THE IMPLEMENTATION AND OPERATION OF A ROAD ASSET MANAGEMENT SYSTEM FOR FIJI

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Abstract: This paper describes the implementation and operation of a state-of-the-art Road Asset and Maintenance Management System for and on behalf of the Ministry of Works and Energy of the Government of Fiji between March 1999 and May 2001. It covers all roads and road assets, including bridges, under the jurisdiction of the Public Works Department (PWD) comprising 900 km of sealed roads, 4,300 km of unsealed roads and 1,200 bridges and major culverts. The integrated system includes bridge and road routine maintenance systems, a bridge renewal system and a pavement management system to prepare rolling programmes of periodic maintenance works. The planning and pilot phase of this project has been reported previously in Baleilevuka, P *et al.* (2000). This paper describes the roll-out of the complete system to all three PWD administrative Divisions including the development of the pavement management system, application of GIS and handover to the Client.

Key Words: road, asset, management

1. INTRODUCTION

The Government of Fiji, as part of the Fiji Road Upgrading Project (FRUP-3) engaged Meritec Ltd to implement a comprehensive Road Maintenance Management System and Road Asset Management System (RMMS-RAMS). The project ran from March 1999 to May 2001 and covers the 900 km of sealed roads, 4,300 km of unsealed roads and 1,200 bridges and major culverts under Public Works Department (PWD) jurisdiction. The project programme called for a pilot system to be implemented in the PWD's Central/Eastern Division by early 2000, with a roll-out of the system to all three divisions by May 2001. This programme was met with RMMS-RAMS currently operating in all three PWD administrative Divisions. A schematic of the RMMS-RAMS is shown in Figure 1.1.

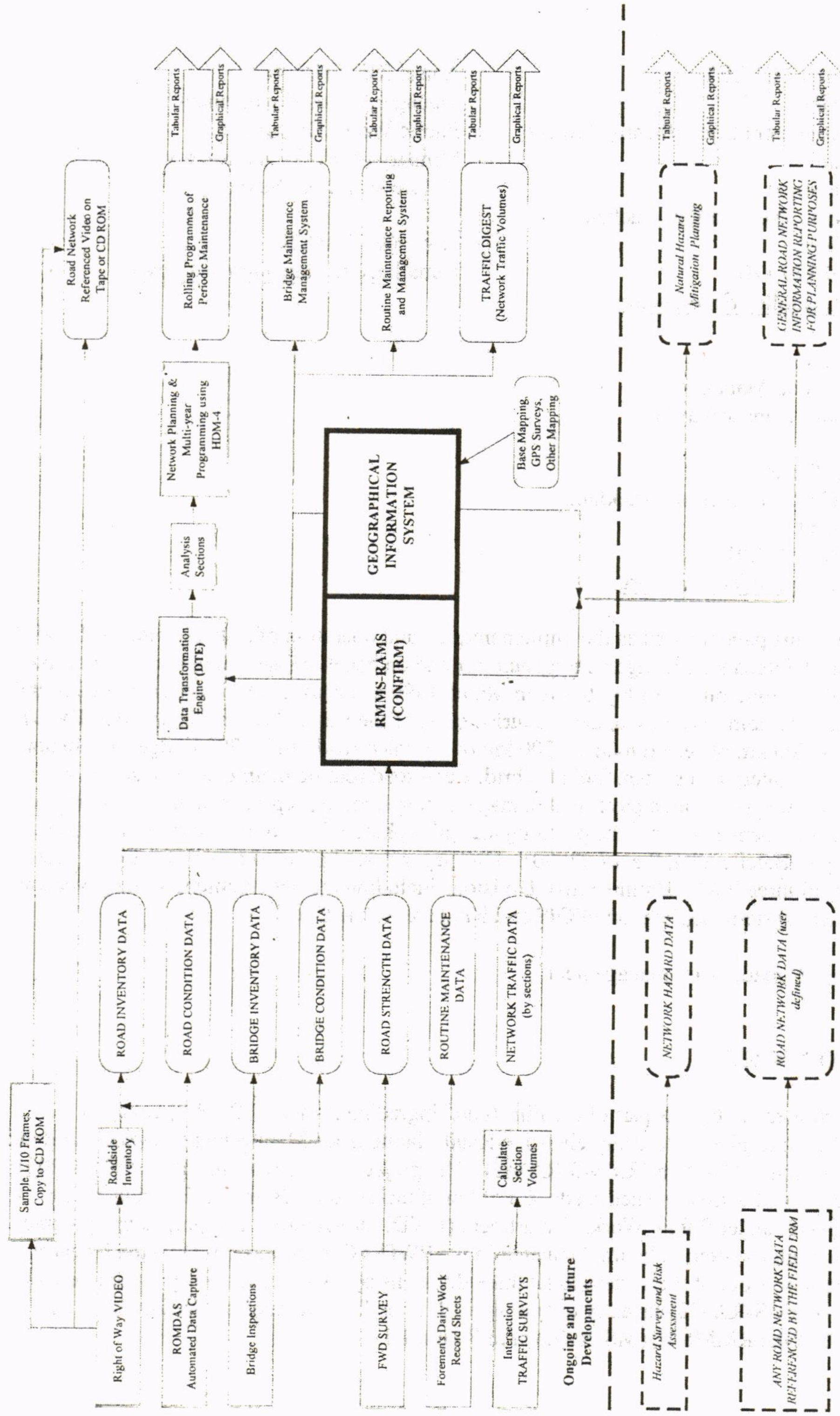


Figure 1.1 - Schematic of RMMS-RAMS

2. IMPLEMENTATION AND DEVELOPMENT

2.1 Implementation

The project's Pilot Stage, which called for implementation of RMMS/RAMS on a trial network, specifically for the Central/Eastern Division road network, was successfully completed by mid-2000 and involved activities under five categories:

- equipment procurement;
- data collection;
- design and development of routine maintenance systems (road and bridge);
- development and operation of the RMMS/RAMS for Central/Eastern Division; and
- development of the pilot 2 year rolling programme and 5 year planning programme for periodic maintenance works in the Central/Eastern Division.

Whilst this was initially a pilot implementation, with further development and refinement required throughout the remainder of the project, the basic routine and periodic road and bridge maintenance systems were ready for operation in the Central Division by mid-2000.

The task for the remainder of the project was to develop, refine and integrate the systems and associated manual and administrative procedures into the day-to-day activities of the PWD and roll these out to all three PWD Divisions.

The first task of the implementation phase was to equip both Western and Northern Divisions with computers, printers and the RAMS/RMMS software. These systems were installed in June and July 2000 respectively, and included copies of the Central Division RAMS/RMMS database for training purposes.

Each of the three PWD Divisions, Central/Eastern, Western and Northern, have separate systems and databases (see Section 3.1) storing both RAMS data (road and bridge network, inventory and condition data, traffic data) and RMMS data (routine maintenance works data). It is only after the road network has been defined in the RAMS, that it is possible to begin loading routine maintenance data from field records, as this information is linked to the road sections and location reference points defined for each section. Thus it is not possible to begin loading field records of routine maintenance until the road surveys are complete and the road network is set up in RAMS.

Databases are considered 'live' when RMMS data starts being loaded on a full-time basis. The Central / Eastern and Western Divisions databases went 'live' at the end of August 2000, the Northern Division in late November 2000.

Roll-out of the RMMS immediately presented three challenges; late submission of field records to Divisional Headquarters from the Depots; a reluctance by road foremen to use the location referencing system to record the exact location of works; and delays in the loading of field records into the RMMS. These problems were overcome by an extensive programme of training as described under Section 4.

There were also practical requirements to be resolved including encouraging the PWD to maintain location reference points, by repainting culvert marker posts for example, and moving towards more robust location reference points based on permanent kilometre posts.

2.2 Developments since Pilot Stage

2.2.1 Bridge Maintenance Management System

Fiji's bridge inventory has been under stress for some time. Although a number of new multi span river crossings had been constructed with funding from multilateral donors, many of the smaller structures were in very poor condition. Nor was there a systematic approach to managing bridge assets. The Bridge Maintenance Management System (BMMS) was thus conceived as a simple, appropriate and sustainable solution to the management of Fiji's bridges and major culverts.

The basic principles of the BMMS were established during the Pilot Stage of the project and fully developed by the bridge maintenance specialist during the implementation phase. A brief description of the operation of the BMMS is given in Section 3.4 and shown schematically in Figure 3.6.

A particularly useful facility available within the RAMS software is the ability to link computer files to any feature (asset) within the database. In the BMMS digital photographs of each bridge, including photographs highlighting particular problems, are stored and linked to the bridge record. Sketch diagrams of each bridge, using the VISIO drawing package, were also prepared and linked to the bridge record. These sketches recorded key inspection findings such as the depth to riverbed level for scour and aggrading.

The bridge maintenance specialist set up the BMMS; completed inspections of all bridges and large culverts in Central Division; prepared a draft replacement programme for these structures; and trained bridge inspectors in all three PWD Divisions.

In March 2001 a PWD engineer was appointed to the position of full time Bridge Maintenance Engineer, a move which is seen as critical to the success of the BMMS and to effective bridge maintenance in general. The previous arrangement, in which responsibility for bridge maintenance was shared between the divisional road maintenance groups and the head office structures section, does not appear to produce a systematic, coherent approach to bridge maintenance, based on medium to long term planning.

2.2.2 Road Maintenance Management System

An outline of the operation of the Road Maintenance Management System (RMMS) is given in Section 3.2 and shown schematically in Figure 1.1.

Although the first objective of RMMS was to replicate the largely paper based routine maintenance systems already in place within the PWD, the potential offered by the system is far greater. The fact that the RMMS stores all of the raw input data for all routine maintenance works means that the PWD now has the facility to manage their maintenance works based on the individual resources consumed (plant, labour, materials), not just on the after event recording of cost estimates of total consumption. This information can also be used to plan and budget more rationally.

Discussions with the PWD regarding the long term development of the RMMS were held in the latter stages of the project and will continue as part of the ongoing support and maintenance activities, see Section 4.2.

2.2.3 Data Collection – Global Positioning System (GPS) Survey

The development of the Geographical Information System (GIS) for this project is discussed in a separate paper presented to this conference. However, one aspect of this development work, a GPS survey of all PWD roads, will be reviewed here as it relates to the overall data collection activities.

A survey carried out for the PWD in 1995 was to have generated, amongst other things, an accurate coordinated centre line (Easting, Northing and altitude) for all Main, Secondary and Country roads in all three Divisions. However our investigations revealed that this information was inaccurate and correcting it was impractical, if not impossible.

Without a reliable route network centre line it would be impossible to accurately model road inventory, condition and maintenance information in the GIS using data from RMMS/RAMS. A GPS survey of all PWD roads in Fiji was therefore initiated.

A Trimble ProXR GPS receiver was purchased in January 2001 and installed in the survey vehicle. The GPS is linked to a 'ROMDAS' data recorder and records centre line coordinates along with road condition and inventory data. The data collected by the GPS as a standalone unit is accurate to 5-10 m horizontally. When corrected using data from the Fiji Native Land Trust Board Base Station, an accuracy of 1-2m can be achieved, as required for the GIS. After correction, the centre line coordinate data is loaded into the ArcView GIS to provide an accurate representation of the PWD road network.

Although the GPS survey was a one-off exercise, the PWD opted to purchase the GPS receiver rather than hire one for the duration of the survey (estimated at a total of 8 months). The main reason for this was that the receiver was then available for hire to other departments within the PWD, such as water supply and sewerage, to recoup some of the costs of the survey. Likewise the coordinated road network data could also be made available, for a fee, to other potential users such as the Department of Lands and Survey, the Department of Forestry, the Fiji Electricity Authority and Fiji Telecom.

2.2.4 Pavement Management System

Situation at end of Pilot Stage

The Terms of Reference for the project required that the RAMS investment analysis module adopt evaluation procedures that were *'fully compatible with the HDM III / HDM-4 technical relationships'* when evaluating road upgrading and maintenance strategies. However, during the development of the Pilot Study the HDM-4 pavement deterioration and user cost models were still being finalised and version 1.0 of the HDM-4 software was still being tested.

It was therefore decided to set up the RAMS/RMMS Pavement Management System (PMS) using HDM III models by hard coding the HDM III relationships into the RAMS/RMMS

PMS, in effect enabling RAMS/RMMS to emulate the actual HDM III software. The reason this was done, rather than creating links between the CONFIRM database and a standalone copy of HDM III, was primarily because HDM III is designed to evaluate individual projects, not a real network of road sections as was required by this project. Another reason was that HDM III does not have the required budget optimisation functionality.

The resultant PMS was used to prepare a draft programme of road maintenance and rehabilitation for the pilot network (Central Division) in June 2000. However, both the Client and the Consultant identified shortcomings in this approach which included the speed of analysis; the need to modify source code when changes were required to the pavement deterioration and vehicle operating costs models to suit local conditions; the complicated user interface; and the need to train users in what was a customised and currently unique PMS.

It was agreed that rectifying these shortcomings could best be achieved by upgrading the PMS to work with HDM-4.

Upgrade to HDM 4

Version 1.1 of HDM-4, released in August 2000, is a fully functional software package offering features and capabilities, which together combine to make it the benchmark of world practice in road investment modelling and analysis. The key benefits to be gained from an upgrade to HDM-4 were:

- HDM-4 is seen as the international standard in highway investment analysis
- It is supported by ongoing and independent research and development through ISOHDM sponsored by major development funding agencies and PIARC member governments
- Software support is available at the HDM 4 Information Centre website
- Excellent training opportunities and support worldwide through PIARC ISOHDM registered trainers
- Software designed to analyse sets of real network sections
- Offers budget optimisation functionality
- Designed to interface with external systems including road network information databases
- Includes modelling of traffic congestion effects
- More comprehensive modelling parameters available with no need to modify the source code
- Provides a wider range of pavement types and structures
- Good user interface
- Includes models for road safety
- Environmental effects (energy consumption, traffic noise and vehicle emissions)
- Easy to model different treatment options (e.g. AC overlays and cement / lime stabilised pavements)
- Allows data to be imported from external databases (e.g. RAMS/RMMS)
- Good library of reports
- Relatively inexpensive at approximately US$ 1,200 per standard single user copy

Following meetings between the Consultant's Systems Analyst and the developers of the RAMS/RMMS software it was concluded that the best way to achieve the benefits described above was to develop a RAMS/RMMS Module to create a database file for a single step import of road condition and traffic data to HDM-4. Making this customisation a Module meant that it could be included in the provision for software Support and Maintenance, see Section 4.2, thus ensuring its functionality is protected from future RAMS/RMMS upgrades. This is important to ensure sustainability of the complete system.

2.2.5 Risk Management

The RAMS/RMMS database is capable of storing any arbitrary data items that can be physically located using the standard field Location Reference Method (Location Reference Point ± offset in metres). This capability, combined with the ability of the GIS to display in geo-schematical format any data that can be referenced using the LRM, makes this a very powerful tool.

An example of such a development, currently being considered by the PWD as an extension to this project, is in relation to the mapping of natural hazards - flooding and landslides - both common problems in Fiji. It is proposed that the data used to manage and mitigate against these risks be stored in RAMS/RMMS in two ways:

- The first approach will be to classify flood risk and slope instability into low, medium and high risk ranges based on field investigations and a desk study. The location of the risk sections will be identified and stored in RAMS/RMMS using the standard LRM.

- The second approach will be to collect data on actual events, located relative to the road centre line using the LRM. Over time this data, combined with data from the assessment described above, will help the PWD identify where problems due to natural hazards are reoccurring so that appropriate mitigation measures can be taken, such as realignment or raising of a section of road.

3. OPERATION

3.1 Data Management

The RMMS/RAMS database is contained in a single Sybase SQL Anywhere file for each of the three PWD Divisions. These databases contain all the road and bridge inventory, road condition, traffic and road maintenance data for their respective Divisions and are of the order of 50 to 100 megabytes in size.

The current hardware configuration of RMMS/RAMS in the three Divisions is shown in Figure 3.1. Central/Eastern, Western and Northern Divisions operate on standalone computers in their respective Divisional Headquarters, each connecting to their own 'live' database. PWD Headquarters operates in a client-server configuration allowing the user to connect to non-live **copies** of the Central/Eastern, Western and Northern Division databases. This allows PWD Headquarters users access to data for all three Divisions for analysis purposes and to prepare network wide survey data for importing to the 'live' databases.

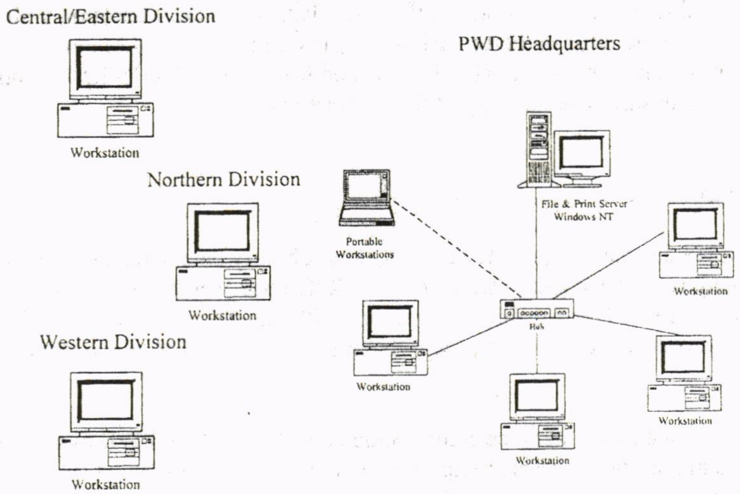


Figure 3.1
RAMS-RMMS Hardware Configuration

The business processes of the Divisions and PWD Headquarters are different. Whereas operations at Divisional level primarily revolve around routine maintenance management and loading of field data, PWD Headquarters is responsible for the collection and analysis of network wide data, including road condition and traffic data. All of this data however ultimately needs to be loaded into the 'live' database for the respective Divisions.

Although copies of the Divisional databases are held at PWD Headquarters, whenever new or updated network wide data becomes available, such as when condition surveys or traffic counts have been completed and processed, it must be imported into the 'live' database. The simplest way to manage this is for the import data files to be prepared at PWD Headquarters and physically taken to the Divisions on CD-ROM for importing to the 'live' database. A copy of the updated 'live' database is then returned to PWD Headquarters for record purposes and further analysis. The steps in the process are shown in Figure 3.2.

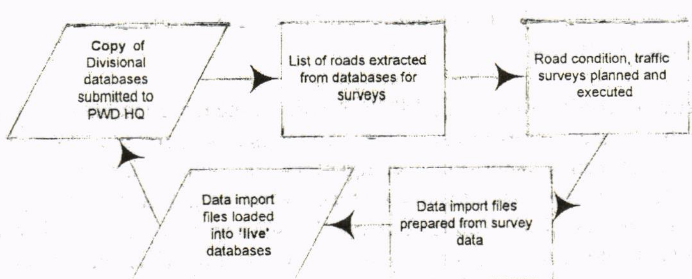


Figure 3.2
Data Management Process

The alternative, of bringing the 'live' database to PWD Headquarters was not considered practicable, as the Divisions would have had to stop loading routine maintenances data until the 'live' database was returned to them.

A key task in managing the databases for the RMMS/RAMS is the regular backing up of the databases. This is done in one of two ways; either daily to tape drive on the client-server configured PWD Headquarters database, or weekly to write-able CD-ROMS in the standalone databases in Central/Eastern, Northern and Western Divisions.

3.2 Routine Maintenance

A key element in the success of the RMMS was the accurate and timely collection of field data on routine road maintenance activities. An existing system for recording data on routine maintenance works, which involved the foreman of each road gang completing a form at the end of the working day, was being operated successfully by PWD. This form, which was submitted daily to the Road Supervisor in the Depot, recorded plant, labour and materials inputs against seven routine maintenance activities - patching of sealed roads; drainage works; grading and re-gravelling of unsealed roads; 'sides' (which included road furniture, road marking and weeding); bridge works; and 'other' including Depot overheads.

As this system, which had been developed over a number of years, was working effectively it was agreed that no major changes would be made in its operation. The only significant change was to require the gang foreman to record, by the use of the location reference method, the exact location of the works being carried out.

Whereas in the past the data from these field records was processed by clerks in the Depots to produce a weekly summary of inputs for use by Divisional managers, the RMMS was set up to store **all** the raw input data directly from field records. This data, which is costed using a standard schedule of rates for the various plant, labour and materials inputs, gives Divisional managers access to a much greater range of reports than were available in the past. The loading of data into the RMMS from field records is carried out by trained RMMS operators at Divisional Headquarters, an example of the computer input form is shown in Figure 3.3.

3.3 Periodic Maintenance

As described in Section 2.2.4 above, the RMMS/RAMS pavement management system is based on the HDM-4 road investment modelling and analysis software. This uses road inventory, road condition, pavement strength, traffic and vehicle operating cost data to analyse a range of treatment options on a programme basis, to prioritise periodic maintenance works for the network as a whole. It is also used on a project basis to assess the economic viability of specific road improvements, such as sealing of gravel roads or road widening.

Following completion of the annual round of condition and traffic data collection, PWD Headquarters export the required analysis data from the updated databases for each Division to a combined Fiji wide sealed roads network. For each road section a series of treatment options, including for example reconstruction of the pavement with either a gravel or stabilised base, double and single coat surface treatments and asphaltic concrete overlays, are tested over a 20-year analysis period. This creates an unconstrained programme of works for each road section that selects the most economically viable maintenance treatment and the year in which it should be applied.

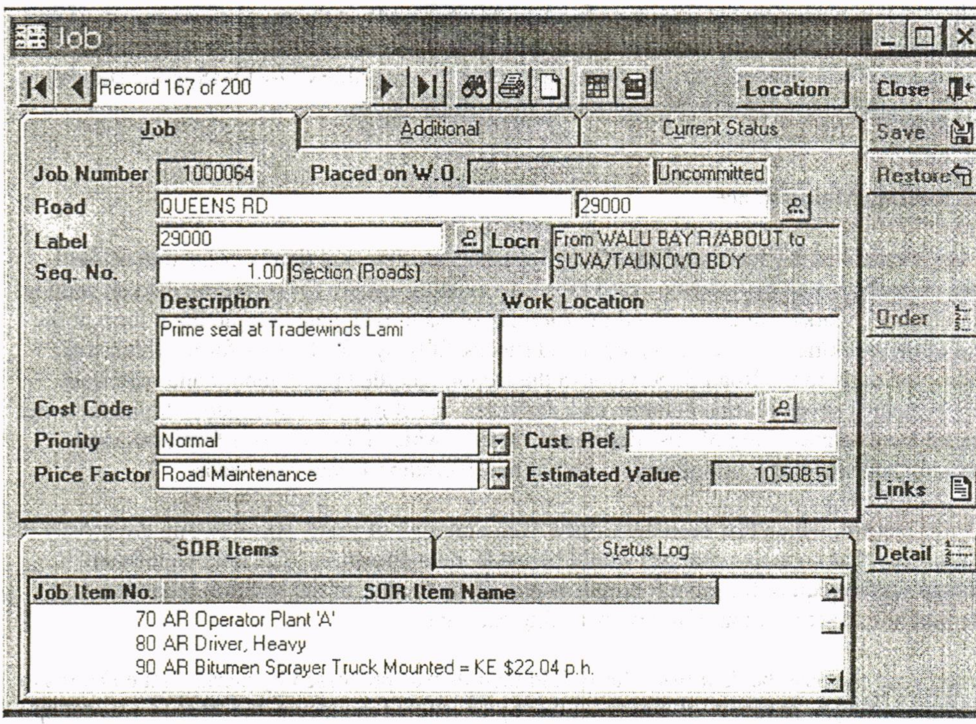


Figure 3.3
Field Works Record Input Form

The unconstrained programme is then tested against a constrained budget using incremental cost benefit analysis to update the rolling programme of works for the next five years. This analysis is repeated every year. This process is shown diagrammatically in Figure 3.4.

It was not considered appropriate to use HDM-4 to develop a programme of periodic maintenance works for unsealed roads, apart from the project analyses carried out for upgrading of gravel roads to sealed standard. The reason for this was because, in the Fijian environment, road roughness on gravel roads is highly dependent on the most recent grading, it changes rapidly under adverse weather and traffic usage, and there appears to be quite high incidence of poor surfaces induced by structural failures and local drainage problems. The local availability of good quality graded gravel is also a factor. Thus roughness is not a particularly robust indicator of average network performance for the unsealed roads.

An alternative methodology for analysing the effectiveness of routine and periodic maintenance treatments for unsealed roads, based on visually assessed, length-weighted, road condition and traffic levels was therefore developed.

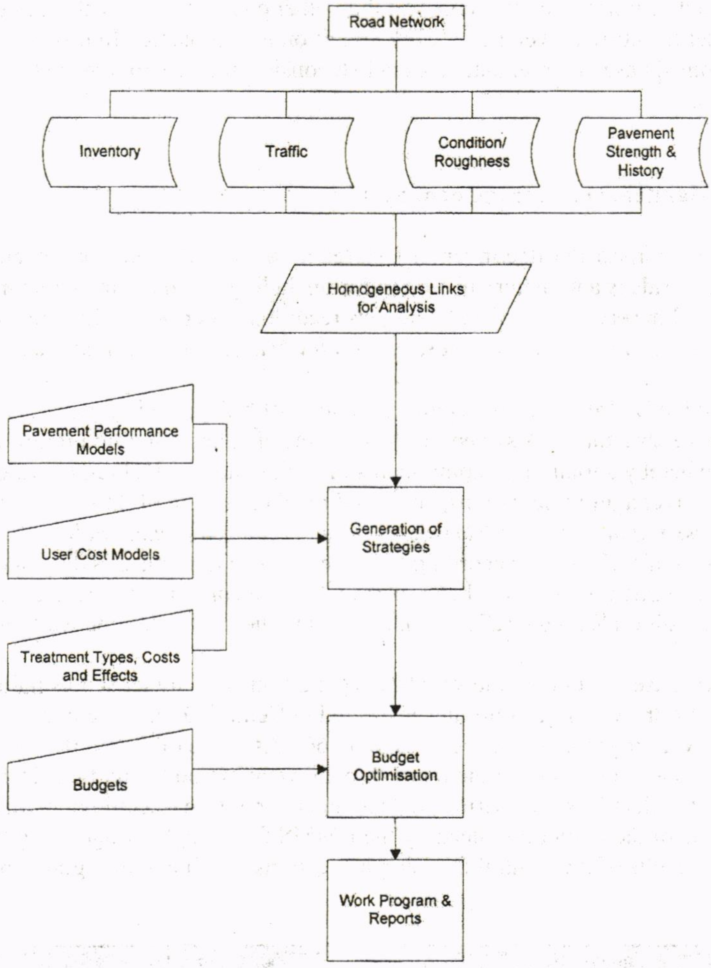


Figure 3.4
Periodic Maintenance Management Process

As part of the road condition survey, unsealed roads are rated on a scale of 0 to 3 depending on their condition. A rating of 0 signifies a road in good condition with a well shaped smooth riding surface which does not require grading while a rating of 3 signifies a road requiring reconstruction with major shape irregularities, potholes and structural failures in the sub-base. This condition rating is weighted according to length for each section of road, to give the average network condition rating, and multiplied by the average daily traffic level, to derive a ranking parameter. This ranking parameter is then used to prioritise periodic treatment works against a constrained budget.

It is not possible from the analysis of a single years data to determine whether a particular budget is adequate to maintain the unsealed network in an acceptable condition. This can only be determined when the new network condition becomes available and the average network condition rating is calculated. If the condition has declined then the budget will need to be increased; if it has remained constant then other considerations will need to be used to judge whether the current average network condition is acceptable. In this way budget levels can be fine tuned based on real data to establish consistent levels of service that meet user's requirements.

3.4 Bridge Maintenance Management System

The BMMS comprises a bridge inventory, stored in the RAMS database, which records the location of all bridges and major culverts in Fiji including details of the structure, number of spans, road width, services etc. Each bridge is recorded under one of 12 categories ranging from '*concrete beams with timber decks*' to '*Bailey bridges*' to '*multi arch concrete culverts*'.

Although the PWD already had a detailed inventory of bridges, this gave no indication of the condition of the structures. A system of visual inspection and condition rating was therefore established whereby a total of 27 components of each structure, including cracking, bearings, deck surface, river aggrading, are inspected and rated on a scale of 0 to 4 (0 = '*good - no remedial works required*' to 4 = '*very poor - action required immediately*'). Each element is weighted on a scale of 1 to 10 according to its importance in terms of safety and/or the integrity of the structure, which, when multiplied by the condition rating and summed, gives the Bridge Condition Rating (BCR). This process is shown diagrammatically in Figure 3.7.

This provides a useful guide to the structure's condition with higher scores indicating a bridge in worse condition. Of the 158 bridges inspected in Central Division, comprising 24 % of the total inventory, ratings ranged between 12 and 366. As a rule of thumb it was considered that bridges with condition ratings in the range 0 to150 were in good condition, 150 to 300 in fair condition, but with at least one serious defect, and over 300 in overall poor condition. Figure 3.5 is a sample of the output produced by the BMMS for a single bridge using this rating system. The results of the Central Division inspections are shown in Figure 3.6.

Records 13-27 of 27

14/09/2000 **Overall Feature Condition (Detailed) list** **Page 1 of 1**

Observation Type	Grade	Score	Weighting	Total
BR SDT Decay or Wear	2 - Below Average	2.0000	10.0000	20.0000
BR SDT Warping & Cracking	2 - Below Average	2.0000	6.0000	12.0000
BR SDT Bolts & Spikes	2 - Below Average	2.0000	6.0000	12.0000
BR SDT Main Member Decay/Frac.	3 - Poor Condition	3.0000	10.0000	30.0000
BR FSS Settlement	1 - Fair Condition	1.0000	10.0000	10.0000
BR FSS Cracking-CORR. INDUCED	0 - Good Condition	.0000	6.0000	.0000
BR FSS Spalling	1 - Fair Condition	1.0000	6.0000	6.0000
BR FSS Abrasion	1 - Fair Condition	1.0000	3.0000	3.0000
BR FSS Reinforcement Corr.	0 - Good Condition	.0000	6.0000	.0000
BR WWS River Agrading	0 - Good Condition	.0000	6.0000	.0000
BR WWS River Degrading	0 - Good Condition	.0000	10.0000	.0000
BR WWS Waterway Adequate	0 - Good Condition	.0000	10.0000	.0000
BR WWS Erosion Abutments/Appr.	1 - Fair Condition	1.0000	10.0000	10.0000
BR WWS Embedment of Found.	1 - Fair Condition	1.0000	10.0000	10.0000
BR WWS Other Erosion/Scour	0 - Good Condition	.0000	10.0000	.0000
			Total :	231.0000
			Total for Road :	231.0000

Figure 3.5
Detailed Bridge Condition Rating Report

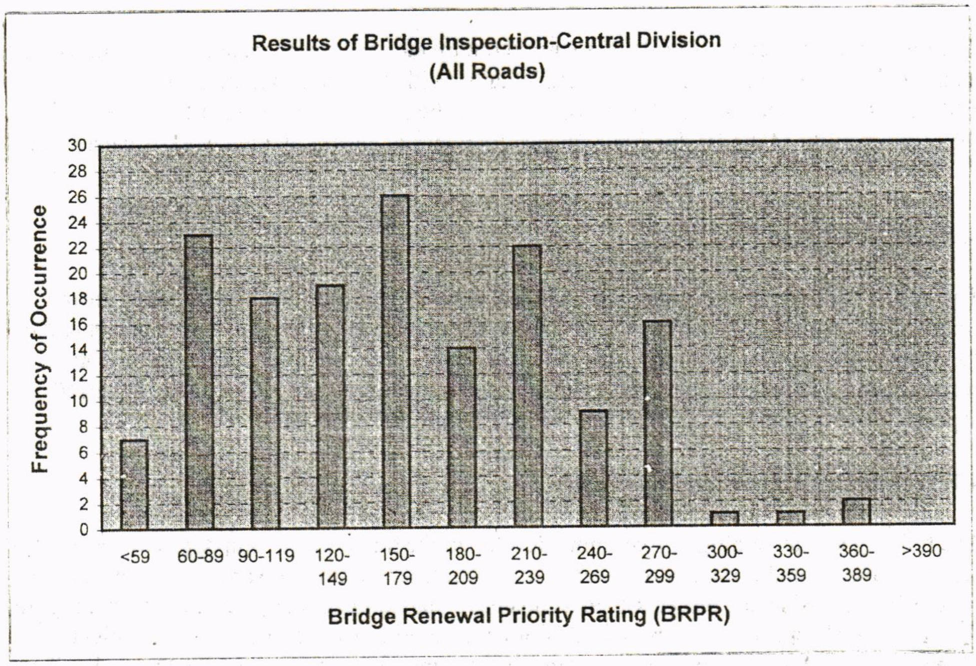
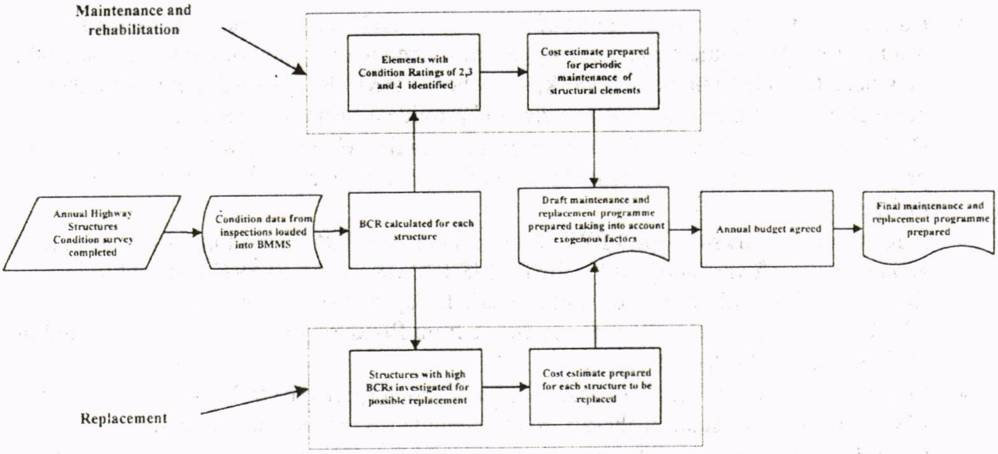


Figure 3.6
Bridge Condition Ratings – Central Division

Although only a broad indicator of a structure's condition, the bridge condition rating was found to be sufficiently robust to be used to identify structures requiring urgent action. This information could then be used as the basis for preparing a bridge rehabilitation and replacement programme.



The routine maintenance of bridges is carried out by the road maintenance gangs and recorded along with routine road maintenance data in daily field records loaded in the RMMS. Although this routine work is the responsibility of the Road Supervisors at Depot level, it is the responsibility of the Bridge Maintenance Engineer to ensure that the work is carried out.

4. SUSTAINABILITY

The key to the long term success of a technical assistance project such as this is to ensure firstly, that technology transfer and training on the objectives, operation and management of the system has been successfully imparted at all levels in the recipient organisation; and secondly that adequate support and maintenance arrangements are left in place, covering all aspects of the system software and hardware, after project completion.

4.1 Training and Technology Transfer

The training and technology programme developed for this project comprises two interlinked strands - operational training downwards and awareness training upwards. Whereas in the past technical assistance projects such as this have tended to concentrate only on training in the operational aspects of the system, this project aimed to ensure buy-in of the project objectives at all levels by providing awareness training to senior management as well. The following outlines the key training activities carried out during the implementation phase:

- PWD Senior Management Progress Review Meetings held monthly in PWD Headquarters. These briefed managers on project progress and programme; raised issues requiring management intervention; discussed problems and agreed on solutions; and provided a forum for open discussion of project objectives.
- Workshops with PWD Divisional Managers to demonstrate the RAMS/RMMS software and to allow managers to familiarise themselves with the operation of the system and the reports that can be produced.
- Half-day workshops with PWD Road Supervisors and Depot Clerks at Divisional headquarters to outline project objectives; describe the operation of the system and what they need to do help to make it work; show how RAMS/RMMS will help make them more effective at managing their roads; and provide a forum for feedback.
- Half-day workshops with PWD Foremen and Leading Hands at PWD Depots to outline project objectives and to describe the operation of the system and what they need to do make it work.
- 3 day training workshop for 8 PWD Engineers on the HDM-4 road investment modelling and analysis software adopted for the RAMS/RMMS run by PIARC certified trainers from Australia. This workshop included a half-day session outlining the principles of HDM-4 analysis for a much wider audience from Road Supervisors up to and including the Minister of Works and Energy.
- Study tours for PWD senior management and counterpart staff to New Zealand to expose PWD managers to 'state-of-the-art' road maintenance management practices.
- Consideration being given to send the designated future manager of the RAMS/RMMS to study for an MSc in the UK in highway maintenance management.

All team members, including PWD counterpart staff, were involved in carrying out these training sessions. As the project progressed responsibility for facilitating and managing training and awareness sessions was increasingly handed over to those PWD personnel who would be taking over the running of the RAMS/RMMS after the departure of the full-time specialist staff. The reasons for this were two fold; firstly as a form of awareness training for the counterpart staff themselves and secondly to expose these personnel to training methods which they would need to use to continue training after the Consultant had left.

To test whether training and technology transfer had been successful a formal review and evaluation process was carried out with key operators and managers of RAMS/RMMS. This was an iterative process which comprised an evaluation exercise - a gap-analysis - to determine the level of competency achieved; followed by appropriate training to fill the gaps in knowledge; followed by a further evaluation. This process can be summarised by the 3 Ts – Train, Test, Transfer (of responsibility).

An important part of training and technology transfer is the preparation of system documentation to assist operators and managers carry out the required tasks. While all of the software and hardware procured for use on the project was provided with operation manuals and instructions, these are not project specific and it was therefore necessary to prepare User Guides and a series of Work Instructions covering all processes within the system. These included a *'Guide to the Measurement of Road Condition Data'*, a *'CONFIRM User Guide'*, and a *'GIS Data Management Manual'*. Ongoing development of this documentation, including the development of low level training documentation, will become the responsibility of the PWD personnel managing the system.

To conclude, the success or failure of a technical assistance project such as this hinges on the success of training and technology transfer in equipping and motivating the recipients, the PWD, to take over ownership and management of the system, and to take the lead in the integration of the RMMS/RAMS into the day-to-day operations of the department.

4.2 System Support and Maintenance

The provision of ongoing support after the departure of the Consultant is essential to the sustainability of a project such as this. This requires a phased withdrawal of expatriate staff from the day-to-day running of the system until such time as all parties are confident that the recipients are able to manage and operate the system without any external assistance.

In this respect it has been agreed that members of the Consultant's team, including the GIS Specialist, the Data Collection Equipment Specialist, and the RAMS/RMMS Training Specialist, will carry out regular visits to Fiji to review progress and help resolve problems. In addition, regular telephone and e-mail contact will be maintained between the PWD managers of the system and these specialists to deal with problems as they arise. This level of support, known as implementation support services, will be provided initially for two years after the Consultant has left, with a review carried out annually.

With respect to software, specific arrangements need to be put in place to ensure the system is sustainable. An important factor when choosing the CONFIRM RAMS/RMMS software package for this project was that it was in use in over 200 installations around the world. It is therefore maintained by an organisation that has the resources to effectively support the software.

Figure 4.1, which shows the support and maintenance structure involving the PWD, the Consultants (Meritec) and the software developers (SBS), comprises :

- Regular visits by Specialists, telephone and e-mail based support from the Consultants based in New Zealand provided through an Implementation Support Services agreement between Meritec and the PWD.
- CONFIRM software support and upgrades from the software developers provided through a Software Maintenance / Support agreement between SBS and PWD.
- A software license agreement between SBS and PWD

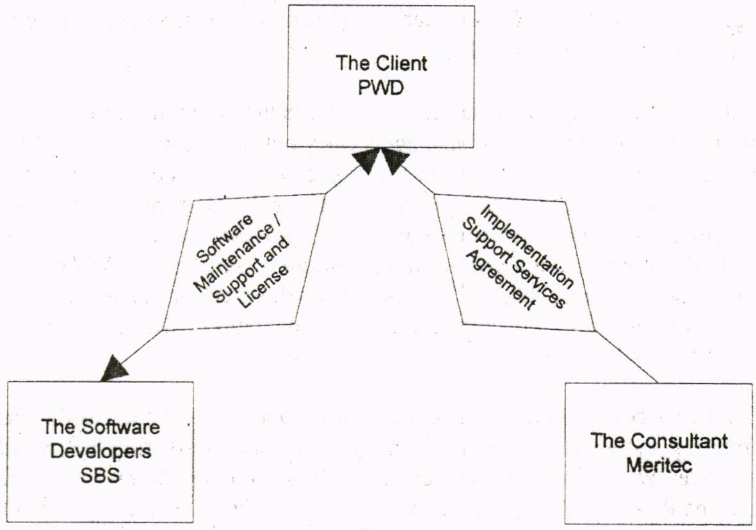


Figure 4.1 - Support and Maintenance Structure

Similarly, and as noted in Section 2.2, one of the main reasons for adopting HDM-4 as the road investment modelling and analysis tool for this project was that it was supported by ongoing and independent research and development through ISOHDM and included software support through the HDM-4 Information Centre website. The alternative of continuing with the development of a bespoke road investment modelling and analysis tool would have made the Pavement Management System very difficult to sustain and support.

To conclude, it is considered that this project would not be sustainable without the support and maintenance provisions described above, elements of which should be included in all technical assistance projects.

REFERENCES

Baleilevuka, P and Salt, PE (2000) A Road Asset Management System for Fiji. **Proceedings 10th REAAA Conference,** Tokyo, Japan, September 2000.