special tools and diagnostic aids required. All such tools and aids shall be provided by the service provider.

14. **Documents to be supplied by the equipment supplier** The service provider shall initially provide documents containing concept overview of LMS and its clients. This document shall be approved and filed at CLW.
    The following documents shall be provided and updated as required by the service provider during the duration of the contract.
    - All software developed shall be documented and provided in source code in soft copies.
    - All configuration files shall be documented and provided in soft copy.

15. **Approval for Design** Kindly refer relevant part of the specification.

16. **Accessories** List of accessories required shall be specified by the vendor.

17. **Training** As listed in the relevant part of the specification. Further The supplier shall arrange for training of Indian Railway personnel in various loco sheds and training schools

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regarding maintenance & trouble shooting of the system supplied. The supplier will provide detailed technical write-up to all the trainees. The frequency and man-hours of training shall be mutually decided by IR and Contractor

18. **Tests and verification** All equipment and software shall be tested for functional working before deployment. Performance tests shall be conducted using the third party APM tools. These tests and verification shall be conducted by CLW or by any other third party. A scheme for testing shall be jointly prepared by CLW and vendor for conducting the tests.

19. **Types of tests**

The following different types of tests shall be conducted at different stages verifying compliance of functional requirements and meeting the performance requirements

19.1. **Proof of concept** The proof of concept shall be tested at the initial stages to prove out the concept of LMS. This shall be done by demonstrating the setup with limited users and simulated data. The complete details of deployment shall be documented and same approved by CLW for further action.

19.2. **Functional test** This test shall be conducted after deployment of LMS servers. This test shall be conducted for checking the compliance to the functional requirements specified in the set of specifications and developed during the proof of concept tests.

19.3. **Load test** Server load test shall be conducted by enabling data transfer from locomotives already equipped with DRAS' ORMS and simulating additional loads of locomotives and clients on the local area network. The load test parameters shall be monitored using third part APM tools. The application performance parameters to be tested shall be monitored as described in part-0 of this specification. These load tests shall be conducted as required for determining stability of the server systems and ability to meet the performance specification.

19.4. **Routine tests** The routine test shall be conducted whenever a new locomotive is to be added to the list of locomotives monitored by the DRAS system. This test shall consist of functional check for all features for the particular locomotive to verify the system is working and operational.

19.5. **Makers test** All items that are outsourced by the equipment manufacturer shall be indicated so. The type and extent of control that has been exercised shall be provided with proper documentation. The manufacturers (of the outsourced sub-assembly) test certificates shall be provided.

20. **Painting labelling and marking** The equipment shall be appropriately painted for aesthetics and protection. The parts, connector ports, mounting points etc shall be clearly marked in a manner that these are easily readable and remain legible over the lifetime of

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the equipment. ID plate Name of Component, Make, Sl. No, Date of Manufacture, Ratings shall be provided on all assemblies/subassemblies..

21. **Packing and delivery** The equipment consists of sensitive and fragile electronic systems. These should be packed with precautions required to prevent damage in transit. All requirements of IRS conditions for packaging and delivery shall be applicable

22. **Guarantee / Warrantee:** Kindly refer part 0 of the specification

23. **Intellectual Property Rights** Kindly refer part 0 of the specification**.**

24. **Information to be supplied by supplier** The equipment manufacturer must provide to CLW, the complete details of algorithms, design and drawings required for the purpose of evaluation of the design and its functionality. Operations and maintenance manuals, spare parts catalog shall be supplied to all users as required in both hard and soft (PDF) copies..

25. **Information to be supplied by purchaser** Required design details and layouts of room to house the mock-up server and other equipment shall be provided by the purchaser.

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