Developing Statewide Systematic Road Asset Management System (RAMS): Standard Approach and Practices

I. Introduction

Road Asset Management System (RAMS) include collection of comprehensive road inventory data sets, requisite software to process the same and develop applications which can address the site specific Road maintenance management by disseminating information through approved procedure. The term “Asset management” contains all the requisite procedures, processes, tools, data and policies necessary to achieve the goal of effectively managing the road assets. It is needed to facilitate the decision-making, since it provides valuable information of optimal timing of maintenance works needed.

The activity of Asset Management happens as a routine process as a part of the system within the road maintenance authorities namely, National highway authority and State Public works department. However, when all the datasets collected from the field with requisite components collected in a structured manner adhering to common standards in a specific duration of time frame and is periodically updated, the results provides immense value to all the stakeholders. Road inventory and condition data are required at all levels but data needs in terms of magnitude, accuracy or robustness vary depending on what level analysis is to be conducted. One of the key features of asset management is integration of all the components. It provides an integrated approach to all costs as well as the use of existing management data sources. The target is to minimize the total road transport costs, which are a summary of the costs of the road agency and road users.

A RAMS can be a very powerful tool for determining the optimal use of available maintenance funding in a transparent manner, as well as for determining optimal budget levels for the repair and maintenance of the existing road network.

II. Problem Statement

Today while dealing with the budget for road maintenance the officials needs to move from one department to other to compile the required information. The information is actually available in bits and pieces in various sections, circles, divisions of the road maintenance authorities. Lots of inventory and geospatial datasets (Paper maps, Digital maps, Files, folders etc.), are available with these authorities but do they know who is having what and how to access those datasets? Are those datasets geo-referenced? Do they follow same standard or do they have a common Projection, datum, scale, formats etc.? Are these dataset sharable quickly? What are the access mechanisms?

Pertaining to road they would like to know the road furnitures at any specific location under their jurisdiction. Simple queries are like - what road assets do they have? Where are they in terms of geo-coordinates or with reference to the chainages marked on the road? What conditions they are in? How much money they have spent on them for past several years? How much money will have to spend on them? What level of service is being provided? Is the customer satisfied? What is necessary to improve the service? How can they operate the business effectively?

III. Problem Analysis

RAMS enables managing of road assets in an effective manner that is, optimizing the budget for road network. Geo-referenced information on road infrastructure is essential for spatial planning, socio-economic assessments and environmental impact analyses. Spatial references are topographic maps, showing roads, bridges, CD structures, villages, water bodies and administrative boundaries which are effectively managed using Geographic Information System software.

As per Asian Development Bank (ADB) their International experience has shown, that optimal timing of maintenance works (right works in right locations) using modern RAMS brings 2–30% savings in total road life cycle cost whereas, running fully operational RAMS is only 1–2% of the total costs. It is important to understand that RAMS operates with different levels.

There are mainly four major components in RAMS project

1) Collation of the existing datasets within the organization in a structured data model
2) Manual survey of the roads through conventional techniques
3) Automated data collection using Network survey vehicles and other modern sensors
4) Web based Application development and dissemination to the stakeholders

India has the one of largest road network across the world, spanning over a total of 5.5 million km. This road network transports 64.5 per cent of all goods in the country and 90 per cent of India's total passenger traffic uses road network to commute. Road transportation has gradually increased over the years with the improvement in connectivity between cities, towns and villages in the country. The Indian roads carry almost 90 per cent of the country's passenger traffic. In India sales of automobiles and movement of freight by roads is growing at a rapid rate.

The annual or multi-annual programs and budgets are carried out at the programming level with the time horizon between one to five years and all the Long-term forecasts of pavement performance or other assets' behavior are typically conducted at the network level looking at a horizon between 10 and 20 years (Source: ADB).

IV. Approach

- To convert/ migrate the departmental road records into digital database through appropriate database design and migrate to industry standard MIS supported by a query engine
- To Survey all State Highways, District Highways and other roads using DGPS, 360 degree panoramic cameras, LiDAR sensors, FWD and conventional techniques
- To structure the datasets as per the data model, add the datasets from the field and Linking of the departmental MIS attributes of the road with the Road segment in Maps (2D)
- To develop web based applications to capture the attendance of the field staffs of PWD with locational details (GPS location and time stamping to be done) by providing them with tablets. Applications in both browser based and app based.
- Departmental officers to have access to the geospatial information and to have provision to update attribute data to keep the system up to date.
- To provide suitable application to records citizen grievances for any road section Citizens should be in a position to post their grievances and post photos for relevant road stretches.

V. Framework of Data Collection and Management

The possibilities to collect 'n' number of datasets pertaining to each asset persist. However judicious engagement needs to be in place in terms of data collection for the RAMS. It is always a good practice to plan well on what data is essentially and optionally required. A RAMS requires a limited amount of data for the entire road network whereas for routine departmental project preparation, more detailed data is required. Annual data collection required for RAMS project should be optimal. As the system evolves more structured datasets can be included.

At state Public work Department (PWD) wherein projects gets implemented, the Section is the source of all GIS data collection and compilation. At Subdivisions, in addition to data compilation, data validation also takes place. At Division level, the key function for GIS and road maintenance management is data analysis and preparation of annual maintenance programs. At Circle level data gets collected from Divisions and data, scrutiny and eventually proposal for modifications are made. Computation and data references should ideally be checked at each level.

Sl. No.	Data Item	Equipment and frequency of data update
1	GPS referencing	Vehicle mounted DGPS (sub-meter accuracy) to collect this information. Normally collected once in a year updates required upon any alignment change or new road construction
2	Right of Way (RoW) imaging	Vehicle mounted 360 degree panoramic camera, DGPS (sub-meter accuracy), and Distance Measuring Instrument (DMI) used at 5 m interval annually. Normally collected once in a year updates required upon any alignment change or new road construction.

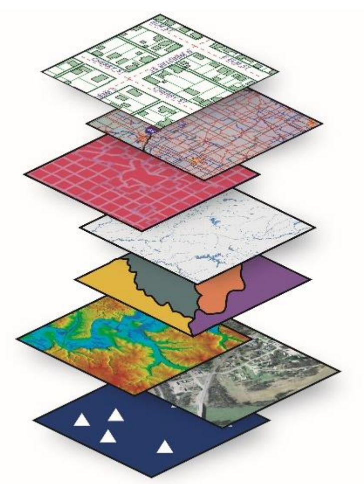
3	Road inventory/ Geometry	Automated Mobile mapping system. DGPS (sub-meter accuracy) Vehicle mounted 360 degree panoramic camera, LiDAR sensor, Normally provided by State PWD offices in either hard or softcopy. To collect from PWD field offices available data in hardcopies/reports /Excel files as existing. Normally collected once in a year updates required upon any alignment change or new road construction.
4	Pavement composition, sub-grade CBR and soil classification	To collect from PWD field offices available data in hardcopies/reports /excel files as existing. To validate/update, and collect additional data in the field by digging test-pits every 2 km (staggered). Consultant may use ground penetrating radar equipment on the automated survey vehicle to obtain the same. Sub-grade CBR can be obtained using DCP tests (at test-pit & toe sample) or soaked CBR lab investigation every 2 km. Soil type will be ascertained in the lab using sub-grade soil samples collected from the test- pits and/or toe of the slope. Collect only once, but update upon any change in composition due to improvement, widening or strengthening.
5	Pavement condition/distress	Mobile mapping survey using LiDAR and 360 degree panoramic imaging system producing high-resolution images integrated with DGPS. Normally collected annually, preferably after monsoon
6	Pavement roughness	Laser-based automated equipment (Class1 type) in both wheel tracks. Collect once a year, preferably after monsoon
7	Pavement structural strength	Vehicle driven Falling Weight Deflectometer (FDW) equipment is used to collect deflection data every 500m. Requisite software used to analyse the datasets. To analyse data using a recognized software. Need based structural strengths to be done periodically.
8	Culvert inventory and condition	Conventional survey using measuring tape. Collected inventory data annually after monsoon and updated upon any upgrade or construction of new roads.
9	Bridge inventory (General)	Dimensions are available with the State PWD engineering division. Collected once annually, but updated upon widening of bridge or completion of a new bridge. To validate the data by measuring dimensions at site using basic measuring equipment, such as, tape, binoculars, ladder etc.,
10	Bridge condition	Visual assessment using basic measuring equipment such as tape, hammer, binoculars, ladder, etc. Collected annually.

11	Classified traffic volume	3-day vehicle count data on designated locations as suggested and inputs provided by PWD. Normally collected bi-annually.
12	Axle-load	Manual method with portable weigh pads at representative locations with varying commercial traffic volume. Collected once in five years.
13	Environment and Social Information	Automated using high-resolution images (post processed from collected data) or LIDAR, installed on the survey vehicles Demonstration only on 100 km.
14	Road Safety	Accident records in road sections to be collected from local police-stations, Hazardous locations – to be identified from 360 degree panoramic imagery using automated network survey vehicles.
15	Maintenance History	State PWD provides data from the field offices which needs to be updated in database. Data collection and update is a routine activity. Annual review on collation of data advisable. For RAMS purpose last 5 years maintenance history is recommended.

Road Asset Management Systems vary from simple spreadsheets with decision matrices, to complicated software requiring many types of data. The structure of the database should be simple and scalable to meet the needs at enterprise level. It should also be flexible to accommodate additional data items based on future needs. The datasets are also required by the departmental officials for statistical analysis. Therefore it must be made easily accessible.

VI. Framework of Data Analysis through Modular Web Based system

The Road Asset Management System is an asset and information management system which are designed to provide inventory and asset condition data for the state road network comprising of State Highways, Major District Roads and other District Roads in all the Divisions Effort should be made to start with simple web based software and not to complicate the process and procedures.

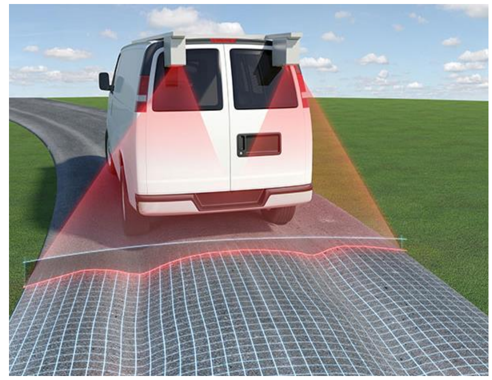


It provides a mechanism to measure the performance of the road network, to induct more scientific principles of resource allocation for maintenance and new construction programs. It provides comprehensive information and overall management of the physical road assets of the State and a logical approach to decision making in the key areas of road maintenance, upgrade and road widening projects. A web based Geographical Information System (Web-GIS) is developed with the following modules

1. Road Information System (RIS)
2. Bridge Information System (BIS)
3. Pavement Management System (PMS)
4. Routine Maintenance Management System (RMMS)
5. Traffic Information System (TIS)
6. Accident Information System (AIS)

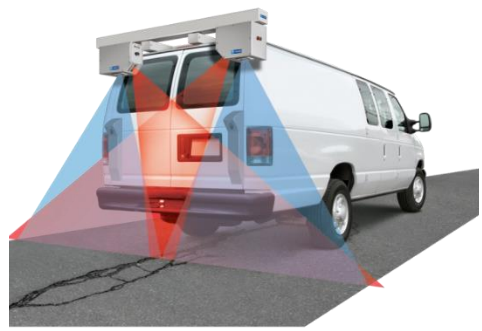
The components are briefly described below

1. **Road Information System (RIS)**
   It consists of web-based applications designed to input / upload, store, edit, update, view, download the road network and asset data such as Road type, Pave surface, pavement width, shoulder width, median type, cross section, side drain type, land use, wayside amenities, road furniture, topography etc are captured as Road inventory details. RIS also manages Users of the system, their roles and jurisdiction access.



2. **Bridge Information System (BIS)**
   Bridge Information System (BIS) is a web-based application, designed to input / upload, store, edit, update, view, download the bridge inventory, inspection data integrated with 360 degree panoramic imagery of the bridges, related scanned documents of engineering designs, referenced over the road network. Structured geospatial queries can be performed in the system to know the situations and conditions of the bridges within any administrative jurisdiction boundary

3. **Pavement Management System (PMS)**
   The data captured in the field through the network survey vehicles pertaining to the Pavement Conditions like Cracking, Raveling, Potholes, Disintegration, Depression, Patching, Bleeding, Edge break, Shoulder condition, Drain Condition etc. are retrieved through the Pavement Management System (PMS) which consists of tools to ascertain maintenance requirements of the road network. Structured queries are performed in GIS operations. These datasets are often linked to the 360 degree panoramic views.



4. **Road Maintenance Management System**
   Road Maintenance Management System (RMMS) consists of various rules, maintenance. standards, treatments and costs built-in to the system which is executed through processes and IT tools to derive most suitable routine maintenance plan considering condition data collected for the pavement & culverts. In the web based system integrated with GIS maps the RMMS module helps in

   - The development of an annual road maintenance program that meets the needs of the road user

- Develop strategies to enable the level of service required by the road user to be achieved;
- Support the preparation of an adequate annual road maintenance budget
- Annual upkeep of the Standard Schedules of Unit Rates and data
- Ensure adequate spread of funding allocation to ensure preservation of roads, bridges and related Infrastructure and safety of the road user
- Identify emergency works required to existing roads, bridges and related infrastructure items to make them safe and keep the road traffic worthy
- Reduce maintenance costs, improve traffic flow, improve road safety, reduce flooding, etc.
- Preparation of monthly maintenance reports

The RMMS requires basic data such as inventory, condition data, and historical data of works which is collected for RAMS, as such. This is the stage at which the RMMS/HDM-4 program is used to develop the strategy to be adopted by the PWD with regard to road maintenance during the next financial year. For each maintenance intervention selected, the program produces a prioritized list of roads which is very helpful to the operational engineers and decision makers. Priority being given to that road which is in greatest need of maintenance based on such factors as current condition and future estimated traffic volumes.

5. Traffic Information System (TIS)

The Traffic Information System (TIS) module is a web-GIS-based custom built application, designed to input, store, manage, analyse and report traffic volume and axle-load data. It provides facilities to conduct truth-in checks by comparing previous year data and validate records.

6. Accident Information System

The key purpose of this module is to manage, analyse and report on accident data for purposes of identifying black spots. One of the major hindrances that leads to unsuccessful Implementation or under-utilization of AIS is the availability of quality information with relevant authorities, such as the police department. AIS provides following key functionality:

- Store accident information (linear and spatial location details) provided by Road authorities and Local police stations
- Identify road sections with black spots and poor geometry derived from accident information (The output of the data comes from LiDAR point clouds which provides 3D data which can be analysed in GIS systems with Line of sight analysis functions)
- Display black spots and high accident prone zones on the overlaid GIS layers in the system
- Capture accident cost rates for use in HDM-4 economic analysis
- Generate the queried dataset graphically in the thematic map form using GIS interface
- Generate summary reports.

VII. Benefits to the Stakeholders

Over the last decade, digital geo-referenced data on roads are becoming increasingly available online. The indicative list of benefits from implementation of RAMS by the Road Authourity is listed below:

- Information retrieval of any section or geo-coordinate of the road section through various modules
- Start establishing an inventory of road infrastructure by conducting regular surveys
- Transparency in the governance process
- Easy to convince politicians in providing funds based on facts and figures
- Easy retrieval of the contractor profile and performance report and contract allocation details
- Track materials and progress of civil work activity
- Track maintenance cycles
- Identify and tag various types of potholes and prioritise the maintenance activities
- Manage assets and resources effectively
- Save time and money for the department
- Generate revenue from effective decision
- Support for planning and monitoring of various projects.

The indicative lists of benefits derived by the Citizens are as follows:

- It provides a minimum expected level of mobility, safety and service
- Through the grievance submission in the system citizens can put pressure on decisions makers for maintaining and improving the road as an asset and a public utility, if the RAMS site is made publicly available (Many cases the websites are password protected and only available for usage to the departmental officials)

VIII. Summary

A RAMS is a technical or operational method for managing or directing and controlling maintenance resources, in a scientific manner, for optimum benefits. The RAMS includes the development of guidelines to devise the methodologies for systematic data collection. The data is collected on the structural and functional performance of all categories of road under varying climate, traffic, and environmental conditions. To adequately quantify the benefits as well as the impacts of roads, accurate and up-to-date geo-referenced information for entire road network of the state is essential. The RAMS project helps government to do better planning, monitoring of the operations in the field and provide a platform to the citizens to post their grievances.

The state-of-art of LiDAR technology employing laser scanners and cameras mounted on vehicles. Data thus acquired is in the form of 360 degree panoramic imagery. Optical sensors capture HD Panoramic imagery. As all 3D scan points are supplemented by 360 degree panoramic imagery, the files can be viewed, navigated, measured and analyzed as 3D models enabling users to experience and work with real-world conditions.

Judicious allocation of maintenance funds is dependent on this data and its analysis. As a best practice it is always recommended to limit the data to be collected, make the database easy to use and start with simple web based GIS software. Over a period of time the system can be made robust. By publishing the annual performance statistics through the system, the stakeholders will have better trust of the operational RAMS. It is always better to integrate into decision-making processes and provide sufficient and predictable funding to regularly update the datasets from the field surveys.