A ROAD ASSET MANAGEMENT SYSTEM FOR FIJI

(Road, Bridge Maintenance Management Systems/Pavement Management Systems)

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Mr Baleilevuka joined the Public Works Department as a technician in 1977 and has been involved in all aspects of road maintenance activities. He was local counterpart to the FRUP 1 and FRUP 2 programs (1987 - 1997), before assuming his present position in 1998 in the US$ 90 million FRUP 3, where he has a key role in promoting the acceptance and ongoing implementation of the new systems. He is a Corporate Member of the Fiji Institution of Engineers and an Ordinary Member of the REAAA and holds a Bachelor of Civil Engineering from the University of Technology, PNG.

Mr Salt is a Senior Consultant with the Roads Division (International) of Worley Consultants Ltd. His 30 year engineering career has been spent working on a wide variety of special projects, lately in the transportation field. He has led major transport management related projects in India and Mongolia and worked on projects in New Zealand, Canada, Africa and Asia. He is a Member of the Association of Professional Engineers and Geoscientists of British Columbia (Canada) and of the Institution of Professional Engineers of New Zealand and holds master's degrees from the University of Auckland, and the University of British Columbia.

1. INTRODUCTION

The Government of Fiji, as part of FRUP-3 has engaged Worley Consultants Ltd to implement a comprehensive Road Maintenance Management System and Road Asset Management System (RMMS-RAMS). The project runs from March 1999 to May 2001 and covers the 900 km of sealed roads, 4,300 km of unsealed roads and 1200 bridges and major culverts under Public Works Department (PWD) jurisdiction. The schedule calls for a pilot system for the Central/Eastern Division in early 2000, and implementation on all three divisions in the year thereafter. The project is running close to schedule.

2. OUTLINE OF THE INTEGRATED SYSTEM

The complete system as illustrated in Figures 1 (input) and 2 (output) is an integrated bridge/road routine maintenance system and pavement management system, sharing inventory and database and making use of a geographical information system (GIS), initially as an output interface. The network condition is measured in terms of roughness (IRI) and a visual condition rating, plus carriageway strength. A right-of-way (ROW) video recording is being made of the entire network. Traffic data is obtained from permanent traffic count stations at intersections.

3. COMPUTER CONFIGURATION

The system is established on a centrally based Local Area Network (LAN), supplemented by standalone work stations at the Western (Lautoka) and Northern (Labasa) Division Offices. The Head Office LAN is shown diagrammatically in Figure 3. The Western and Northern Division installations (not shown) will consist of a workstation, including a tape backup, laser printer and an A3 colour bubble jet printer.

4. DATA COLLECTION EQUIPMENT

4.1 The Test Vehicle

A 4WD landcruiser type of vehicle is used to host the data collection equipment. The laser profilometer is mounted on the towbar fitting; video cameras are mounted on a custom roof rack; the bump integrator is mounted in the vehicle cabin floor over the rear axle and the calibrated odometer is fitted on the back right hand wheel. The profilometer and bump integrator outputs are recorded directly on a laptop computer. The equipment is operated from a small wooden bench installed in the rear right seat. All equipment is demountable and can be easily packed for shipping. The only non-standard vehicle requirement is an 80 amp alternator or larger. A data acquisition system is used to record visual condition of the road and location reference points (LRPs). The equipment was assembled, tested and calibrated in NZ by subconsultants, OPUS Central Laboratories, prior to installation in Fiji. The bump integrator was calibrated in Fiji against the laser profilometer. With minor exceptions, the system has proved to be sufficiently robust for Fiji operating conditions.

4.2 The Bump Integrator

The common, spring loaded, retracting wire type bump integrator is attached to the centre of the rear solid axle in a half car configuration. The calibration is specific to the vehicle and is dependent on the state of the vehicle load/shock absorbers/springs/tires. Output is speed dependant so a reasonably uniform recording speed is required. Frequent re-calibration (or validation against test sites) is essential for accurate measurements. It is used on gravel roads, but for calibration/validation it can be used simultaneously with the laser profilometer on sealed roads.

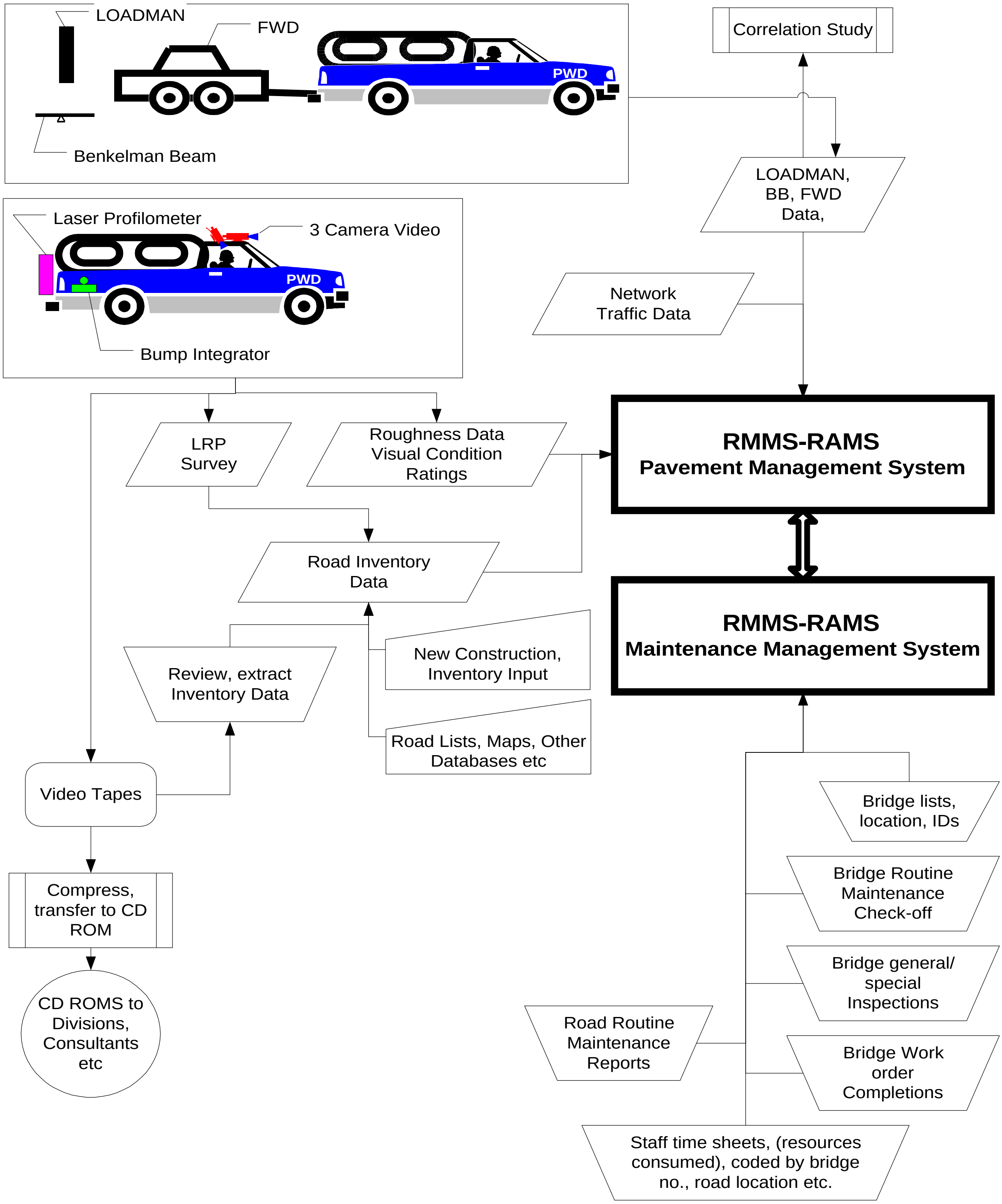

Figure 1: System Outline, Input

4.3 Laser Profilometer

The system uses a commercially available, two-laser, portable profilometer for measuring roughness (IRI) and texture on the sealed roads. The system was checked for calibration against test sites in NZ established using a Class 1 walking profilometer (for roughness) and the Transit NZ Stationary Laser Profiler (SLP) for texture.

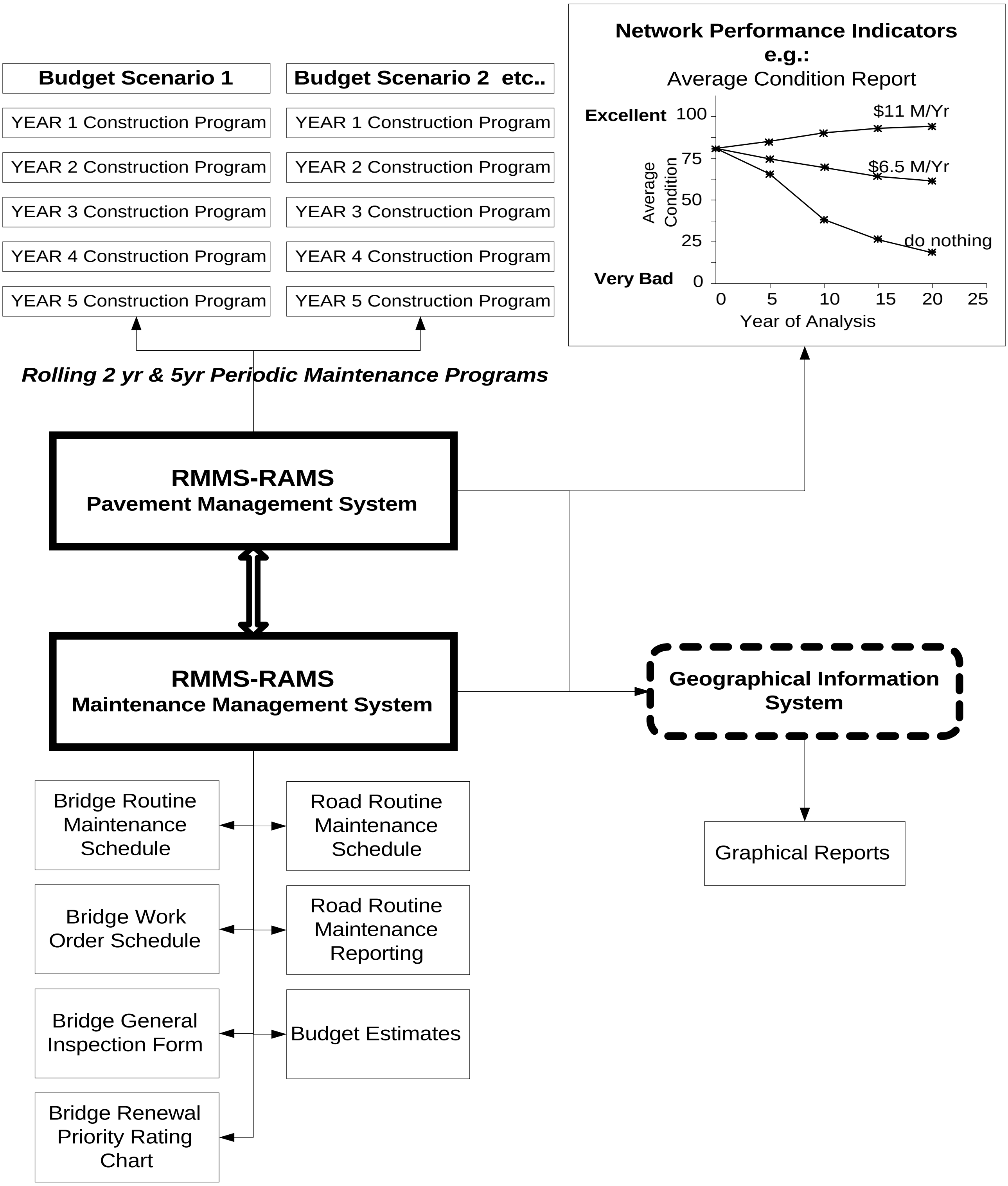

Figure 2: System Outline, Output

4.4 Strength Measurements

The terms of reference for the project specified carriageway strength testing using an FWD and allowed a provisional sum for equipment purchase. However contracting services rather than equipment purchase proved to be a more attractive option. This was due to combination of the high cost of new equipment and the very competitive tenders received for contracted services. Capacity of the equipment was also a factor. The Fiji wide survey of sealed roads, including validation tests took only about three to four weeks. Purchased equipment may have stood idle for much of the 2 - 3 years between network surveys.

In conjunction with the FWD testing, a correlation exercise has been carried out using coincident measurements with Benkelman Beam (BB) and LOADMAN (LM), a portable drop hammer type of device. The correlation was not strong, but some promising results were obtained and monitoring of the test site strengths using the BB and LM is continuing.

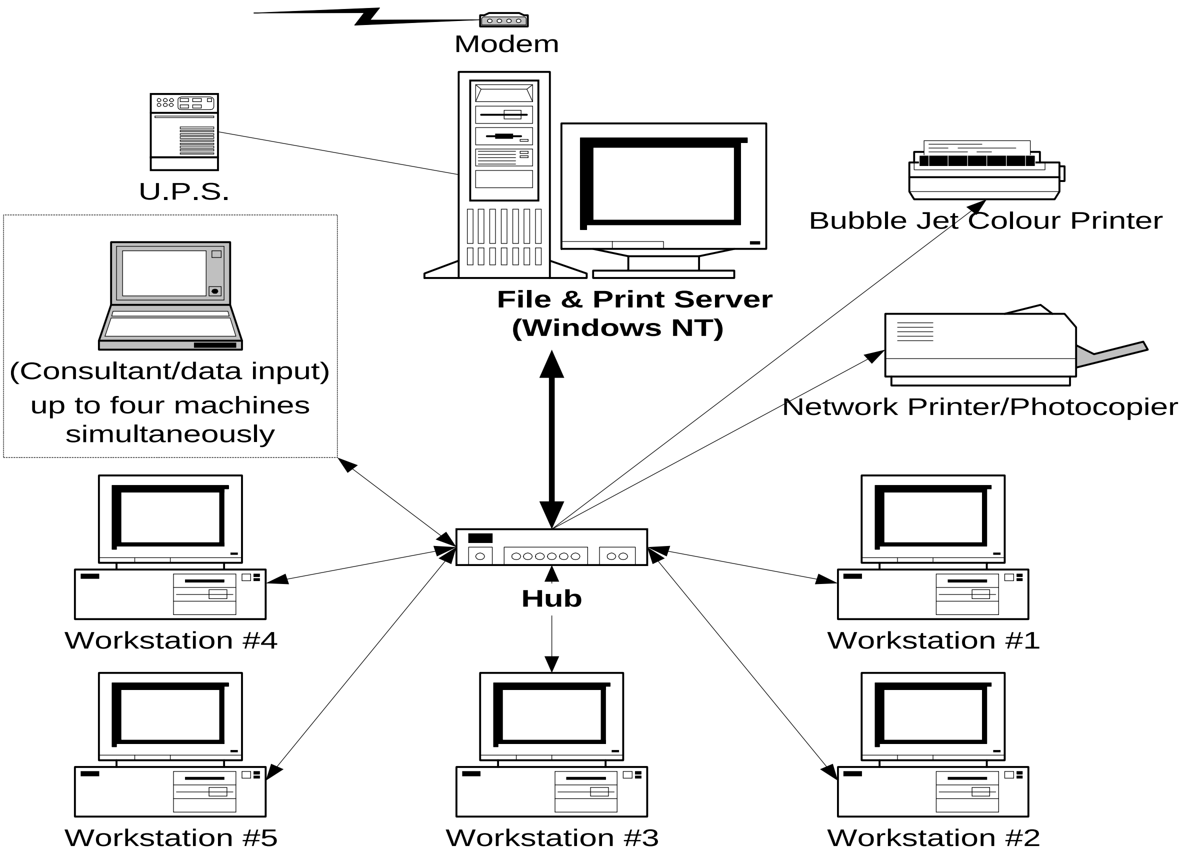

Figure 3: Computer Configuration

4.5 Right-of-Way Videos

The host vehicle was fitted with a three-camera video logging system using commercially available cameras installed in weather proof mounts on a custom roof rack. The miniature recorders were linked with customized adapters and controllers. The camera mounting locations, directions, focus etc were determined during acceptance trials in NZ and adjusted on the host vehicle in Fiji. The video image has a header data overlay consisting of the road name and the unique road ID number (entered by the operator), the date and continuously recorded odometer and vehicle speed readings. Most of the right-of-way (ROW) video tapes have been converted to a compressed digital format for copying on to CD-ROM disks for distribution to Divisions and staff of the PWD.

5. LOCATION REFERENCING; INVENTORY, TRAFFIC, ROAD CONDITION DATA

5.1 The Location Reference System

The project uses the classical approach to location referencing. A clear distinction is drawn between:

- the *location reference method (LRM),* which is the field method of specifying location on a highway. Fiji, like most highway jurisdictions, uses the ± offset distance in metres from a known physical point (location reference point, or LRP). A positive offset is in the defined positive direction of the road (i.e. start to finish), negative in the opposite.
- the *location reference system (LRS),* which is the set of office procedures, maps, known relative and absolute locations of LRPs, the computer system etc which will allow the LRM to be interpreted in terms of accurate, global and relative locations.

The project inherited culvert markers as the default LRP system, an unfortunate choice for various reasons. The Consultant has recommended phasing out these in favour of kilometre posts. Locations and listings of existing LRPs were neither comprehensive nor accurate, so an LRP survey was a high priority, carried out in conjunction with the bump integrator and video survey.

5.2 Collecting Inventory Data

Collecting accurate, reliable road inventory data by manual methods in the field is tedious and time consuming. Most, but not all inventory data can be obtained from video tapes. While this does not eliminate the tedium, it does transform the process into a routine office exercise, more flexibly scheduled around staff availability than field work. Processes have been developed and tested for obtaining inventory data from video tapes for direct entry on custom designed spread sheet forms for later import to the RMMS-RAMS.

5.3 Traffic Data

Traffic information required for the RAMS consists of classified AADT or ADT for each of the network links, traffic growth trends, seasonal factors for roads affected by seasonal variations and average ESAL for vehicle class, road class and region. For network planning purposes, traffic counts should be repeated at regular intervals in order to establish growth patterns, both with time and with changing traffic distribution.

During the Inception Stage, the Consultant Traffic Engineer led a review and discussions on procedures and coverage and made some recommendations. Thereafter all data collection has been managed and executed by the Traffic Group within PWD Head Office.

The PWD had permanent counting stations covering most of the significant roads, in terms of traffic volumes in the Fiji network and had a good recent counting history. The counting station configuration was oriented towards design, with classified, directional counting occurring mostly at intersections. There was a gap in extended duration counts needed to determine the daily/weekly/monthly/seasonal variations in AADT estimates and there were some minor lapses in network coverage. Before this project, there was no sustained program for axle load surveys, although excellent portable weigh stations were available.

RMMS-RAMS uses homogeneous link counts. These can be obtained from intersection counts by inspection and manipulation, determining which intersection counts contribute to which link counts and confirming the resulting "link" counts are homogeneous, i.e. the intersection counts at each end of a link and any mid link counts are approximately equal. A simple task in principle, but which in practice takes about a person month for each division. Fortunately it needs to be done only once.

5.4 Road Condition Data

A visual survey of the road condition is made at the same time as the bump integrator/LRP survey. Coded condition indicators are entered directly to the data acquisition system by an operator using a keyboard from the vehicle front seat while travelling at 30 - 60 kph. Codes are kept as simple as is practicable. Unsealed roads have a four step code (graded, gradeable, requiring re-sheeting, requiring reconstruction). Sealed roads are assessed on the basis of cracking (4 steps), ravelling (4 steps), edge distress (3 steps) and rutting (2 steps). Step 1 is always the "satisfactory" indicator.

6. SOFTWARE SYSTEMS

6.1 Introduction

The project included supply of all software, including office productivity applications. The LAN uses Windows NT and the usual range of applications software. ArcView has been recommended as the GIS software and will be acquired and installed in August 2000.

The RAMS-RMMS software is being supplied by a UK firm, SouthBank Systems Plc, who were nominated subconsultants in the proposal and who assisted in its preparation. For this application existing software is being customized and redeveloped. A major necessary adaptation is to embody a location reference system so that all data, inventory and activities can be accurately located in terms of the accepted location reference method (LRM). Bulk data is assembled in spreadsheet format before being loaded into the RMMS-RAMS database. The bridge, road maintenance and asset (pavement) management systems are set up as procedures and menu structures in the RMMS-RAMS.

6.2 The Bridge Maintenance System

The bridge maintenance management system encompasses two processes:

- a *routine maintenance process*, to ensure that all bridges are visited on a three monthly cycle and are subjected to the routine maintenance procedures (mostly cleaning and debris removal) on a regular basis by road maintenance gangs and;
- *a bridge inspection process*, for inspection and grading of specific bridge components by qualified personnel every 1 to 2 years. The gradings contribute to an overall renewal priority rating for the bridge and may also generate work orders for repairs.

The processes are shown diagrammatically in Figures 4 and 5 respectively. Any components which show significant deterioration will automatically generate work orders, whose degree of urgency, ranging from action within one week to action within six months is the basis for the grading.

The priority for bridge renewal is established by a weighted sum score of individual components. Weighting is heaviest on the key structural/safety components. The overall rating process will be further evolved as experience is gained with the Fiji bridges.

6.3 The Road Routine Maintenance Management System

The process for road routine maintenance is shown in Figure 6. It is very similar to the process described by Figure 4, for bridge routine maintenance, with one key difference. Road maintenance activities are assigned a location, either point or extent using the standard location reference method, i.e. a named location reference point ± offset in meters. This feature will facilitate central reporting of troublesome and expensive routine maintenance areas and thus will assist in national level strategic planning and budgeting.

6.4 The Road Asset Management System

The terms of reference for RAMS requires the use of HDM III/4 modelling in evaluating road upgrading and maintenance strategies that maximise the economic returns from road maintenance expenditure.

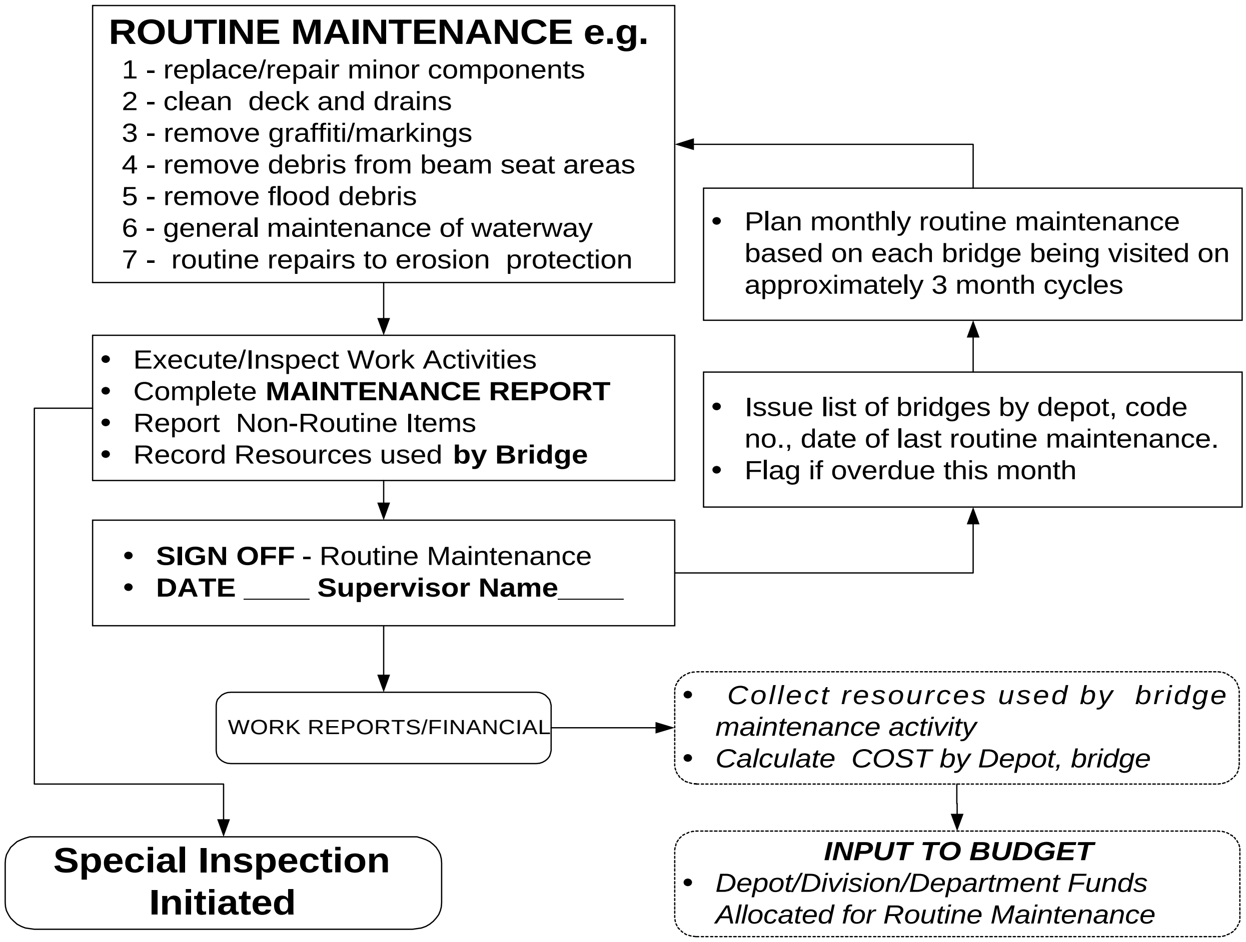

Figure 4: Bridge Maintenance System, Routine Maintenance Process

The proprietary RMMS-RAMS is a software tool that acts as a shell, much like a calculator, allowing the user to enter pavement deterioration models to predict a road's performance, and the economic benefits relative to a "do nothing" scenario for various maintenance options. Benefit is in terms of reduced vehicle operating costs.

Several maintenance strategies are generated for each road section, ranging from a low cost, low benefit "holding" strategy to higher cost, higher benefit reconstruction. This is the setting for the classical linear programming problem of selecting, over the entire network, the set of sections and their treatments which will maximise overall benefit for the network under a cost budget constraint.

At present, the HDM 4 pavement deterioration and user cost models are not yet finalised; release of the HDM 4 software is imminent. In the interim, the Pilot Study RMMS-RAMS is being set up using the HDM III models. In effect, the RMMS-RAMS emulates HDM III software by using the same equations that have been hard coded into the latter.

For the Pilot Phase a very limited series of maintenance strategies are being considered, since the immediate goal is to rescue the aging network from further serious deterioration in the medium term. As the system application matures, more emphasis will be placed on fine tuning maintenance strategies to reflect long term planning and steady upgrading of the highway network. Figure 7 outlines the analysis process.

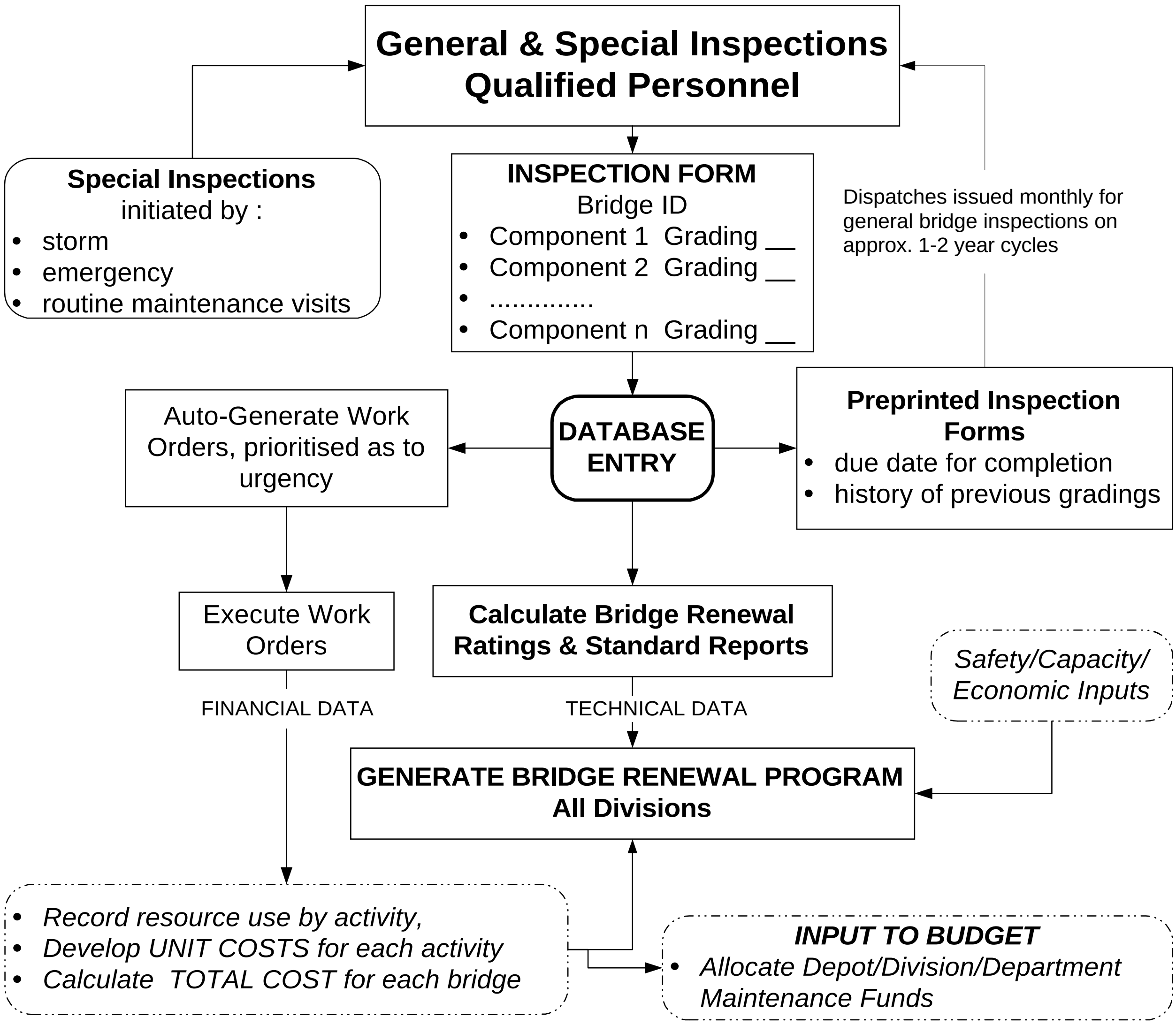

Figure 5: Bridge Maintenance System, Bridge Inspection and Renewal Program

6.5 The Geographical Information System (GIS)

The RMMS-RAMS as supplied is interfaced with GIS which will operate on existing hardware. GIS will be installed on both the Head Office LAN and the Division workstations commencing in August this year. The use of GIS is well established in Fiji and there is a suitable digital reference base available from the Fiji Land Information System (FLIS), Fiji Department of Lands and Survey. A previous road survey established coordinates on most roads at 10 metre intervals.

While the GIS has been initially conceived as a specialist output system for the RMMS-RAMS, it is highly likely that as skills increase and the database is extended, GIS applications will assume much greater importance as a separate and distinct tool in the overall highway information system.

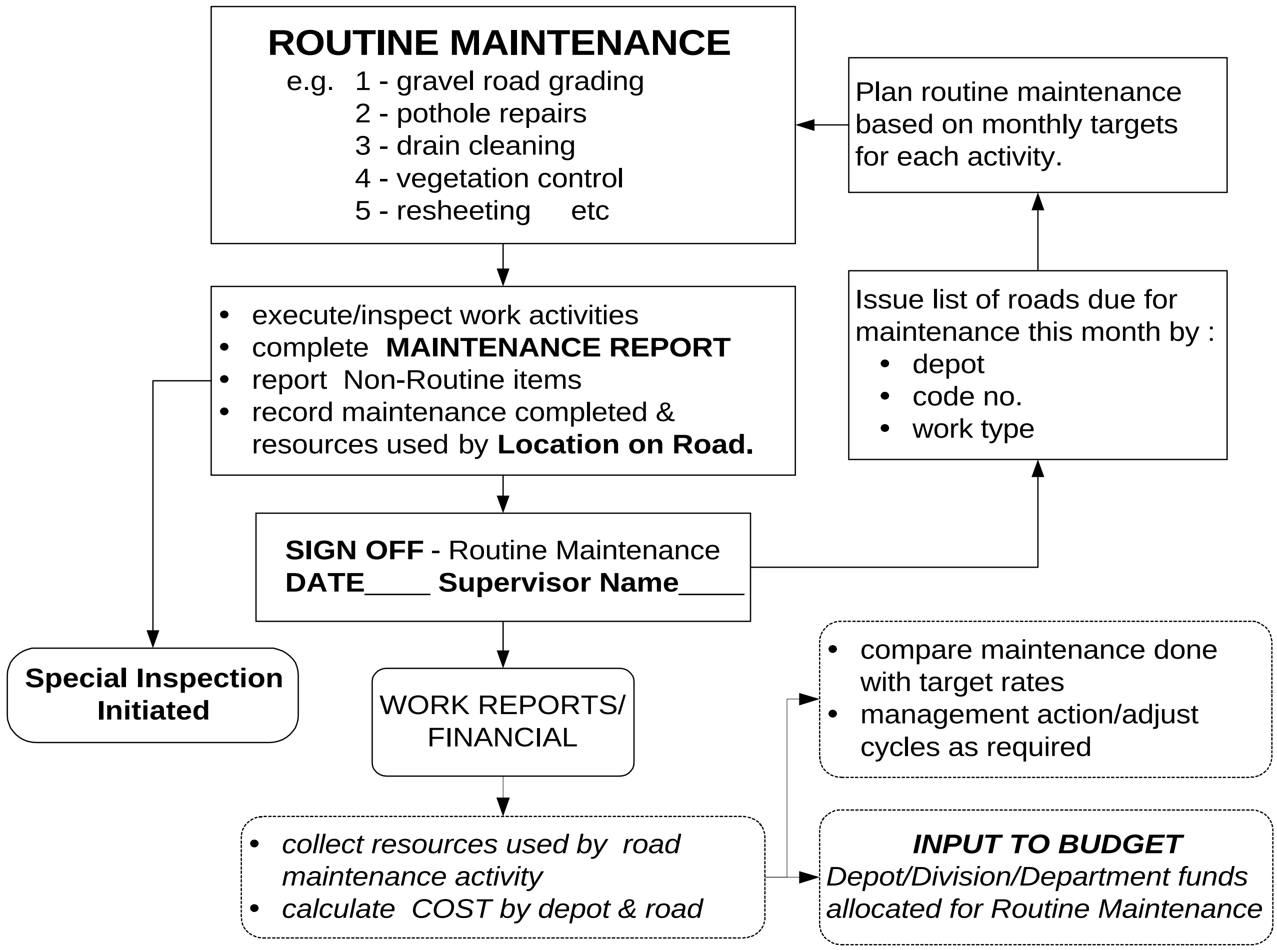

Figure 6: Road Maintenance System, Routine Maintenance Process

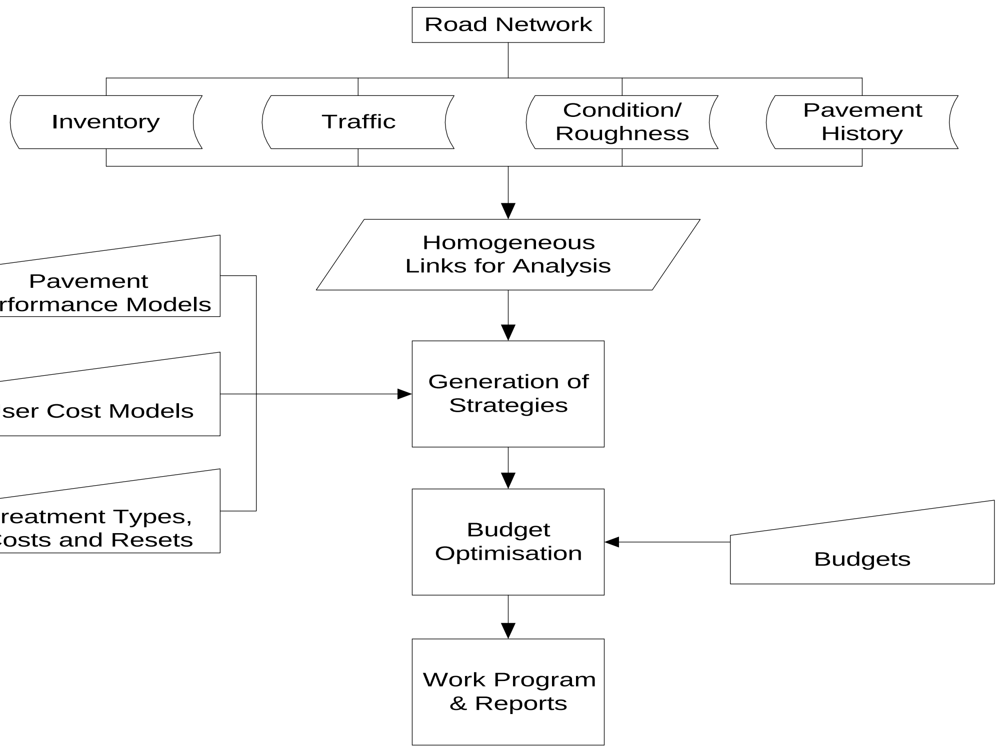

Figure 7: The Road Asset (Pavement) Management Process

7. IMPLEMENTATION AND TRAINING ISSUES

The RMMS-RAMS will be handed over to PWD staff as a going concern in May, 2001. A full time counterpart who will eventually assume responsibility for the management of the system is working with the team and all data collection is being carried out by local staff, after initial training and supervision by the Consultant equipment operations specialist. There is still a major component of training pending as the operational responsibilities are transferred to divisional staff during the implementation stages. The system represents changes to the present operations of the PWD, complementing already foreshadowed organisational changes designed to produce more effective road network management.

The Consultant cannot bring about the necessary changes. That is ultimately the prerogative of operations management. At best, the Consultant can operate as a change manager. Figure 8 illustrates the process. To this end, regular presentations have been made to senior staff throughout the project to increase general awareness. Training and technology transfer must be driven both from the top down as well as the bottom up. The operators of the system must be trained to promote their new skills and output, and their superiors in the organisation must be made aware of the opportunities arising from the new systems and information.

Ultimately the PWD will assume responsibility for implementing changes to operations to take full advantage of the opportunities offered by this state of the art system. This is a challenge which lies ahead for the Fiji Public Works Department, and its successors.

Implementing Change

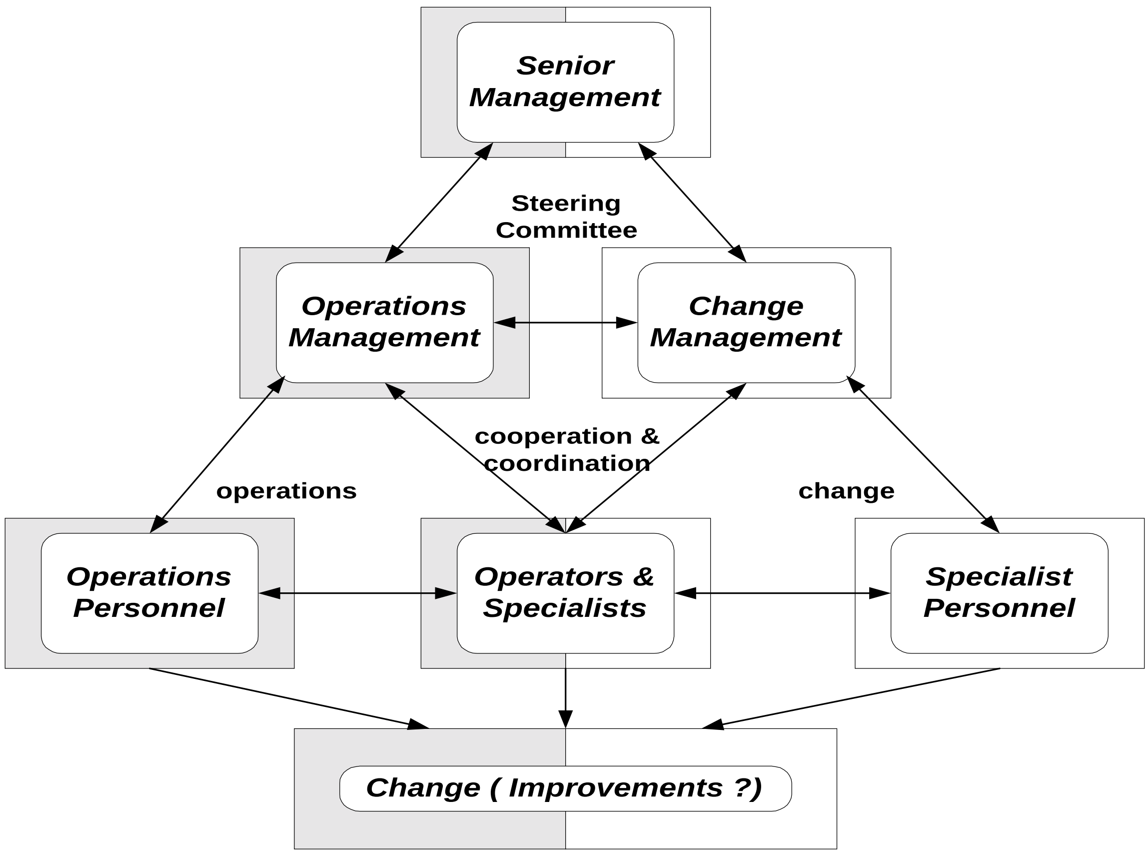

Figure 8 Training Issues, Change Management