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***RDSO -SPN-RE-MVIS-2018 (Draft)***

**Machine Vision Based Inspection System for Rolling Stock**

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## 4.0 Introduction: -

Current practice for preventive maintenance inspections of rolling stock over IR is largely based on manual inspection which is either trackside or pit examination of stock in stationary or slow moving condition. Visual inspections are performed by trained manpower either in a pit or trackside location but remains dependent on individual judgment. Besides, the stationary inspection deprives the maintenance staff of significant information of dynamic behavior of the vehicle.

Automated inspection by machine vision based systems has the potential to overcome these limitations of human inspection. The systems can be placed closer to the track or between the rails where it may be considered unsafe for a human to be positioned when a train passes.

This specification covers requirements for design, development and supply of all-weather Machine Vision Based Inspection System, herein after referred as MVIS, of Rolling Stock based on trackside/ within track mounted Equipments.

The purpose of this specification is to spell out the functional and technical requirements of a MVIS system.

## 5.0 Technical Requirements: -

1. The MVIS System for Inspection of running trains should be able to monitor the following parameters/defects for all types of Rolling Stocks, at speeds upto 100 Kmph.

### A. Side view defects

- i. Broken / Missing Axle Box covers
- ii. Major damages in Wheel Disc
- iii. Open/hanging Doors of Wagons
- iv. Laterally displaced Springs/ Shock Absorbers, as applicable
- v. Measurement of wheel diameter
- vi. Standard Wheel Profile defects (hollow tyre, deep flange, thin flange)
- vii. Brake pads/ brake block Worn or missing
- viii. Broken or missing Brake beams and pull rods
- ix. Broken or missing suspension springs.

### B. Underframe defects:

- i. Visually detectable structural integrity defects like cracks etc. of underframe, as visible from ground below the underframe between the tracks.
- ii. Yoke pin support plate bolts missing or broken for CBC stock
- iii. Damaged Centre sill or other under frame members as visible to the human inspector's naked eye.
- iv. Missing CBC knuckle pins
- v. Missing/ Damaged Springs
- vi. Missing CBC operating handles
- vii. Damaged/broken Empty Load devices
- viii. Missing Brake gear items
- ix. Broken or Bent Brake beams
- x. Missing Brake Block or key
- xi. Missing/damaged brake pipe hose/feed pipe hose
- xii. Missing/ damaged hand brake wheels
- xiii. Hanging parts

### C. Top view defects:

- i. Deformed/Bulged side walls, uneven loading of consignment etc.
  - ii. Open/hanging doors of wagons
2. It should conform to following national/international standards:
    - A. Degree of protection for electronics- IP66
    - B. Degree of protection for optics- IP 54
    - C. Wheel contacts- IP67

- D. Auto calibration functionality should be inbuilt into the system, details of which shall be submitted along-with the offer.
- E. It should function in either direction of movement of train.
- F. Time between passing of the train and communication to the central control server should not exceed 10 minutes.
- G. The system should be capable of automatic detection of approaching train, automatic switching-on of relevant sensors, automatic monitor the defects while the train is in motion, automatic transmission of data, alarms and reports and automatic switching off of relevant sensors to conserve electrical power.
- H. The system should be able to work in ambient temperature range of -10° to 70°C and relative humidity up to 100%.
- I. System should have character recognition feature to extract details painted on side walls of rolling stock for use in automatic report generation.
- J. Supply, installation and commissioning of Suitable illumination for round-the-clock working of equipment shall be provided.
- K. **Camera Features** (for all three types of camera)-
  - i. 8 bit monochromatic camera or better
  - ii. CCD types or better
  - iii. Camera interface-GigE
  - iv. Camera types
    - a. **Line Scan camera**
      - i. Resolution- 4K (4096 px \* 1 px) or better
      - ii. Min. Line rate- 80 KHz
      - iii. sensor size- 14.3 mm or better
      - iv. Max. Pixel size- 7 μm \* 7 μm
    - b. **Area Scan camera**
      - i. Resolution- 1920\*1080 or better
      - ii. Min. Frame rate(frames per second) - 500
      - iii. Sensor size- 2/3 inch or better
      - iv. Max. Pixel size- 4.8 μm \* 4.8 μm
    - c. **Stereo camera**
      - i. Image resolution- 1920\*1080 or better
      - ii. Min. Frame rate- 60
      - iii. Baseline distance (max.)- 0.5 m
      - iv. Sensor size- 2/3 inch or better
      - v. Depth- 6 meter & depth resolution 10 cm at 6 m
  - v. Auto Exposure/Auto Gain
  - vi. Auto Tap Balance & Pixel Correction
  - vii. The system should have at least 11 ( 2 line type, 2 stereo vision camera and 7 area scanning type) camera arrangement as per sketch no. 1 of this specification fitted suitably to cover wide range of Coach/Wagon designs so as to cover required parameters/defects as per Para 5.0(1). The general arrangement of camera will be as follows:

Camera No. as per sketch 1	Camera scan type	Location as indicated in sketch 1	Parameters to capture	Approx. Distance from camera to object (mm)	Approx. area of Object (mm)
A	Area	Between the rails	To capture under-frame defects	1200	Width 3250
B, C	Line	Side of track	Wheel profile data	700	Line scan
D,E	Area	Both Side of track	Bogie side view related	1000	Vertical height upto 1200 mm from rail level
F, G	Area	Both Side of track	Side view of rolling stock superstructure including text	1000	3200 mm vertical height starting from 1200 mm from rail top level
H,I	Stereo vision camera	On the portal/ top side corners as suitable	To capture uneven loading, top view of consignment/roof/ coupler top view	3000 to 5000	3250
J,K	Area	On the portal/ top side corners as suitable	Deformed/Bulged side wall panels, hanging/open doors	3000 to 5000	1000

**L. Operational capability requirements –**

- i. Operating speed – up to 100 Kmph (Max.)
- ii. Train length- upto 1000 axles
- iii. Typical track profile- As per IRPWM 2004 amended from time to time: Latest correction Slip(ACS-144)

**M. Tolerances applicable for various parameters/ defects –**

S.no.	Parameters/Defects	Tolerances
1	Broken in two pieces or missing Axle box covers	<ul style="list-style-type: none"> <li>• False positive alarms should not be more than 10%.</li> <li>• False negative alarms should not be more than 5%</li> <li>• Reporting should match the seeded test condition</li> </ul>
2	Hanging parts	
3	Major Damages in Wheel Discs	
4	Open/hanging Doors of Wagons	
5	Laterally displaced Springs/ Shock Absorbers	
6	Brake Pad missing	
7	Broken or missing Brake beams and pull rods	
8	Broken or missing suspension springs, in the visible range	
9	Structural integrity of underframe, as seen from bottom area between the track	
10	Yoke pin support plate bolts missing or broken for CBC stock	
11	Damage in Wagons	

Standard Wheel Profile defects		
1	Measurement of wheel diameter	+/- 4 mm
2	Deep Flange	+/- 1.0 mm
3	Thin Flange	+/- 1.0 mm
4	Brake Pad/brake block Worn	+/- 0.5 mm

**N. Regulation and norms applicable-**

- i. EMVA 1288
- ii. EN 55011:98 + A 1:99 + A2:02: class B
- iii. EMV550121-4:00(immunity test)
- iv. 73/23/CE, 93/68/CE
- v. EC Directive 2006/860/CE
- vi. EN55022:98 class A
- vii. EN55024:98
- viii. EN61000-6-4:01
- ix. EN61000-4-2:2009
- x. EN61000-4-3:2006 +A1:2008+A2:2010
- xi. EN61000-4-4:2004 +A1:2010
- xii. EN 301489-1
- xiii. EN 55011-2-3:2017
- xiv. EN 55022:2010
- xv. EN 55024 :2010+A1:2015
- xvi. EN 55032
- xvii. IEC 61000-6-4:2018
- xviii. IEC 61643-12,61312, 61214 & VDE 0100-534
- xix. EN 50125-1:2014

The system design shall relate and comply with the above mentioned standards. (In case of any contradiction, the strictest standard shall apply). In addition to above, any other national/international standard which is relevant to the technology for similar application in the railway domain will also have to be complied with.

The system should be modular, auto-calibrating with self-diagnostic features. The system should be designed for compatibility with all important Railway Standards, some of which have been mentioned in this document above.

The MVIS is expected to run in 24x7 mission critical modes (available around the clock) without any human intervention. The system should be programmed for two self-checks daily. This self-test must test all vital elements. The result of self-tests shall be indicated on central server.

The system should be equipped with robust, networked, alert-management software with full suite of graphical analysis and diagnostic tools. Full TCP/IP support should be inbuilt into the system to facilitate smooth integration into all existing railway data networks.

**6.0 Installation requirements: -**

- i. The MVIS system shall not infringe the IRSOD and shall be installed in consultation with authorised Railway Engineer. The tenderer must submit the installation drawings of equipments for scrutiny and approval by the purchaser. Installation clearance for specific sites shall be provided for individual sites by the respective DRM-Mechanical based on the equipment

drawings and other documents submitted by the tenderer, as required by DRM-Mechanical.

- ii. The MVIS systems shall be installed such that they do not either require or cause stoppage of train traffic when they are functioning/not functioning/under breakdown/under maintenance.
- iii. AC voltage range 110V to 230V, 50 +/-3Hz. shall be made available at installation site by Railway. The maximum load on the power supply system should not exceed one KVA.

#### **7.0 Functional requirements: -**

- i. The system should be able to monitor all parameters/defects as mentioned in Para 5.0(1).
- ii. System shall log the date of train passing, time of train passing, speed of train, number of axles passed, total number of vehicles in the rake.

#### **8.0 Hardware requirements: -**

- i. In case the cameras are mounted on the rail or tie/sleeper or specially designed sleeper by tenderer, the technical details and drawing(s) of such sleeper shall be submitted along-with the offer.
- ii. UPS system of at least 8 hours on back-up power and to charge the back-up batteries from main power shall be provided to automatically switch to back-up battery power in case of failure of main power.
- iii. The MVIS system shall have provision for integration with RFID reader likely to be installed by IR in future for automatic identification of vehicles.
- iv. System should have capability to integrate with 3<sup>rd</sup> party system for which Interface control document (ICD) will be provided by Indian railways. Firm will supply the ICD for the MVIS to the Indian railways.

#### **9.0 Software requirements: -**

- i. The trackside equipment shall have the capability to record and locally store raw captured data/images for last upto 500 trains and the processed reports for upto 10000 trains.
- ii. The supplier shall be responsible for providing required software for collecting data, storage and presentation of reports sent by the trackside equipment.

#### **10.0 Safety Requirements: -**

The equipment shall not fail on wrong side due to harmonic interference generated by 3 phase thyristor, single phase thyristor, chopper controlled, tap changer or other such technologies, locomotives and 25 KV Single Phase OHE Supply.

#### **11.0 Output requirement: -**

- i. The supplier shall launch, operate and maintain an internet-based website during warranty and during comprehensive maintenance period for making available the train reports.
- ii. The website shall have the following features: -
  - a) Password based access so that only authorized personnel by DRM-Mechanical can enter/edit/view/download data and reports

- b) Differential privileges to different levels of users to access the resources of the website
- iii. The supplier shall supply a desktop computer at nominated place by DRM-Mechanical of the configuration as specified in the clause on concomitant accessories.
- iv. The system output shall consist of data reports. Data acquired by the system shall be sent to a web server and the following reports shall be available to the users on demand.
  - v. Detailed report: - This report shall be in detail showing all parameters as acquired by the remote wayside detector.
  - vi. The Software should produce a train consist list, comprising train arrival & departure times, number of axles, axle spacing, axle speed, vehicle type, number & image number for each vehicle.
  - vii. The system shall generate alarms based on the interpretation of the data. It should give exception report and audio-visual alarm at preset value of defects. It should be possible to individually set preset value for different type of alarms at each site from Central Control. The Tenderer will work jointly with IR and assist in developing acceptable limits for the various parameters. For providing relevant alarms to Divisional controllers, it should be possible to map each site to one or more C&W Divisional controller.
- viii. The system output shall consist of data reports. Data acquired by the system shall be sent to a web server and the following reports shall be available to the users on demand
  - i. **Detailed report:** - This report shall comment on all parameters as acquired by the Machine Vision Based Inspection System for parameters/defects mentioned in Para 5.0(1) respectively and shall be saved for review/reference.
  - ii. **Exception report:** - This report shall be an abridged version of the detailed report showing only the list of rolling stock where the parameters have exceeded the prescribed limits. This shall serve as a working report for the maintainer and shall be used for planned repair.
  - iii. **Diagnostic reports:** - The system shall be capable of running self-diagnosis programs and report the result through the website. The system shall be able to communicate alarms and acquired data to users immediately after passage of a train without any human intervention. All reports/ messages shall convey the following minimum data:
    - a) Date / time of train
    - b) Direction of movement
    - c) Vehicle position from start of train
    - d) Rolling Stock Number, if recognizable by the system, where the parameters were found out of range.
    - e) Short description / error code (should be easily understandable without need of referring to a table)
  - iv. In case, IR decides to include new types of alarms in the system, then supplier shall modify the software within a reasonable time at no extra cost to Indian Railways.
  - v. Where required by special site conditions, OFC / Copper cable / RF-Link connectivity shall be provided by the system provider for transfer of data.
  - vi. The backend server systems shall be maintained and operated by the



- system provider. These servers shall be capable of storing and displaying (upon demand) parameter reports for up to last 5 years.
- vii. The access to these reports shall be provided by web based clients suitable for use from desktops / laptops / netbooks and smart phones. Users of the systems shall be provided logins / passwords for accessing the data.

## 12.0 Submission of documents:

- (i) **Test certificates:** Test records, test certificates, performance curves, tables, etc., of all inspections and tests, whether or not witnessed by IR personal , shall be supplied as soon as practicable after performance of each inspection or tests. Two (02) sets of above mentioned documents shall be supplied properly bound in books.
- (ii) All test certificates shall be endorsed with sufficient information for identification of the equipment and, material to which the certificates refer.

## 13.0 Type of Tests:

- (i) Inspection and testing of the equipment shall include all inspections, tests, checks, procedures etc., whether mechanical, electrical or software related as required to ensure that the equipment supplied meets the requirements of the specification.
- (ii) Inspection and testing shall comprise, but not limited to :
- Mechanical and chemical testing of materials
  - Destructive and non-destructive tests of materials
  - Checks of fits and assemblies.
  - Dimensional checks.
  - Inspection of paints and coatings
  - Electrical tests
  - Functional tests performance tests
  - Acceptance tests:
    - Type tests
    - Routine tests
    - Proving-out tests
- (iii) The techniques, equipment and instrumentation to be use for these tests, checks, inspection, examinations, etc. shall be in accordance with internationally accepted standards, rules or codes, and in particular those mentioned in the specification.
- (iv) If in IR's opinion, instruments, apparatus, devices, etc. used by the supplier need calibration or re-calibration, then such instruments, apparatus, devices, etc. shall be calibrated by an independent authority or institute approved by IR.

## 14.0 Proving-out test requirement: -

The supplier and the DRM-Mechanical shall conduct the following proving out tests after commissioning: -

- i. **Consistency test: -**
- All the trains should be correctly recorded with regard to direction of motion, date and time of passing, speed, no. of axles, no of locomotives, no of vehicles other than locomotives. Acceptance shall be at 95%.
  - The complete data report of the trains passed shall be generated.

c) The complete data report generated for various parameters/ defects (as per para 5.0(1)) should be within applicable tolerances as per para 5.0(2-M).

- ii. **Calibration test:** - In addition to calibration test during the commissioning of system, the auto-calibration functionality shall also be demonstrated at the site during the commissioning of the system. The error should not exceed 2%.

#### 15.0 Literature: -

The supplier shall provide following literature in two copies to DRM-Mechanical along with the delivery of MVIS system.

- i. Complete drawings
- ii. Operating manual
- iii. Maintenance manual
- iv. Spare part catalogue

The tenderers shall provide a list of literature to be supplied with the machine in his offer to the tender.

**16.0 Scope:** - The MVIS system shall be supplied on turnkey basis. The MVIS system shall mean and include all equipment by the side of the track, cables – electric, server computer, website, client computer, software of the track-side equipment and software of the central server and any other element necessary for optimal functioning of the system. The scope shall include

i. **Supply:** - Supply of

- a) MVIS site equipment
- b) Concomitant accessories
- c) Spares
- d) Maintenance tool kit
- e) Literature
- f) Material, as required for civil engineering work
- g) Power cables, as suitable to the trackside equipment
- h) Modem, as suitable to the trackside equipment

ii. **Installation at site:** - Installation of the system would be done by and under the supervision/direction of firm's Engineers. It shall include the following: -

- a) Civil engineering and other allied works (if required) such as construction of hut of suitable size to house UPS, batteries, electronic and electrical equipment, solar power system etc.; grouting supports for steel enclosures/equipments, control box, battery box etc., necessary work e.g. trench etc. for power cables for a maximum distance of three km. In case the offered system requires track crossing or sleeper replacement, the offer shall be evaluated by Research Directorate of RDSO in consultation with Track Directorate of RDSO and necessary approvals shall be organized. Therefore the supplier shall provide the required technical details in the offer.
- b) Electrical engineering: laying of power cables for a maximum distance of three km from the site to the main power distribution box where the DRM-Mechanical has made the availability of electrical power of 230 V 50 Hz.
- c) Provision of mobile connection and internet connection for transfer of data and display of reports and audio-visual alarms from site of installation to centralized location (as finalized by DRM-Mechanical of concerned Division of Indian Railways). The recurring expenditure on mobile connectivity for first one year from the date of commissioning

shall be borne by the supplier. Subsequent expenditure shall be borne by Indian Railways for which the necessary arrangements have to be done in advance by DRM-Mechanical.

**iii. Web-server** – The supplier shall launch and maintain an internet web – server at any location with following features-

- a) Multiple User password protected log-in
- b) Differential access and usage rights to multiple level of users e.g. write-only, read-only, administrator rights
- c) Facility to export data in other data base formats e.g. MS-Excel and XML.
- d) The supplier shall offer at least two designs for web-user interface for selection.
- e) Sufficient capacity to handle data traffic with fast data transfer rate for all authorized users (to be controlled by providing username and password) who shall access through public internet access.

**iv. Ownership and confidentiality of data and software:** - All the data being generated by the MVIS equipment, website, servers etc. with respect to Indian Railway operations shall be the property of Indian Railways.

- i. The data shall be compiled, stored in a medium, transferred and made available in a format as finally decided by Indian Railways in consultation with final supplier preferably in MS-Excel at present but other formats may be accepted later by Indian Railways if found suitable.
- ii. The data shall not be divulged by the supplier to anyone other than DRM-Mechanical and to those authorized by DRM-Mechanical.

Apart from the details mentioned in this documents, any other accessory/component/system(s) essentially required for proper functionality of the MVIS system, will fall under the scope of supply of the tenderer.

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### Sketch-1

