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Kemitraan Australia Indonesia

STRATEGY REVIEW OF THE CURRENT INDONESIA ROAD MANAGEMENT SYSTEM

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INFRASTRUCTURE
INITIATIVE

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September 2010

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Jens Chr. Helbech Hede

Jakarta, September 2010

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ACRONYMS

AADT	Annual Average Daily Traffic
AAR	Annual Asset Report
BBD	Benkelman Beam Deflection
BMS	Bridge Management System
CAT	Client Approval Test
COTS	Commercial-off-the-Shelf
DGH	Directorate General of Highways
DMI	Distance Measuring Instrument
EHIM	Executive Highway Information Module
EINRIP	The Eastern Indonesia National Road Improvement Project
ERM	Economic Review Module
ESA	Equivalent Standard Axles
FWD	Falling Weight Deflectometer
GIS	Geographical Information System
GPS	Global Positioning System
GUI	Geographical User Interface
HDM-4	Highway Development and Management
IRE	Institute of Road Engineering
IQL	Information Quality Level
IRI	International Roughness Index
IRMS	Indonesian Road Management System
LRMS	Local Road Management System
LRP	Location Referencing Points
MCA	Multi/Criteria Analysis
MPW	Ministry of Public Works
MTEF	Medium Term Expenditure Framework
NAASRA	National Association of Australian State Road Authorities (predecessor of Austroads)
NAM	Network Analysis Module
NPC/C	Net Present Cost divided by Cost
NPV	Net Present Value
PIARC	World Road Association
PPBP	Planning Programming and Budgeting Procedures Project
RDWE	Road Deterioration and Works Effect Models
RED	Roads Economic Decision Model
Renstra	Rencana Strategy (Line Ministry Five Year Strategic Plan)
RIS	Road Information System
RMMS	Routine Maintenance Management System
RUC	Road User Costs
SAM	Strategic Analysis Module
SDI	Surface Distress Index
SEPM	Strategic Expenditure Planning Module
SMD	Data Entry System
VPD	Vehicles Per Day
VOC	Vehicle Operating Costs

EXECUTIVE SUMMARY

During the preparation of the first Medium Term Expenditure Framework (MTEF), problems were encountered with the Indonesia Road Management System (IRMS), including: (i) bugs in the system; (ii) system output was not reliable; and (iii) some data was unreliable. Before additional resources are to be allocated to improve the situation, it was decided to review the whole IRMS in terms of its suitability and sustainability for the Directorate General of Highways (DGH) on a medium to long term. This included review of the strategic options available to DGH.

The situational review revealed that the IRMS is a system with many features suitable for DGH operations, and that the IRMS does comprise the standard modules expected by modern road asset management systems, though there is a need for system and model improvements. The review further showed that the data collection approach is excessive and that data quality assurance is at best fragmented, which leads to poor data quality. Furthermore, it seems that the IRMS staff who should be the IRMS champions and drive the IRMS operations, in most cases have been sidelined during the actual use of the IRMS and thus do not have the required capabilities. The IRMS staff are thus not taking the role intended and needed.

The main issues to address include the poor data quality, the weak staff capacity, the lack of business processes that detail how and by whom the system is to be used, and weak implementation of the IRMS system itself. These issues relate to all three factors which have been identified in surveys as needing to be successful, for the implementation of road management systems to be successful (processes, people and technology). It is concluded that the main challenges for DGH in the short term is not the IRMS, but rather the poor data quality and the lack of business processes supporting the implementation of the IRMS.

In order to institutionalise and sustain the IRMS, several improvements are needed; some leading to a re-engineering of the current approaches.

In the short term, the focus should be on:

- Developing and implementing business processes for the planning and programming activities at DGH. It needs to be made clear how the management systems are used in the organisation, and who is responsible for which tasks.
- Adopting a re-engineered data collection approach where the data collection is out-sourced to the Institute of Road Engineering (IRE) and equipment based approaches adopted.
- Undertake a system calibration of the current IRMS and implement some minor system changes. This will ensure that the IRMS will support the business processes where relevant.
- Train the staff involved in implementing the business processes, including system managers and operators as well as those in charge of planning and programming.

In the medium/long term, the IRMS should be replaced by a commercial-off-the-shelf (COTS) system in order to overcome some of the structural barriers within DGH; most significantly system maintenance and staff training. Adopting a COTS system this will be supported by the vendor, through maintenance contracts and training and participation in user groups.

It is noted that only if the short term tasks are completed successfully, will the benefits of the COTS system materialise. If the proposed short term improvements fails, any adopted system (bespoke or COTS) will also ultimately fail.

CHAPTER 1: INTRODUCTION AND BACKGROUND

This activity provides support to the Directorate General of Highways (DGH), under the Ministry of Public Works (MPW), in providing an overview of the strategic options available to DGH in order to sustain and institutionalise the use of the IRMS and Indonesia Bridge Management System (IBMS). The Terms of Reference (ToR) for this assignment requires the following output:

1. Situational analysis
2. Appraise strategic options
3. Workshop to discuss options with senior staff1
4. Development of recommendations
5. Report preparation

At the outset of the services it was agreed to initially only focus on the IRMS; hence the report only provides guidance in relation to the IRMS.

DGH has been managing and operating an IRMS for at least the last 15 years, though early steps were taken in the early 1980s. The IRMS comprises several modules, including: (i) road database; (ii) data entry system; (iii) sectioning module; (iv) network analysis module; (v) strategic expenditure planning module; (vi) programming module; (vii) economic review module; (viii) budgeting module; (ix) enhanced highway information module; (x) statistical analysis module; and several interface features with third party software.

During the preparation of the first MTEF, a number of issues were identified which reduced the benefit of the IRMS application and hindered the IRMS in providing the needed input to the MTEF. The main problems reported were within the: (i) software application (system bugs); (ii) system output; and (iii) data quality. The system exists in multiple versions, several of these still in use, and it is reported that the most recent version (2.1) is not working in the new computer systems in DGH. When preparing the IRMS output for the MTEF, the output shows a preference towards betterment works, and only little focus on preventive periodic maintenance. And finally, while roughness data are considered to be reliable, problems with surface distress data is reported. Based on these problems, it was decided to undertake a strategic review of the IRMS in order to provide the background for a future IRMS strategy for DGH.

It should be noted that if the data used in the analysis is of poor quality, then no system would be able to produce reliable analysis' results. Thus, quality data is required for any system.

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[1] MS powerpoint presentation attached

CHAPTER 2: SITUATIONAL ANALYSIS

In order to provide guidance and a strategy for the future development path of the IRMS, the consultant has reviewed the current situation relevant to the IRMS. This includes not only the IRMS software itself, but also its organisational setup, including the data collection approach adopted.

2.1 IRMS WORK FLOW

The following organisational units are involved in the IRMS work flow:

- Sub-Directorate of System Development and Performance Evaluation; who is responsible for system management and data analysis.
- Sub-Directorate of Planning; who is responsible for planning.
- Sub-Directorate of Budget and Programming; who is responsible for programming.
- Sub-Directorate of Data and Information; who is responsible for data collection management and data collection quality assurance.
- Balai (and their representatives posted in the provinces); who is responsible for data collection, assists in maintenance programming and in monitoring and implementation of maintenance works.

The work flow is described in greater detail below.

2.1.1 Collection and Management of Data

The Sub-Directorate of Data and Information is responsible for management of the *data collection*. The actual data collection is carried out by the Balai's; partly through the 10 Balai offices, and partly through the Balai staff posted at the provinces.

From 2010 and onwards, two annual surveys are to be conducted: (i) one in April-June; and (ii) another in October-December. The October-December survey will include collection of all data (inventories, surface condition, roughness and traffic) and will form the background for forward year budget, while the April-June survey only includes condition data (surface condition and roughness) and is used for reviewing the maintenance programme being implemented for the next fiscal year.

The data is supervised by Balai's staff posted in the provinces, while the actual data collection is carried out by local consultants. Data is entered locally into the IRMS and then quality assured by the Balai's before being submitted to the Sub-Directorate of Data and Information. The quality assurance should involve check of calibration reports, data coverage as well as check for data quality and inconsistencies. It is reported that the quality assurance in the Balai's is still rather weak, and only a few Balai's are actually doing quality assurance to some level. When receiving the data, the Sub-Directorate of Data and Information is assumed to undertake its own set of quality assurance; however, from the discussions it seems that this task would primarily focus on data coverage (i.e. whether all data is submitted). The Sub-Directorate does not make spot checks of data in order to review data quality. It is reported that the data collection and data preparation is often completed late, as compared to its schedule.

The Sub-Directorate of Data and Information has two staff members allocated to the management of the IRMS data collection. These staff members give training to the staff of the Balai's, assist the Balai's when requested and undertake the central level data quality assurance. Training sessions are conducted annually and provides training in data collection, in calibration of the National Association of Australian State Road Authorities (NAASRA) roughness equipment and in data entries into the IRMS. Each training session is for six days.

Data collection budgets are available, but might be distributed late and will reportedly not be sufficient for the bi-annual surveys now adopted.

2.1.2 Data Analysis

When the data collection has been completed and merged into a single database, the data is handed over to the Sub-Directorate of Budget (who is the official recipient) and Sub-Directorate of System Development and Performance Evaluation.

The IRMS system is then used by the Sub-Directorate of System Development and Performance Evaluation to perform network level analysis using the Network Analysis Module (NAM), and Strategic Expenditure Planning Module (SEPM) for optimization of the maintenance expenditures. Three and/or five year programmes are prepared and the output is handed over to the Sub-Directorate of Budgeting, which has also provided the budgets to be used for the constrained analysis.

The Sub-Directorate of System Development and Performance Evaluation is using the outdated version 1.9 for the analysis. Version 2.0 from 2007 (and the later version 2.1), though being available to the Sub-Directorate, has never been adopted. It is also clear that the IRMS is applied with outdated analysis control parameters as well as outdated unit rates for maintenance works and for road user costs. This data has not been updated since 2003, and there seems to be some confusion about who is actually responsible for updating this data.

It is reported that two staff members have the capacity to conduct the analysis. However, the interviews also clearly show that this capacity only refers to the actual navigation of the IRMS, while understanding the analysis' principles and being able to control and/or revise analysis output would be only marginal. It is, in this respect, worth noticing, that the primary IRMS analysis user has an IT background, not a road engineering background.

2.1.3 Planning

The Balai's, through their planning units, are also looking at maintenance needs for the road network under their jurisdiction. At least some of the Balai's are using Highway Development and Management (HDM-4) to do this, instead of the IRMS. However, the main programming is done at the head office level.

The Sub-Directorate of Planning is responsible for five year planning, which would include the Rencana Strategy or Line Ministry's Five Year Strategic Plan (Renstra). It is reported that the IRMS does play a role in this, but not to the degree possible; especially in terms of planning under budget constraints. The IRMS output is used by the Sub-Directorate for comparison to plans submitted by the Balai's. However, as the IRMS is only looking at current roads, while the Renstra includes capital (development) projects as well, the IRMS can only provide input to part of the Renstra. Further, the final Renstra would also include policy requirements (e.g. special focus of development on selected geographical areas).

Ideally, the IRMS should provide the information needed for the Renstra for existing roads. However, for the current Renstra, IRMS has not been used; at least not as intended, even though at least one staff member seems to have a good understanding of how it could provide input to his tasks. Instead, the Sub-Directorate of Planning has been extracting the segment data from the IRMS (NAM) and loaded these into a spreadsheet. Using this data and a linear deterioration model for development in roughness, the Sub-Directorate has estimated maintenance needs (type, cost and timing). This is then directly used in the Renstra, where data is aggregated to provincial level (thus losing the locational reference of each project). The Sub-Directorate also operates with a link based list of roads, where road condition for the link is based on weighted averages of data from the segments (where data is also based on averages). It has been reported, that when the Renstra is prepared the programmes are prioritised as follows: (i) preservation works; (ii) widening project trigged by capacity problems; (iii) widening projects based on policy decisions; (iv) prioritised corridors; (v) ongoing projects; and (vi) projects from the national strategic road plan.

The Sub-Directorate of Planning is not undertaking traditional strategic expenditure planning, though the Renstra would have elements which could be considered as part of such planning. Hence the IRMS capabilities for supporting development of strategic expenditure plans have not been adopted by the Sub-Directorate.

2.1.4 Five year programmes for road maintenance

The Sub-Directorate of budgets is preparing five year programmes, where work type (routine maintenance, periodic maintenance or betterment work), cost and timing are given for each link. It is noted that, contrary to normal best practices, routine maintenance is not assigned to each link annually. While the works are given on link basis, it may cover only part of the link, and may include a combination of work types. While this is what the IRMS is designed for, it is not used by the Sub-Directorate due to experiences with the poor data quality, proposed costs, and proposed work types[2]. If IRMS output is applied, it seems to be narrowed to comparing needs between provinces. Instead, the Sub-Directorate estimates the portion of each link which is in good, fair, poor and bad condition and uses this to estimate the maintenance needs[3]. The data used for this is originally captured from the IRMS, but is corrected with additional information; for instance from the local government. Having adopted a link based approach, where the condition of the link is grouped into portions of link length in good, fair, poor and bad condition, the maintenance works are not referenced by location, but exists only as aggregated lengths within the link. Normally, maintenance programmes would locate the section (with a ‘from and to’ chainage) needing maintenance work. The maintenance works are based on roughness alone, though the Sub-Directorate does report pavement cracking to be an issue on the roads.

Contrary to the prioritisation mechanism reported by Sub-Directorate of Planning, the Sub-Directorate of Budgeting prioritises under budget constraint corridor expansion before preservation

[2] The two latter might be a result of the first

[3] Good and fair portions will receive routine maintenance, poor portions periodic maintenance, while bad portions will receive betterment work

works[4]. Within road preservation and rehabilitation, the periodic maintenance and betterment works gets first priority[5].

When preparing the programme, the Sub-Directorate is analysing the needs for maintenance to increase the portion of the road network in stable condition from 86 to 94 percent by the end of the programming period. This is done by estimating how much road length needing periodic maintenance or betterment work is required to be maintained to increase this percentage by 8 percentage points. While this approach will certainly move poor and bad roads to the good category, the analysis does not include an evaluation of how many of the roads in fair condition (or good condition) will fall into the unstable condition during the period of the proposed programme, if not maintained properly.

2.2 OWNERSHIP AND MANAGEMENT OF IRMS

The IRMS system is *owned and managed* by the Sub-directorate of System Development and Performance Evaluation. The Sub-Directorate is divided in two units; (i) System Development; and (ii) Performance Evaluation. While the System Development Unit takes ownership of the IRMS, the Performance Evaluation Unit reports on different statistics[6].

The System Development Unit has about six staff members; most of these being graduate engineers, while a few have only high school diplomas. The latter staff members are tasked for data processing for reporting purposes.

The staff is responsible for operating and management of the IRMS.

In terms of *system management* it was reported (though conflicting statement was noted) that they conduct regular meetings to discuss the system bugs and appropriateness of the system; the most important of these is an annual meeting with internal IRMS stakeholders and end users of system output. The outcome of this meeting is a list of issues which could improve the use of the system. The sub-directorate is assisted by a local consultant to review the list of issues and make recommendations on their implementation. In terms of appropriateness, it seems that the sub-directorate can take a critical view of the IRMS and its analysis output; the review of the pattern between periodic maintenance and betterment work programmes for different combinations of conditions and traffic being an example.

The sub-directorate is managing and overseeing the implementation of the agreed enhancements; but the actual work is carried out by contracted local consultants. It was reported that local consultants were engaged on one-year contracts to support system maintenance. However, no evidence of this could be found (except for the ongoing contracted assistance that commenced only recently).

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[4] Due to the policy target of widening 19,370 km of roads

[5] As these works types supports the overall policy of reaching 96 percent of the road network in stable condition

[6] Statistics on speed, veh-km, length of new roads and road network condition (stable/unstable)

2.3 OTHER STAKEHOLDERS

In terms of IRMS operations and management, other stakeholders could be of interest. The main among these would be the IRE, which is reporting to the Agency of Research and Development under the MPW. The institute is organised in two units: (i) technical advisory; and (ii) planning. While the planning unit, on a case-by-case basis, is called upon to review plans made by the DGH, the technical unit undertakes road and bridge surveys. The surveys are not part of the IRMS surveys, but focuses instead on project level surveys. Besides road and bridge condition surveys, the institute has its own material testing facilities, and thus also performs material testing of asphalt, unbound materials, concrete/steel and road markings. For road condition surveys, the institute operates a limited list of equipment. It has one vehicle with Hawkeye equipment (video for cross section recording and laser beam); another vehicle with laser beam only and a Falling Weight Deflectormeter (FWD). It is reported that the equipment is in good shape and is calibrated properly.

Though several staff members have been trained in the IRMS, IRE does not have a copy of the system and is not using it. Similarly, about four staff members have been trained in HDM-4, but the system is not in regular use. In total, IRE has about 320 employees, of which 75 are labelled researchers (most of them being engineers).

Another potential stakeholder to the IRMS would be the universities. In general, it has been reported, that the universities are lacking behind the needs of society, as research is often done through the projects that the universities are involved in, rather than through up front research. The three most important universities have formed infrastructure agreements in order to stand stronger for application for research funds[7] and for promotion of research in infrastructure. In infrastructure, courses are offered in: (i) roads infrastructure; (ii) waterways; and (iii) sanitation. Within roads infrastructure, structures are the preferred choice of the students, but roads are still considered a popular choice. All studying roads will need to take the mandatory Highway Engineering course, which includes training in basic road knowledge (materials, geometric design). In addition to this, more advanced courses are also provided such as: (i) advanced geometry; and (ii) advanced payment design. In the latter course (which has an average of 15 students at the University of Indonesia), the students will have issues which touches on road management (e.g. road maintenance), but there is no course which is specially focusing on road asset management (the mindset and how methodologies and systems can be applied).

2.4 STAFF CAPACITY

The ownership of the IRMS rests with the Sub-Directorate of System Development and Performance Evaluation, which makes this Sub-Directorate a cornerstone in the IRMS application. They maintain the official central IRMS database and support the DGH in data collection, analysis and presentation. Of a total of about 35 staff members in the sub-directorate, about six would be working on the IRMS to some level. However, it was an external consultant who presented the IRMS to the consultant. This clearly indicates that while the DGH staff might be able to handle some data processing, the capacity in DGH to operate and manage the IRMS is limited and needs instant improvement. This is also supported by the fact that only a couple of staff members can actually run the IRMS, while no staff member understands the intelligence adopted in the system.

[7] Since 2009, 20 percent of the national budget has been allocated to education. This includes a number of research grants, which the universities are competing for

It also seems that training has not been applied since 2007, where the last IRMS consultant demobilised.

On the positive side though, it is noted that there is a local industry which can be involved in IRMS maintenance and development, both in terms of training in system operation/application (to some degree), and also in terms of system software maintenance and development. However, in terms of the software development, the local industry has not been involved in the core and complicated parts of the IRMS (such as the NAM and SEPM modules). Thus, changes in these modules would be difficult to undertake by the local industry.

It is noted that several key staff persons involved in programming and planning activities using the IRMS, while being engineers, actually do not have a road engineering background. This is reported to be a structural barrier in DGH (and other similar organisations).

In the Sub-Directorate of Data and Information, only two staff members are assigned to IRMS activities, and only part time. For management of the data collection, this is insufficient.

The number of staff members in the Balai's ranges from 30 to 50. In some Balai's they do have acquired knowledge on how to adopt the HDM-4 for programme level analysis; the Jakarta Balai's is thus now training 2-3 other Balai's in the use of HDM-4. However, this capacity level cannot be stretched to the rest of the Balai's, and there is assumed to be significant capacity levels between the Balai's, the Balai's from Sumatra and Java being those with the highest capabilities.

2.5 USE OF IRMS

It seems that the IRMS output has been contributing to the development of the current Renstra. Though it is unknown as to who has done the analysis (whether IRMS staff or [local] consultants), is shows that the IRMS has its place in the business processes of DGH and can provide output for further processing.

The IRMS has also recently been used by an international consultant to support the development of the MTEF8. Besides this, it seems that IRMS is used regularly by Sub-Directorate of System Development and Performance Evaluation to development input to different tasks which rests with the sub-directorate. One of the tasks undertaken is the annual reporting on the overall condition of the road network (percentage in good, fair, poor, bad and very poor9) and analysis of maintenance needs for the maintenance programming which, however, is not used in the actual programming (see earlier section). The IRMS is also used to provide input to specialised assignments/report10.

While the IRMS has Geographical Information System (GIS) mapping capabilities, it is significant and noted that no maps from IRMS were hung on the walls or readily available. Maps are a very suitable communication tool for road data; thus the fact that no maps were available indicates that the IRMS, with its large amount of data, is not used to support the daily activities in DGH to the extent possible either because DGH is not aware that mapping can provide great benefits to its operations, or because IRMS staff cannot operate this module of the IRMS.

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[8] However this is where significant output issues were reported

[9] This condition reporting is purely based on roughness figures

[10] See for instance the 'National Road Sector Assessment, 2005-2009, and Strategic Plan 2010-2014', DGH, November 2009, where a 'IRMS footprint' can be seen

It is clear that the IRMS currently is not used to its full potential. There are many features of the IRMS which is not used which potentially could provide benefits to DGH, and the IRMS output is not fully adopted in the business processes in DGH. If the current IRMS were to be used to its full potential, this would assist in system institutionalisation and organisational commitment.

2.6 DATA COLLECTION FRAMEWORK

Data is collected on: (i) road inventories; (ii) roughness; (iii) road surface condition; and (iv) traffic.

Road inventories' is collected *annually* and includes a range of information on the existing roads, including: (i) road type; (ii) surface information (year, type, width); (iii) shoulder (type, width); (iv) ditch (type, depth); (v) road alignment (vertical, horizontal); and (vi) land use.

Roughness is collected *bi-annually* using bump integrators (NAASRA). This is a practical approach which is deemed suitable for the conditions in Indonesia. Each province has its own bump integrator equipment. To return reliable roughness values, the equipment needs to be calibrated before surveys. This is typically done with the dip-stick. Ten sets of dip-sticks are available, and it is reported that the systems are used to calibrate the bump-integrators in the provinces prior to data collection. It is also reported, that the Sub-Directorate of Data and Information makes spot checks of the reported roughness with the five sets of Roughometer residing centrally. There are, thus, quality assurances in place in relation to the data collection on roughness.

Data on surface distresses is collected *bi-annually* by visual inspections by teams of 2-3 staff members. But it is not clear if this is done from a moving vehicle or by foot (conflicting reports have been given). During the visual inspection, the surface distresses are recorded by indices rather than actual absolute values, which is an appropriate approach considering the data is needed for modelling.

Classified traffic data is generally collected *annually* for all links. For links with permanent traffic count stations, traffic data is logged twice a year. For other links survey time is either 40 hours (for roads with traffic levels of more than 5,000 vehicles per day [vpd]) or 16 hours (for roads with traffic levels less than 5,000 vpd). It is the classified data which is keyed into the IRMS (which then estimates Annual Average Daily Traffic [AADT]).

Structured data collection on ongoing projects, committed projects and works history is not collected.

2.7 IRMS

A computerised IRMS has been in place at DGH for more than 15 years, starting with the 1992 version. The IRMS comprises of a number of modules, each focusing on separate tasks within maintenance planning and programming. In Annex A is included an overview of the IRMS[11].

Over the years the system has kept its same core, but modules have been improved, replaced or dropped between versions. The latest version includes the following models:

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[11] From Medium-Term Expenditure Framework and Performance-Based Budgeting in Directorate General of Highways, Indonesia, Indonesia Infrastructure Initiative, Activity Progress Report, April 2010

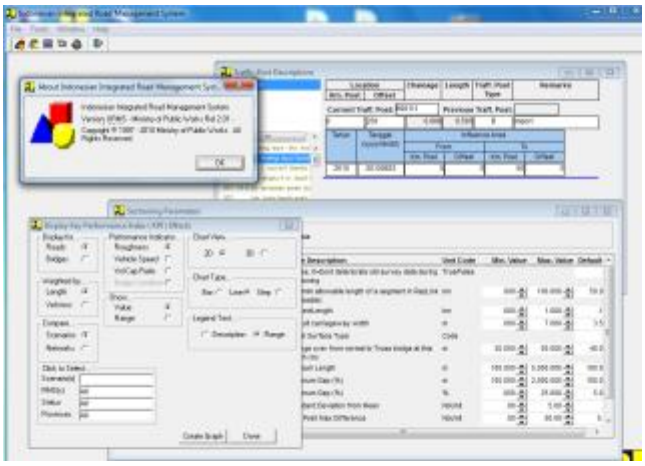
- Data Entry System (SMD)
- Sectioning Module
- Network Analysis Module (NAM)
- Strategic Expenditure Module (SEPM)
- Programming Module
- Economic Review Module (ERM)
- Budgeting Module
- Interfaces with other systems (this includes Bridge Management System [BMS], HDM-4, Local Road Management System [LRMS])
- Executive Highway Information Module (EHIM) and
- Statistical Analysis Module (SAM)

For a brief description of each of the modules please refer to Annex A.

The main analysis output of the IRMS is:

- three or five years' maintenance programme;
- 10 years strategic expenditure plan;
- road network statistics (processed data); and
- road network information (survey data).

The multi-year maintenance programme is output on a link basis (using the Bina Marge model); however, the system does behind this, have a multi-year programme based on maintenance sections.



The latest version of the IRMS is version 2.1, which was developed as part of the The Eastern Indonesia National Road Improvement Project (EINRIP)[12]. Before that (in 2007), a version 2 was issued, which included a range of improvements. However, DGH seems not to have adopted these

[12] EINRIP Planning Studies: Documentation of IRMS Development, Project Preparation Consultancy, Final Report, April 2009

later versions and still uses version 1.9, which reportedly comprises system bugs. Besides a number of minor improvements, version 2.1 includes significant enhancements (compared to version 1.9) to the: (i) Data Entry System (SMD); (ii) Network Analysis Module (NAM); (iii) Economic Review Module (ERM); and (iv) Executive Highway Information Module (EIHM).

In the SMD were added features for digital upload of survey data collected by Roughometer; an equipment used to measure roughness (International Roughness Index [IRI]). In the NAM, the models for handling unpaved roads were enhanced (in earlier versions, unpaved road modelling was by large neglected). The enhancements include deterioration modelling, traffic profiles and evaluations. The ERM has been extensively modified to add features and reports that have been required in the EINRIP project activities, including:

- Internal modelling and evaluation of projects has been eliminated and NAM is now used to perform the analysis;
- additional reports for better display of data;
- evaluation of multiple provinces, a single province or a single package;
- output of KML13 file for display of ERM projects in Google Earth;
- storage and printing of key global parameters used in the section analysis; and
- ability to display surface type, program and roughness graphically for better discernment of treatment allocation.

In the EHIM, the mapping feature has been revised to include additional mapping themes, and the video display feature has been improved. The changes made to the IRMS from version 2.0 to the current 2.1 version are not documented; but is reported to only refer to bug fixing and minor adjustments. The changes from version 1.9 to 2.0 are documented[14].

It is noted that the enhancement of the IRMS included features to create KML files, which can be used in Google Earth. Google Earth is being increasingly used in road asset management, as data can be shown in its real environment, which improves the understanding by the user. Furthermore, Google Earth is a tool which most computer users have experience with, which makes this mapping tool much more accessible than other mapping tools. However, Google Earth cannot replace a traditional GIS system.

The foundation of the IRMS is the database. This includes data on: (i) road alignment; (ii) road inventories; (iii) road condition; and (iv) traffic. The system relays generally on an Information Quality Level (IQL)-3 level of information[15], which is deemed suitable for the IRMS focus on maintenance programming and expenditure planning.

It seems that the system is build around a location reference system using location referencing points (LRP) and off-sets when linking data to the road network. However, it also seems that the approach has not been adopted in its true sense, as all km post has been adopted as LRPs[16]. Most of the data is thus entered on km basis and not on a survey segment basis. The approach taken makes it difficult to manage changes to the road network, and it is thus recommended that DGH would adopt the LRP’s system in a more true sense in the future. This is also illustrated by the problems currently

[13] KML files (Keyhole Markup Language) is used for displaying data on Google Earth
[14] See for instance ’The IIRMS Network Analysis Module, Technical Description of the System, July 2007
[15] See Annex D
[16] For an elaborated discussion on Location Referencing Systems see for instance ‘Data Collection Technologies for Road Management’, World Bank, February 2007

encountered by the revised SK2009 network description[17]. However, for the immediate use and application of the system, the adopted approach represents no threat to the IRMS, though it does mean, that historic data is difficult, if not impossible, to maintain.

Based on the data in the SMD, the IRMS has the ability to screen the road network and divide it into homogenous maintenance sections. The sectioning routines use the following parameters for the sectioning process: for *automatic* (forced) segmentation

- link;
- road type;
- surface type; and
- traffic volume.

and for *dynamic* segmentation:

- road width;
- surface distresses (SDI);
- roughness; and
- pavement strength.

Data is collected for all these parameters expect for pavement strength, where default values are assigned by the IRMS.

Looking at the analysis models adopted for the IRMS, these are clearly developed around the HDM-4 principles. The methodology is the same; however the models have been simplified. The economic analysis is based on a benefit-cost analysis, where the benefit and costs of different treatment alternatives are compared to a 'do-minimum' solution. The 'do-minimum' solution is not a 'do-nothing' solution, as it has been defined as: '*maintaining year round passability of all existing motorised roads with basic safety aspects'*. The operations included in the minimum case are:

- patching of potholes and local restoration of severely damaged pavement areas;
- repair of pavement edge break;
- maintenance of side drains and culverts;
- clearance of land slips and debris;
- repair or replacement of road furniture which affects road safety (warning signs, barriers etc.);
- maintenance of traffic signals;
- repair or replacement of retaining walls in critical condition;
- control of vegetation as dictated by road safety needs; and
- erosion protection (bio-engineering).

It should be noted that though these works are all considered essential for keeping the roads passable, it also reduces the Net Present Value (NPV) of the treatment options analysed, as the road

[17] As it has not been possible to adjust the current IRMS location referencing to match the revised network classification described by SK2009, DGH has embarked on re-entering the entire road network into the IRMS database, rather than revising the current data in the IRMS

in the 'do-minimum' scenario is better than if the base scenario would be a 'do-nothing' solution. However, the approach taken is appropriate for the programming analysis, as roads' sections where treatment options would lead to negative NPVs, would retain the maintenance regime defined by the 'do-minimum'.

The two main components in the benefit-cost analysis are: (i) capital and maintenance costs for road maintenance; and (ii) road user costs (RUC). Capital and maintenance costs are defined by the analysed treatment options and the relevant long-term maintenance strategies assumed for each applicable treatment; while the RUCs are defined by the costs of the road users (vehicles, time and goods) under the given condition regime of the pavements. The RUCs are as in HDM-4 roughness driven. While the RUC models does use the same components as HDM-4, the speed models adopted for the IRMS is based on the Indonesian Highway Capacity Manual, and is thus specifically chosen to model Indonesian experience.

The system has the ability to analyse maintenance needs and prioritise these under budget constraints. The optimisation process is the same as in HDM-4, as the efficiency frontier[18] analysis approach is adopted. Under an unconstrained budget scenario, the IRMS will select the projects with the highest NPVs for each section. Under budget constraints the following objective function is applied: '*To determine the combination of strategies (one for each representative road link)* that*, within a specified set of annual financial budgets, will give the highest total Net Present Value'*. The same objective function can be found in HDM-4 (which, however also does provide an additional objective function optimising IRI). As is the case for HDM-4, the IRMS output for the programme analysis is treatments for road sections, and of the strategic expenditure plan (using a matrix approach) costs for different road categories and work types (routine maintenance, periodic maintenance and betterment works).

Overall, the IRMS analysis builds on the HDM-4 principles, but with some important differences:

- In deciding the treatment for each section, IRMS applies a decision tree[19]. Based on: (i) surface type; (ii) roughness; (iii) widening needs; and (iv) SDI[20], the decision model will return the treatment type (betterment, periodic or no treatment). For unpaved roads and for paved roads with IRI between a user given minimum and maximum, the IRMS will be able to return both, a periodic as well as a betterment option for the same section in the same year. The economic prioritisation will then select which option needs to be applied. For all other IRI combinations, only one option will be available per section.
- HDM-4 would be able to analyse several treatment options for each section; for instance several overlay thicknesses for the same section. However, the treatment triggers used (surface type, IRI, widening needs and SDI) are similar to those typically adopted in HDM-4. Thus, the two approaches are still similar, though HDM-4 would provide a more advanced approach. The fact that IRMS is only returning one treatment per section (though for some sections there might be both, a periodic option and a betterment option) was to link the programming/planning analysis with the project level maintenance design, in order to operate with similar cost regimes at the different analysis levels. If budgets allocations are reasonable compared to the total needs, this is appropriate, as maintenance should be applied to its optimum design, rather than reduced design thickness in order to cover more of the network.

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[18] For more information please see HDM-4 Documentation, PIARC 2000
[19] See NAM Technical Manual, 2007
[20] SDI (Surface Distress Index) is an index modeled from: total cracked area; crack width; number of potholes and rutting.

- The maintenance and betterment design in HDM-4 is done arbitrarily (and consequences are then analysed). In contrast, IRMS includes models for maintenance and betterment design dependent on the actual condition of the road21. The treatment design approach follows DGH pavement design standards (CBR and HRODI, from the BINTEK Road Design System22). Thus, in designing maintenance treatments, IRMS is more advanced that HDM-4.
- For both HDM-4 and IRMS, long term strategies are adopted after the triggered treatment option. But while HDM-4 would define long term strategies by a combination of treatment options and trigger values, IRMS only analyses for 30 mm overlays triggered by a combination of IRI and AADT. This is a simplification compared to HDM-4. If overlays in Indonesia would be triggered more often by cracks and potholes rather than roughness, the model adopted in IRMS would be inappropriate for Indonesian standards. It should be noted that this is only affecting the NPV calculation and it does not significantly distort the actual planning and programming analysis, as the approach is used across all sections and one would expect no subsequent treatment in the three or five year programme.
- In terms of costing maintenance treatments, the IRMS is more advanced than HDM-4. While HDM-4 is using a unit rate approach for the treatment and for a few preparatory works, the IRMS builds up the costs from a list of quantities (similar to a Bill of Quantities), though it does have the option of applying unit rates also (which is highly recommended).
- The RUC model is simplified and in IRMS, only dependent on roughness, vehicle speeds and user defined coefficients (k1-k5). HDM-4 estimates the RUC using a highly complex regime of equations. The approach taken by IRMS resembles the Roads Economic Decision (RED) model, also developed by the World Bank. In RED, the RUC is given by roughness only, but the coefficients are determined to ensure that the RUC output is the same as would be given by HDM-4. The coefficients in the IRMS RUC model, similarly, can be calibrated to match what would be given by HDM-4. Thus, though a different approach is applied, IRMS would be able to return comparable RUC costs as HDM-4.
- When determining the final maintenance treatments, the IRMS uses the 'Bina Marga' approach, which translates the combination of periodic maintenance and betterment works into a single works category (periodic or betterment) for each link. This is a significant difference from HDM-4, and most other road management systems, which would base the programme on maintenance treatments for each homogenous road section. The use of the 'Bina Marga' model will lead to an emphasis on betterment works, as either sections with periodic maintenance works are left out23 or grouped under betterment works. The IRMS does have treatments per homogenous section and can thus provide the same output if using the 'detailed programme' option rather than the 'Bina Marga' model.
- The programme analysis in IRMS includes features for deferring maintenance treatments to later years if not chosen in the optimum year (HDM-4 does not have this functionality, though it is possible to define the set of treatment strategies to overcome this problem). If works cannot be deferred, it means that the programming analysis is an 'in or out' analysis, where a treatment is either selected in the optimum year, if budgets are not exhausted, or not at all. If treatments can be deferred, the treatment would have a chance to be included in the subsequent programming

[21] E.g. in HDM-4 the user will need to input the overlay thickness to be analysed across all sections, while IRMS includes modes for estimating the actual overlay thickness needed for each particular section.

[22] The CBR method is used for unpaved roads and roads needing reconstruction, while the HRODI method is used for overlay design and widening projects

[23] E.g. a link of up to 25 km, where up to 20 percent of the road link length is eligible for preventive maintenance will not be included in the periodic programme (the average link length is 14 km according to SK2009, so there are potentially many of these situations).

years. As IRMS has this ability, IRMS in this matter is more advanced than HDM-4. Furthermore, as the maintenance treatment in a particular year is designed based on the condition regime estimated for that year (development in IRI, cracks and potholes are progressed over the years), the maintenance options would also theoretically be more expensive, as the condition worsens, as this would result in increases of thicknesses of overlays which will need to be applied.

- In the analysis, the IRMS can identify committed and ongoing projects (if so entered into the database) and treat these separately in the analysis. HDM-4 does not have the same option. The user inputs whether the project is committed or ongoing and then records a string of information including start date, number of construction years, contract sum and yearly distribution, and design details such as pavement type, thickness and width. In the analysis, these projects are treated as given (forced) sections, which will be pre-selected in the programme (if so chosen in the analysis). In the economic analysis, the NAM will use the recorded actual cost, rather than IRMS' unit rates.

Based on the review of the IRMS, it is concluded that the IRMS would be able to output quite similar maintenance programme results compared to HDM-4, if calibrated properly and the detailed programme analysis output of the IRMS would be used instead of the 'Bina Marga' model. Thus, there would be no merit for replacing the IRMS with HDM-4 based on system facilities alone.

The Sub-Directorate of System Development and Performance Evaluation informed that regular back-up of the road database is performed. It was also mentioned, that the Graphical User Interface (GUI) used for the IRMS is suitable for the operation of the system, though the system was operated using the English screens, as running it using the Indonesian translation makes the system operation very slow.

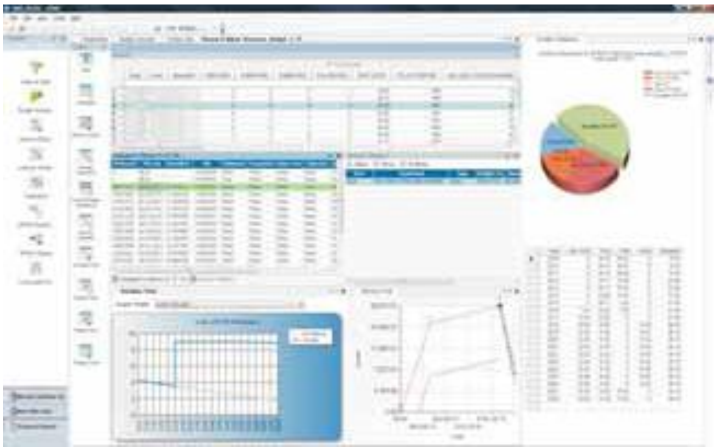
The IRMS is a Windows based system, loaded with the latest version on a common platform (Powerbuilder), and adopts Sybase as its database (Powerbuilder and Sybase is from the same supplier). This platform is suitable for some more years, and has the advantage that local knowledge in this platform is available. It is prepared for a LAN setup (but not currently applied as such), where eight users can access the system simultaneously. The system is scalable, and if more licenses were to be purchased, more users could operate the system simultaneously.

2.8 IRMS AND COMMERCIAL-OFF-THE-SHELF SYSTEMS

While many road organisations have developed their own bespoke system there are a number of commercial systems available[24], with each having their strengths and weaknesses and varying in terms of capabilities and modules.

Commercial systems will often provide modern Windows-based user interfaces, where several windows can be operated simultaneously (see example below from dTIMS CT). The user can thus select the windows most relevant for his line of work. The IRMS has the same capabilities.

[24] See for instance: www.deighton.com; www.goodpointe.com; or www.himsltd.com



Commercial systems often build on well designed and proven *road data management* systems. This is the core and focus of the entire system. This makes it easy to update and manage road and bridge information, including adopting changes to the road network. In contrast this is considered one of the weak features in the IRMS, which is not well prepared for road network changes.

Commercial systems often include a *range of assets management* by road agencies; including: (i) roads; (ii) bridges; and (iii) drainage systems. While the modelling might not be integrated, the asset information would be; which enables a much better overview of the assets managed. The IRMS is focusing on roads; though it does store bridge information, and some analysis can be carried out within the IRMS. However, it cannot substitute a BMS.

The *models* adopted by commercial systems are often less complicated compared to bespoke systems, as they will need to meet the requirements of a broad range of road agencies. However, most often there are some possibilities of customising the analysis models, and some commercial systems have links to HDM-4. However, overall the IRMS would provide DGH with a more advanced approach to modelling and analysis, though this can also be considered as one of the problems with the IRMS; as only little model flexibility is available in the IRMS.

In some commercial systems a range of optimisation models (also called objective functions) will be available (such as maximise benefits, minimise agency cost, reduce public costs and delays, maximise performance measures). In the IRMS only one optimisation model is available (maximise benefits).

Commercial systems would also, like the IRMS, be integrated with GIS. Some systems will be fully integrated (the GIS system will be imbedded with the RMS systems), while other systems will adopt other commercial GIS applications (such as ArcGIS). The IRMS is also integrated with a GIS tool, though the user flexibility is limited.

Commercial systems are used by many clients and the vendor is responsible for making sure that the system is meeting the technical requirements of road agencies, which most often have entered into maintenance agreements with the vendor. This implies that commercial systems continually follow developments in computer operating systems (for instance now Windows 7 is becoming the standard) and developments in other commercial systems (such as GIS systems) in order to make sure that the system is operational. It is thus expected, that commercial systems will always be in line with the current trends. As this cost is shared between all road agencies, the cost of the individual agency is much less than compared to bespoke systems. With bespoke systems, like the IRMS, the agency will need to bear the entire costs, which often means that bespoke systems are trailing sector standard.

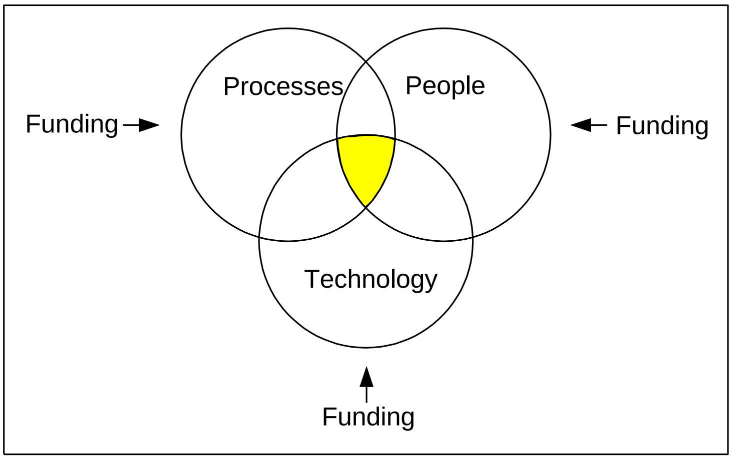
The features of commercial systems will be shaped by the wishes of its (many) users. Again, as features will be used by all users (expect in cases where features are fully developed and paid by a single agency), features might be of more general use. In contrast, the IRMS is developed specially to meet the needed features for DGH, and will thus be easier for it to be tied into the business processes (as long as these are kept constant).

CHAPTER 3: KEY ISSUES

Based on the situational analysis above, a number of issues have been identified, which is hampering the use and institutionalisation of the IRMS.

When identifying the key issues, emphasis has been placed on the results of a World Bank survey[25], including experience from 21 road agencies in 16 different countries, which documented that if road management systems should lead to a successful implementation, success within each of the following fundamental components is necessary.

Figure 1: Dimensions for Successful Implementation



If the *technology*, which is applied in the IRMS, does not meet the requirements of DGH, the system would not be able to support maintenance planning and programming. If the output of the system is not used in the business *processes* of DGH or if the data collection processes are unsustainable, the system would not provide any benefit to DGH. If the staff members do not know how to operate the system and the organisation (operational levels as well as executive levels) do not show commitment to the system, the system will fail. Finally, if any of the success factors are not receiving suitable *funding* (for instance, no budget allocations are given to data collection or for system maintenance); the system will not be properly institutionalised. An overview of the recommendations of the study is attached in Annex B.

Thus, the key issues below will focus on barriers which currently affect the success in all three main components.

The key issues can be grouped under the following headings:

- Data collection
- Road management system
- Business processes
- System operation and management
- Staff capacity
- Decentralisation

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[25] Success Factors for Road Management Systems, World Bank, October 2005

Though described separately below, these issues cannot be met and resolved individually. For instance, complaints about the usefulness of the IRMS output might be a result of poor data quality, and poor data quality might be a result of lack of clear business processes.

3.1 DATA COLLECTION

From the review it can be concluded that poor data quality represents one of the primary challenges for the institutionalisation of the IRMS and is one of the most significant issues, which have lead to the current failing of the system in DGH. Data is not collected timely and in the quality needed. The main issues related to data collection are:

- Poor data quality
- Inappropriate data collection framework

In general, it can be concluded that quality assurance processes are not formalised and only marginally applied during data collection (except for roughness data). The lack of quality assurance contributes significantly to the poor data quality reported. As quality data is a prerequisite for institutionalisation and acceptance of any road management system, the applied fragmented quality insurance is deemed insufficient.

The decentralised approach to data collection is contributing to the quality problems; especially as the data collection is carried out manually. Experience shows that to streamline the data collection process and produce quality data, strict supervision and well developed quality assurance processes are needed; none of which is adhered to currently.

Data collection frequency and coverage is excessive compared to the needs of a network screening[26]. There is no reason for collecting all the data currently being collected. This puts too much stress and pressure on the organisation and is one of the reasons why data is either not collected or collected with poor quality.

Data on structural capacity of the roads is not collected, though the IRE under the MPW does maintain a FWD. As the maintenance design model uses structural pavement parameters, leaving out structural data is deemed to contribute to the experienced cost differences between programmed maintenance treatments and the actual needed treatment derived during the design stage.

Similarly, important data such as on: (i) ongoing projects; (ii) committed projects; and (iii) works history is not systematically collected, if collected at all.

In order for the IRMS to be institutionalised, the road data collection framework will need to be reengineered entirely, including a revised approach to data types, data collection frequencies, data coverage, technologies applied and the data collection management, including quality assurance processes.

It should be noted that if the data collection fails, all other downstream activities will also fail, and the IRMS won't receive the needed recognition. However, it is also noted, that data collection always is one of the most challenging tasks to get right, so the focus on this should never be underestimated.

[26] See for instance 'Data Collection Technologies for Road Management, The World Bank, February 2007

3.2 IRMS

The IRMS system is not currently outputting results which can be used by the organisation; and the output is consequently not used in planning and programming. This is, to a large extent, due to the poor data quality.

It should be realised that no system will ever be perfect, and all systems will provide challenges which the organisation will need to address through its business processes. IRMS also presents challenges. However, based on the review of the IRMS, it is concluded that if it is properly calibrated and updated with latest quality data, it would be able to output results which could form the basis for suitable and robust maintenance programmes. However, it does represent a number of issues:

- It does not provide sustainable road data management facilities.
- It does not provide sufficient filtering options during analysis.
- It does emphasise on betterment works programmes27.
- It does not provide any flexibility in the maintenance treatment analysis setup, as it is built on the BINTEK design manual which results in limited number of treatments[28] for the analysis and in-built design life assumptions[29].

The road network changes over time; thus it is important that the IRMS has suitable and robust road data management features. That the IRMS does not have this is illustrated by the problems of adopting the new road classification, and the consequential loss of historic data. The data management system is a core of any road management system, and thus not easily changed once developed and the data used in the analysis applications. It is thus deemed that upgrading the current IRMS to modern data management standards would be a significant task, which would also result in many changes in the analysis applications also. This would consequently be reviewed as a significant upgrade of the system.

When doing analysis, the IRMS can filter to a certain province. However, often further data filtering is needed before analysis. However, often users need to analysis corridors or other sub-networks, and as roads and/or corridor selection is not possible, such analysis is currently not supported by IRMS.

With the models adopted in the system and the current default values, emphasis is on betterment works; especially in terms of programme type. This results in a tendency to output programmes with excessive levels of betterment works compared to preventive maintenance. The models are briefly described in Annex E.

However, the *IRMS would be able to focus more on preventive maintenance and could be brought to make sensible input to the MTEF* if the threshold values in the treatment decision tree is adjusted (lower the IRIMIN[30] and SDI thresholds). With the SDI threshold currently in use, road sections with more than 30 percent fine cracks (and no other distresses) would not be selected for maintenance. Neither would a road section with 10-30 percent cracks larger than 3 mm (with no other surface distresses). Thus, with the current threshold it would be presumed that many cracked roads would not be found eligible for preventive maintenance. By an adjustment to the indicated thresholds, the

[27] Though a betterment work programme can include several sections with only periodic maintenance.

[28] Currently the IRMS estimates the technical optimum treatment, and does not allow for this treatment to be downscaled, as the budget constraint increases, though some sections might be assigned a periodic option as well as a betterment option.

[29] The design model is based on the BINTEK Pavement Design Manual.

[30] A user given mimimum roughness used in the design decision tree

IRMS could be calibrated to focus much more on cracked roads compared to the current calibration, which focuses on roughness. Similarly, the SDI calculation can be adjusted to increase the influence of cracking on the SDI. Both of these measures can be done without software programming.

The IRMS has adopted the BINTEK pavement design approach. It is thus not analysing as many treatment options as most other road management systems. If funding levels are high, this is not so problematic, as treatments should then be applied to their optimum. If multiple treatment options were to be adopted, the IRMS would need a severe overhaul, as the BINTEK pavement design model would need to be removed and replaced by other condition triggered interventions. This would represent a significant change in the IRMS methodology.

Furthermore, a parallel component under IndII is reviewing the pavement design approach. If concluded that this approach should be replaced by, for instance, a mechanistic approach, this would mean that the IRMS also will need to be changed accordingly. This is a complex and significant change to the IRMS.

Besides this, *all analysis and calibration parameters* should be reviewed. Most of these are from 2003. Calibration will involve significant data analysis (IRMS data and preferably also other sources, due to the quality assurance problems with the IRMS data) as well as comparison of IRMS output with the engineering solution of selected road sections/segments.

3.3 IRMS OPERATION AND MANAGEMENT

It is clear that the current capabilities in system operation and management are insufficient. Some of the main issues in terms of IRMS operation and management are:

- Operating using old versions rather than new and significantly improved versions;
- analysing using outdated analysis assumptions (e.g. unit rates and vehicle operating costs [VOC data]); and
- system features not being used.

Though the Sub-Directorate of System Development and Performance Evaluation has had a revised system since 2007 (version 2), which provided significant improvements compared to earlier versions, the Sub-Directorate has never managed to operate the system; lack of training and system bugs quoted as the reasons. No matter what course of action is taken in terms of system choice, it is clear that significant training will need to be applied and sustained.

The Sub-Directorate is still using unit rate data and VOC data from 2003, and the analysis parameters which control the analysis models are also left unchanged. While unit rates should be updated annually, the analysis parameters should be updated regularly based on comparisons between analysis output and actual needs of identified road sections (this procedure often takes forms as hit-rate analysis).

The IRMS has the potential to assist DGH much more than what it is currently. For instance, the system can assist in expenditure planning, which is an important task of the Sub-Directorate of Planning, and it can, through the EHIM and SAM modules, provide a range of data, statistics and maps which would be helpful for most of the sub-directorates. One of the issues behind the lack of system use and institutionalisation is that the system is not used to its potential.

3.4 ORGANISATIONAL CAPACITY

The overall organisational capacity to undertake the tasks related to IRMS is very weak. The issues include:

- Staff levels insufficient;
- staff capacity not sufficient and
- training structures not provided.

From the workflow analysis it is clear that the capacity in many of the steps is insufficient. In particular, the capacity in the Sub-Directorate System Development and Performance Evaluation and Sub-Directorate of Data and Information needs significant strengthening, if the IRMS is to be operated in-house.

The unit responsible for the IRMS shall have the necessary capacity to manage the system, both from a software point of view and from a system operational point of view. In terms of *software management*, the unit shall ensure that the IRMS is kept bug free; is updated as needed (for instance when operating systems are updated); that versions are managed and all users use only the latest version; and that requests for changes and upgrades are being prioritised and implemented. In terms of *system operation*, the unit shall ensure that all analysis parameters are properly updated, including unit rates, VOC, calibration factors; and shall understand well the analysis models in order to understand the calibration techniques and control possibilities, and shall be able to review the appropriateness of system output. This capacity is not currently available in the Sub-Directorate of System Development and Performance Evaluation.

The unit should include staff fully allocated to undertake each of the following ‘specialists roles’: (i) road network management; (ii) data preparation and analysis; (iii) GIS reporting; (iv) management reporting; and (iv) IRMS software and database management. These duties should clearly be divided between the allocated staff.

The unit which will be made responsible for the *data collection* will need high levels of data management skills as well as technical skills. They should be able to monitor and track progress, and should intervene properly and swiftly when needed, in order to keep the data collection process on track. Furthermore they will need to undertake technical reviews of data equipment calibration as well as the collected data. It should be realised that data quality assurance is a time consuming exercise which is a vital step in deriving the quality data needed for the IRMS operations. Data quality assurance involves activities before, during and after data collection, and includes spot check of data on site.

The unit has only two staff members allocated for the IRMS data collection management, which is far less than the required allocation for management of the data collection. The figures below are based on general experience[31] for supervision, management and quality assurance of data for 10,000 km of roads:

- Roughness Data: 1–2 full-time client staff for the duration of the data collection (which may be up to nine months, depending on circumstances and logistics).
- Inventory Data: Depending on the number of inventory items and their number of attributes, 2–3 full-time client staff for the duration of the data collection. If video data is being collected

[31] ‘Data Collection Technologies for Road Management, The World Bank, February 2007

under the same contract, and where there is the ability to cross-check video with inventory, then should have a provision for 3–4 client staff full-time.

- GPS Data: One client staff member full-time for the duration of the contract. The person working on GPS data is required to have good GPS/GIS skills.

The Balai should quality assure their data. As this reportedly is not performed, the Balai's focus more on data collection management (contracting and progress), whereas the quality assurance rests with the two part time staff members of the Sub-Directorate of Data and Information, which is far short of the capacity needed for quality assurance.

In general, the number of staff members performing the various roles and functions, falls short of the actual capacity needed to conduct those tasks. It is fundamental that the capacity needed to manage the different steps in the IRMS works flow be shared by several staff members, in order to ensure continuity and capacity levels, both in numbers and in knowledge.

One of the structural barriers is the lack of training provided. Either none or very little training is provided to the key staff involved in the IRMS operation and management. Training seems to be entirely linked to international consultancy packages which may be in place from time to time. There are no structured approaches to training; including peer-to-peer training, in order to ensure that knowledge is imbedded in several staff members, rather than just a few key persons.

3.5 BUSINESS PROCESSES

In order for the IRMS to take its intended important role in DGH, it needs to be described how the system and its output are used in its business processes. Such description, often labelled as a road management framework, is not available in DGH. Lack of clear business processes leads to:

- Uncertain roles and duties of those involved;
- lack of connectivity between tasks;
- lack of transparency within tasks;and
- difficulties in evaluating and measuring performance (lack of accountability).

Unless a clear cut responsibility is set forth on the staff members for different tasks, none will assume responsibility and feel committed to undertake those tasks. When sub-directorates, and in the end the staff members, are not committed to described tasks and duties, these will not be prioritised in a work environment with many competing tasks.

Even though some tasks are undertaken, there are various other tasks that might not be performed, leading to no coherence and connectivity between the efforts. This reduces the benefits of the output and consequently of the outcome.

Furthermore, as the business processes are not described, the transparency in undertaking the tasks is lost. Tasks are solved on a case-by-case basis, and similar tasks might be solved differently between sub-directorates32. It also makes it difficult to see how one task feeds into the next, and in turn to ensure that the data and information provided is sufficient and relevant to this next task.

[32] For instance the prioritisation mechanisms used in the Sub-Directorate of Planning and in the Sub-Directorate of Budgeting did not have the same priority ranking for preservation works.

As the roles and duties are not clearly detailed and established, it is not easy to review performance within each task. This makes it difficult to point to the weakest links and enforce corrective measures. This in turn leads to lack of accountability within the organisation as there are no consequences of not undertaking the related tasks.

The business processes should also detail an approach to integrated strategic network planning, where plans are derived considering corridor approaches and where roads and bridge planning is integrated. The IRMS can be helpful in supporting this as it can output needs for maintenance and rehabilitation of roads (and for bridges) and the data in the database can be used to identify roads and corridors not meeting standards (primarily width standards). The processes should lead to a project pipeline, which is supporting achieving the set policy and strategy targets, and which can undergo preliminary designs in order to prepare the projects for funding.

3.6 DECENTRALISATION

Maintaining and running a road management system is a challenge for any organisation. Besides getting the data collection right, one of the more difficult tasks are developing and maintaining sufficient capacity to operate the management system, as this requires specialists, which most often would not be trained through their university studies, but which will need to be trained within the organisation. As experience shows that it is difficult to build and sustain such capabilities at a central level, it makes it even more difficult if capacity shall be built and sustained in a decentralised setup. Thus decentralisation has additional challenges such as:

- Difficulties in sustaining capacity
- Differences between system application

DGH has learned how difficult it is to sustain and develop the needed capacity at central level. Decentralising the IRMS operation to the Balai’s will increase this problem, as it must be expected that the availability of suitable resources, in numbers and capacity, will be less as compared to central levels. Decentralisation thus adds to the sustainability concerns.

Another issue is that the maintenance programming will then be undertaken on 10 different locations, by 10 different teams. It has to be expected that the analysis assumptions (unit rates[33] and analysis parameters) will vary between Balai’s, which makes it difficult to consolidate the analysis output at a central level. There is, thus, a concern regarding compatibility between decentralised analysis outputs.

[33] While there are grounds for unit rates to differ due to regional settings and conditions, decentralisation has often shown large and un-explained differences between unit rates.

CHAPTER 4: MTEF/RENSTRA AND THE IRMS

It is clear that the IRMS should take a prominent role in the development of the MTEF, as it can output network level (or on portions of this) multi-year maintenance and betterment programmes under user given budget constraints. The IRMS would be able to provide output data directly compatible with the MTEF (if baseline projects would be marked as committed projects). It is understood that the MTEF should assist in meeting the targets set in Renstra (DGH's static five year plan for the national road sector 2010–2014). These have been translated into three strategic targets34: (i) Percentage of road networks in stable condition increased to 94 percent; (ii) Increased level of road usage on national road links to 91,55 billion vehicle-km per year; and (iii) Improvement of facilitation, guidance on technical implementation of regional road operations to 70 percent. These three strategic targets have been elaborated under a range of detailed targets.

It would be logical that also the IRMS, which is used to develop the MTEF, would consider the objectives of the Renstra. As the Renstra objectives are specific for Indonesia, IRMS would only be able to support this if it is so specially customised. However, as the Renstra objectives are set for periods of five years, it is deemed suitable to adjust the IRMS on such five year basis in order to support the particular Renstra in force.

In Annex C is listed the Renstra objectives/targets, and indicated how the IRMS would be able to support these objectives either directly or indirectly.

Add-on modules could be added to the IRMS which could support several of the targets; especially how the network is developing compared to the targets. The add-on modules could also take form as 'what if' analysis, where the IRMS analyses what would be the budget needed for reaching the targets (e.g. the target on road widening of selected corridors; the IRMS could analyse the costs of widening the corridors to the target standards).

For the Renstra, is needed the following information:

- Work Programme.
- Work Treatments, treatment length, year and costs.

The IRMS is already providing this output from its programme analysis as well as the strategic analysis. Thus, no changes to the IRMS are needed.

It would not be feasible to establish a direct link between IRMS output (or database) and the Renstra as input to the MOF database. The output of the IRMS is an important input to the Renstra process, but it is not the 'final answer'. Thus reviews and changes are needed before the IRMS output is translated into the Renstra. This is best done by exporting the IRMS output to spreadsheets and rework as necessary.

Similarly, it is not feasible, nor practical, to assume that what comes out of the IRMS would be directly used as the MTEF or the annual RKA-KL[35]. Engineering judgment is needed, and the list of maintenance works will need to be revised to meet changing/shifting policies and conditions, which

[34] Strategic Plan 2010-2014, Directorate General of Highways, April 2010

[35] DGH has to input annual budgets into the RKA-KL software, which is then submitted to MOF for inclusion in the main Oracle database.

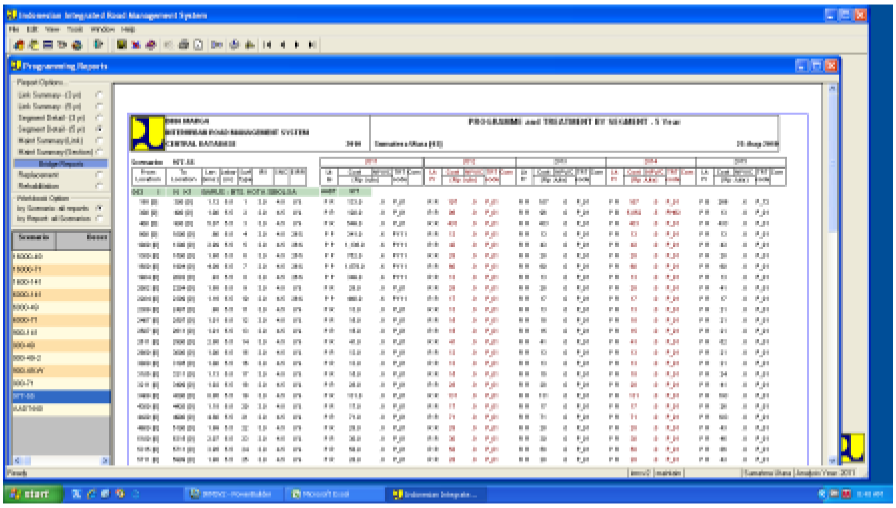
is not well captioned in the economic analysis (e.g. network connectivity or special emphasis on development of certain regions).

The IRMS should, thus, not be programmed to exactly meet the current MTEF requirements, but should rather provide the needed basic data, which is then used in a flexible process, which can build in the policy trends.

The current IRMS programme analysis (segment level) is outputting:

- Road and Link ID
- Road class
- Link name
- Section location (from and to)
- Traffic (AADT)
- Surface width
- Surface type
- Roughness
- Structural number (currently only default data is available)
- Economic internal rate of return (EIRR), for the selected strategy
- And for each of the three or five years:
  - Link programme and section programme
  - Cost
  - NPV/C
  - Treatment type (routine, periodic, betterment)

If enhanced with Surface Distress Index (SDI), the report on road preservation works can then be used in the further processes, including a Multiple Criteria Analysis (MCA) approach, to support the targets set for the MTEF, and for the budget year.



In the Draft MTEF Manual[36] it is proposed that road development options should be ranked adopting a MCA approach. The benefits of this are that the ranking adopts criteria which are not based on economics only. The IRMS can assist in providing the needed baseline data (e.g. inventories and traffic levels) which can be used. Such information can already be extracted from the database through the reporting modules. The IRMS can also be used to estimate the economic benefits of the development option (using the ERM Module).

[36] Director General of Highways, MTEF Manual, Initial Draft, July 2010

CHAPTER 5: STRATEGIC OPTIONS

When developing a sustainable strategy for the institutionalisation of a road management system, several overall strategic options need to be considered before going into the details of the system features and organisational institutionalisation. The options include:

- Bespoke system or Commercial-off-the-shelf system (COTS)
- In-house system operation or out-sourcing operation
- Data collection approach

There are advantages and disadvantages for all the listed options; thus no clear general recommendation can be given. The strategic choices must thus depend on the review of the general advantages and disadvantages seen in a situational context; in this case the context of DGH.

In the tables below is given an overview of selected advantages and disadvantages for each strategic option. After each table is provided a short discussion on how this relates to the situational context of DGH.

5.1 BESPOKE OR COTS SYSTEMS

Road management systems can either be bespoke systems, developed to a specific organisation, or a commercial-off-the-shelf system which is developed by vendors based on knowledge of the general needs of the road organisations. Below are listed some of the advantages and disadvantages for the two options.

Table 1: System – Bespoke/COTS

	Advantages	Disadvantages
Bespoke system	Current system is suitable and meets many of the key functional require-ments for RMS systems, expect for road data management and other small improvements. Tailored to meet specific organisational requirements. Often tailored to the capacity of organisation. Some capacity already exists. Often higher institutional acceptance.	Longer development time. Expensive support, maintenance and development. Weak strategy for the development (often project based). Based on specific design principles. Models need enhancement and calibration.

	Advantages	Disadvantages
Commercial-off-the-shelf system	Lower purchase/development costs. Most often state-of-the-art system, based on requirements from many client organisations. Documented higher success-rate[37]. Professional support (including bug-fixing) and continual development. Robust systems, based on multiple users and proven technology. Participation in user groups. Probably already web-enabled.	Will not meet specific requirements. Client requests implemented slowly. Timing of upgrades decided by supplier. Dependent on one software supplier. Likely to need customisation to meet client's requirements (special needs/models). Might have integration with HDM-4 (difficult to use[38]). Maintenance agreements needed (about 10-20 percent of original cost of software).

The main advantage of a bespoke system is that it can be tailored to the needs of the specific organisation. Thus, special business procedures adopted by the organisation can be directly reflected in the system logic and output, which is also the case of the IRMS. This often enhances the organisational acceptance of the system. However, being tailored to one specific organisation, this organisation will also be solely responsible for maintaining and upgrading the system to meet evolving requirements (technical as well as IT requirements). This is expensive and provides challenges for most organisations.

In relation to DGH, which has adopted a bespoke system, it is clear that these potential advantages have never materialised, as only very few features of the developed system have ever been adopted. Similarly, DGH has not been able to overcome some of the disadvantages, as sufficient system support and maintenance have not been available.

The main advantages of the COTS systems are that maintenance and support is provided by the vendor at costs much lower than for bespoke systems, and that COTS systems most often will keep close track with the development within the industry as well as in IT. Thus, the systems are constantly being updated and upgraded. A further advantage is forming of user groups, in which users can meet with peers and discuss the use of the system. This helps support the development of the needed operational capacity. It is probably these features, which has lead to COTS systems having a higher implementation success rate as compared to bespoke systems.

It is clear; DGH not having been able to materialise the advantages of bespoke systems, would benefit from the advantages of adopting a COTS system; especially in terms of system sustainability, as the system will be updated regularly and staff will be provided continual training. Though a COTS system will not be able to meet some of the specific features of the current IRMS; especially the treatment design method and the Bina Marga model, this would not be considered a major obstacle for success, as these features are also considered some of the more problematic issues in the IRMS. The fact that a COTS system is not tailored to DGH is not seen as a major challenge, as the needs of DGH does not variate significantly from those of other organisations. However, some flexibility will need to be built into the business processes in order to adopt the system output properly.

[37] See for instance 'Success Factors for Road Management Systems', World Bank, October 2005.

[38] However, it should also be noted that HDM-4 offers many features which would be highly valuable for many potential clients (including DGH).

It is thus recommended that DGH will, in the future, adopt a COTS system in order to ensure that the system will be sustainable.

5.2 SYSTEM OPERATION: IN-HOUSE OR OUT-SOURCED

While most road organisations would operate their road management system with in-house staff, a few have adopted approaches where the operation is outsourced. Below are listed some of the advantages and disadvantages for the two options:

Table 2: System Operator – In-house/Out-sourced

	Advantages	Disadvantages
DGH	Hands-on control over analysis output. Can review analysis when needed and as appropriate. System to provide output to a range of DGH activities.	Analysis tasks compete with conflicting tasks. Need for continuous updated training of staff. Needs to sustain a dedicated technical unit to carry out analysis. Difficult to sustain capacity if decentralised.
Out-sourced (IRE, universities/private sector)	Reduction of peak workloads at DGH. More academic approach (universities). Upgrading technology can be built into the outsource contract.	Slow response time for ad hoc analysis. DGH will not be able to sustain road asset management knowledge. Lack of capacity of consultancy industry (DGH would be the only client, project). Standard application (local consultancies[39]). Rather expensive approach, if outsourced to international companies. Cycling application (less benefits of having the data).

Any outsourcing would be conditional on the capacity of the local universities, research institutes or private sector, which are the likely domestic outsourcing options.

As the consultancy industry presumably would not have taken a lead role in any road asset management operation, outsourcing operations to the local consultancies would, at best, lead to standard system applications. Outsourcing to international companies would result in quality output, but would also result in rather high costs and difficult liaison in relation to analysis adjustments and enhancements.

The universities are generally lacking behind the needs of the industry, and within road asset management, no special courses are offered. Thus, while the universities may be able to provide the theoretical knowledge, they will not have practical experience, which could add to the quality of the analysis.

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[39] As it is presumed that the local consultancy industry generally is not involved in operation of road management systems, their lack of capacity would probably lead to system applications using standard IRMS setup (including calibration factors).

The IRE has some experience in road management, primarily through surveys and material testing. To date, they have not established road asset management system capabilities, though it must be deemed that such capabilities could be developed at IRE.

There is, thus, not a local industry which is ready to take over the operational obligations, and it must be expected that if out-sourced, standard analysis applications of the system will be applied, especially if outsourced to the local consultancy industry.

One of the most important factors arguing against outsourcing is the loss of internal capacity within DGH in road asset management. If DGH would have to depend on external partners to run the IRMS, DGH would gradually lose their knowledge on road asset management and the understanding of the road network.

In addition to this, the data in the IRMS should be put to much more use that just as input for different analysis. If this is to be achieved, DGH must have a unit which operates the IRMS and provides information, data and analysis output to IRMS stakeholders, internal as well as external.

It is hence recommended that the DGH would retain the operation of the IRMS. However, for this to be successful and sustainable, *significant and continual* training will need to be provided to the IRMS operators as well as to managerial level staff.

Further, it is recommended that the local universities and/or IRE would be invited to participate in the IRMS operation, especially in relation to IRMS model calibration. The universities would be able to study pavement and model behaviour and recommend on model calibration (DGH would supply system and data, while the universities would supply academic knowledge and students). This approach would also help increasing awareness among students to road asset management, and hopefully improve the base for future recruitment of staff.

5.3 DATA COLLECTION APPROACH

The main strategic option when looking at data collection is whether to do it in-house or out-source it and whether the data collection should be carried out centralised or decentralised. Some of the main advantages and disadvantages are listed below.

Table 3: Data Collection – In-house/Outsourced

	Advantages	Disadvantages
In-house	Often the most inexpensive solution (if adopting equal technologies). Maintain knowledge and expertise in data collection in-house. Quicker mobilisation.	Often problems with meeting deadlines. Risk of data manipulation by surveyors. Applies significant pressure on staff during periods of data collection (peak workload). Locked to the chosen technology.

	Advantages	Disadvantages
Out-sourced	Reduce the peak workload. Shortened period of data collection and higher likelihood of meeting deadlines. Applied equipment often in better condition and calibration. Flexible on the technology used, as client will ask for data, not processes	Higher costs (overhead costs of consultants). Would probably presume multi-year contracts to make investments attractive and ensure quality. Requires good contract and project management skills by client (normally not found in RMS units). Needs to go through often lengthy procurement processes.

Table 4: Centralised or Decentralised Data Collection (if in-house data collection)

	Advantages	Disadvantages
Centralised	Quicker mobilisation. Consistent data across regional/provincial borders Fewer tendencies to manipulate data. Equipment based approaches more feasible.	Does not in general know much about the network. If same technology is applied (as if decentralised), the period of data collection would be longer.
Decentralised	Those working with the network daily also collect the data (first-hand knowledge). Can be collected relatively quick.	Most often based on manual approaches. Non-equipment based surveys will show inconsistencies between provinces. Collection by organisational units, who are not the primary end-users of the data. Difficult to supervise from central levels. Higher risk of data manipulation.

Currently, the data collection is managed by the Balai's using local consultants as surveyors, while the central level is involved in training and quality assurance. The data collection thus, has elements of in-house approaches, and also carries many of the disadvantages of in-house data collection. Deadlines are often exceeded, data is not meeting quality standards, possibly because some of them are manipulated, and the data collection is done manually (a feature often linked to decentralised approaches), leading to significant subjectivity in the field surveys. It is thus clear that DGH suffers from many of the disadvantages from decentralised in-house data collection.

One of the main problems is data quality. One way of overcoming this issue is by adopting equipment based approaches. Such technologies are only suitable for centralised approaches. The rather large network under DGH's jurisdiction would also justify adopting equipment based approaches. Thus, it is recommended that DGH would adopt an equipment base centralised approach.

Out-sourcing of data collection also often leads to improved data quality, as responsibilities become clear between involved parties, and it is much easier to relate professionally to the data quality and request re-doing these (or part of) if needed. Thus it is recommended that an approach which builds on contractual obligations will be adopted. This means that data collection should be done by either the local consultancy (in much larger packages than currently) or by the IRE, with which a data collection contract could be entered.

If combining centralisation, out-sourcing and equipment based approaches, out-sourcing to IRE would come out most advantageous. If the private sector were to invest in advanced data collection equipment, this equipment will only be applied to the data collection contract, and would be idle between surveys and/or contracts. In order to make better use of the equipment which represents a considerable cost, it is thus proposed that IRE would be contracted to do the data collection, as they will be able to apply the equipment for other purposes, such as detailed pavement investigations as well as in research projects.

It should be noted that in an out-sourced approach, DGH would need to focus on contract management; data collection supervision; and quality assurance (acceptance of data). Outsourcing to IRE will also overcome the procurement issues, as procurement is not necessary, though it is important that a contractual corporation between DGH and IRE will be established, and IRE will be treated no different from any other consultant assisting DGH. If a contractual approach is not strictly adhered to, the situation will be parallel to in-house data collection, and quality problems are likely to persist.

CHAPTER 6: RECOMMENDATIONS

The first and foremost important recommendation is that management commitment needs to be the driving force for the institutionalisation40. The management layers of DGH will need to be very explicit in its commitment to the IRMS operation and use, and will need to take active part in the development of a road asset management mindset in the organisation. Only when a road asset management mindset is established, will the institutionalisation of the IRMS be achieved and be sustainable.

However, even with management commitment, there are a range of issues and barriers that need to be overcome. From the review of the issues it is clear that improvements are needed in all three success factors: (i) processes; (ii) people; and (iii) technologies.

DGH needs to develop clear business processes which detail how the IRMS is to be used in planning and programming. The staff involved will need to receive training in both, system operations and management, as well as in system output processing. The data collection approach, which is one of the primary issues, will need to be entirely re-engineered and the IRMS will need to be calibrated in the short term and replaced by a COTS system in the medium term.

It is important to note that the current IRMS, if better calibrated, will provide suitable input for the tasks at DGH. The short term focus should thus not be on the system, but rather on all the other tasks related to operating a system, most significantly the business processes and the data collection. If these issues are not improved, bringing in a new system will not change the situation and the organisation will not be able to capitalise on the new system. When the organisation is clear on how to adopt the IRMS (the business processes) and it has proven that it can collect quality data; then focus can be shifted to improving the IRMS, preferably through moving to a COTS system. This would bring the success factors into a more balanced situation[41].

6.1 PROCESSES

From the review it was clear that business processes into which the IRMS could be embedded did not exist. It should be made clear that the IRMS is only a tool in the business processes, and won't be institutionalised if processes for its use are not developed, implemented and adhered to. Thus, DGH will need to develop and describe a set of business processes which detail how the IRMS is to support the activities within the DGH.

The business processes will need to detail:

- All tasks relevant to the planning and programming.
- The activities and steps within each task should be described.
- Clear responsibilities should be assigned for each task.

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[40] During the Consultants presentation, it was noted that managers were not present. This is a clear example on commitment not being explicit.

[41] Currently the system is rather advanced, while other factors such as data collection, business processes and staff capacity is very weak, if not missing.

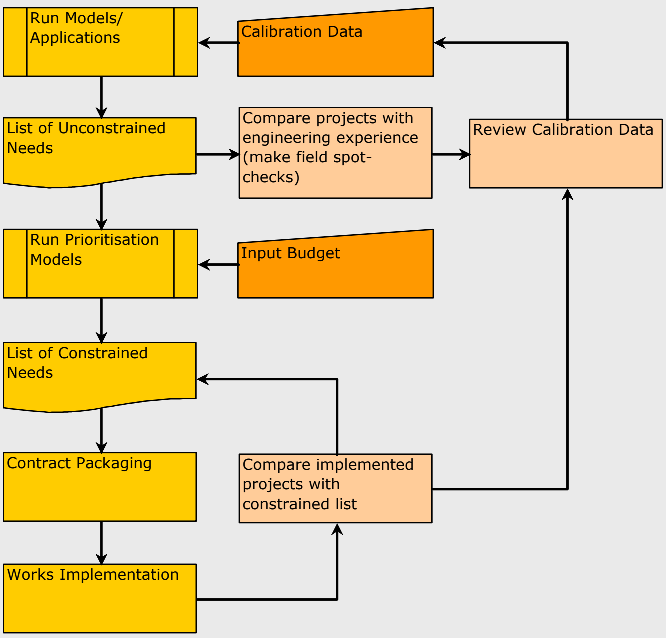
- Linkages between the tasks, including what input is needed and what output is to be generated.
- A time schedule for all tasks, which also shows task dependencies, in order to track progress and review consequences of delays.

The business processes should cover all planning and programming activities; not only those that are strictly related to the IRMS operation and management.

Finally, the business processes should also include procedures for continual improvements of the processes and systems. This should include hit-rate procedures which is a formalised process, where the analysis output is compared to the 'real' situation on the road sections. Data is collected and analysed to indicate where improvements in the model calibration can provide improved estimates.

Example – Hit-Rate Analysis

The Hit-Rate Analysis could be carried out on different levels in the maintenance and rehabilitation programming and implementation cycle.



6.2 PEOPLE

It is clear that the staff involved in the IRMS and related activities are in instant need of training. However, again it should be stressed that this not only relates to the operation of the IRMS, but also to all other tasks within the defined business processes (see above).

In relation to the IRMS operation, it is recommended that job descriptions are developed for key tasks such as: (i) management of road network; (ii) data collection; (iii) data management; (iv) management reporting; (v) data analysis; and (vi) system management.

Training needs to be provided in the use of the IRMS as well as in general road asset management principles. The training specific to the IRMS will not be lost when moving to a COTS platform, as many of the principles adopted in the IRMS is of general nature, and would also be found in most COTS systems.

In the longer term, structures for peer-to-peer training as well as more formal training to handle staff replacements are needed. If such training mechanisms cannot be established, the short term training will not be sustainable. As part of this, it is recommended that the universities will be invited to participate, to prepare training programmes specific for road asset management, and also provide opportunities for post-graduate studies for involved DGH staff. This could support training and career paths of the staff, and help make it more attractive to be involved in road asset management.

6.3 TECHNOLOGIES

The technologies refer to the: (i) data collection; and (ii) road management systems.

6.4 IRMS

The long term recommendation for the IRMS is to replace it with a COTS system in order to overcome some of the structural issues in DGH (system maintenance, project based development and training).

However, in the short term the use of IRMS should be continued, though it should be ensured that the latest version is adopted. In order to better support the programming and planning tasks, it is recommended that the following enhancements be implemented.

- SDI included in the programme reporting
- Filter for analysis network

It is not needed to address the additional issues identified in an earlier section (such as revised setup for maintenance treatment design and revised road management facilities), provided the medium term recommendation of adopting a COTS is followed. The additional weakness identified is not providing a barrier for the immediate use of the IRMS.

However, all calibration factors should be reviewed and updated; this should include focus on outputting more realistic programme for periodic maintenance. The steps for this should include: (i) derive a set of trusted data; (ii) update unit rates and RUC; (iii) review calibration factors; (iv) run analysis and review output; (v) compare output with site condition (engineering judgements); (vi) redo the steps until output is reliable. Doing this will ensure that the IRMS is calibrated sufficiently until it is replaced by a COTS.

In the medium term, the IRMS should be replaced by a COTS system as this would overcome some of the structural barriers in DGH; such as system maintenance and training. The vendor of the COTS will undertake system maintenance (provided that a maintenance agreement is signed) and will also offer regular training in system application, as well as participation in user groups, where experience can be shared with other users of the same software. DGH has clearly shown that system management and maintenance and system operational capacity is difficult to sustain; thus moving to a COTS systems, where these issues are tackled by the vendor will enhance the changes of making the IRMS sustainable.

As the current tailored parts of the IRMS is not adding significant benefits to DGH (they might even represent barriers), moving to a COTS system will not significantly reduce the benefits of implementing a road management system. Overall, the advantages of the COTS system thus overweigh the disadvantages.

The timing of the system change should be when the processes are developed and implemented, as this will assist in developing and detailing the requirements to the COTS system. It is deemed that this would take 2-3 years, which would probably also coincide with challenges in terms of development in IT platforms.

6.5 DATA COLLECTION FRAMEWORK (ROAD MONITORING FRAMEWORK)

The current data collection framework is one of the main concerns and barriers for institutionalisation of the IRMS. If data quality is not good and data cannot be trusted, all other downstream tasks will fail. It is of utmost importance that DGH acquires good quality data which fits the analysis models. Currently, too much data is collected for some data types (and in poor quality), while other needed information is not collected.

The data collection approach thus needs to be re-engineered. This involves: (i) revised data sets to be collected focusing on the model needs42; (ii) adopted technologies for the data collection; and (iii) revised organisational setup. Furthermore, sustainable data collection schemes would have clear and explicit data collection policies and procedures, which is understood by all those involved with data collection. There must also be strict data quality assurance processes in place so that all system users have confidence in the data and analysis provided to them.

When developing the data collection policies, one would need to look at: (i) technologies applied; (ii) frequencies; and (iii) coverage. The technologies refer to the equipment adopted, while frequencies and coverage refer to how often the data collection is carried out for each data item and how much of the network is measured each time. It is generally recommended that:

- Road inventory data would be collected in a one-off exercise. After this, surveys should be restricted to those roads which have been constructed/reconstructed. However, data should be verified or updated every five years.
- Road surface condition for main roads should be collected at intervals of 1-2 years for paved roads and annually for unpaved roads.
- Road bearing capacity should be measured with 3-5 year intervals.
- Traffic volumes should be collected at cycles of 3-4 years.

Based on the above, it is recommended that the following data collection approach (Road Monitoring Framework) is adopted.

[42] Many organisations tend to look for 'nice-to-have' data, which is data that is not really needed, but which would be good to have, if needed later. This only complicates that data collection and increases costs, without providing direct benefits.

Survey	Data[43]	Frequency	Technology[44]
Location referencing	Road alignment, road number, road class, point features, LRP's	Only after major improvement	GPS Digital DMI
Road Inventory	Surface type, pavement width, shoulder type, shoulder width/length, topography, photos	Only after major improvement (1)	Manual Digital DMI GPS Video logging
Roughness (paved roads only)	IRI	50 percent surveyed annually (7)	Laser Beam (2)
Bearing capacity	Deflection	25 percent annually (3)	Benkelman Beam/FWD (4)
Paved surface condition	Cracks, potholes, patches edge break, shoulder condition, drainage condition	50 percent annually (7)	Digital Imaging
Unpaved surface Condition	Gravel thickness, drainage condition	Annually	Manual Digital DMI
Traffic volume	Classified counts of each link (5)	3-5 year cycle	Tubes or if permanent stations inductive loops
Axle load surveys	Axle loads (6)	Annually on selected locations	Portable scales
Maintenance Works	Location, type and cost of maintenance works actually applied	Annually, when the works are completed	Manually
Ongoing/Committed Projects	Location, type and cost of committed and ongoing projects	Annually, when annual programmes are approved	Manually

[43] Further data items may be added depending on the in-depth analysis of the model data needs
[44] In line with the recommendations in 'Data Collection Technologies for Road Management', World Bank, February 2007

Notes:

(1) A complete survey should be carried out every five years to verify/update data.

(2) If a laser beam is mounted on the vehicle used for digital imaging, this survey can be combined with the surface condition survey.

(3) A baseline survey will need to be undertaken in 2010/11 in order to populate the database.

(4) The current IRMS model uses only the deflection; hence Benkelman Beam Deflection (BBD) measurements should suffice.

(5) It seems excessive to make 40 hours and 16 hours counts for planning and programming purposes. It is recommended that 16 hours counts are adopted for all roads, combined with some 24x7 counts to derive variation factors for roads with relative low volumes.

(6) Not used directly in the IRMS, but Equivalent Standard Axles (ESA) will need to be estimated as this is an input to the NAM.

(7) For the main corridors, surveys could be done annually.

The structural capacity is an important parameter in the design of treatments, but is not measured as part of the network level survey and thus, not part of the treatment design when programming works. In order to get a better design of the maintenance treatments, bearing capacity measurements would need to be included in the survey framework.

A significant and important change with the recommended approach, compared to the current approach, is leaving the subjective nature of the manual pavement surface survey and instead adopting more objective equipment based technologies, like digital imaging of the road surface. This involves digital recording of the pavement surface and using this in an analysis routine to estimate the amount of surface distresses.

Figure 2: Example of Digital Imaging Equipment

While such equipment is rather expensive (in the order of USD 200,000-300,000 per equipment[45]), it provides a number of advantages which would suit DGH's needs. These include:

- Surveys can be undertaken at high speed. With the rather large network under the responsibility of DGH (some 38,000 km) and the distribution of this over many islands, it is necessary to apply techniques which collect data quickly (as a centralised approach is recommended).

[45] Would include digital imaging equipment, installation, vehicle, analysis software and training

- With a large network as is the case for DGH, investments in such rather advanced equipment is justifiable.
- The base data collected (the digital images) is objective and cannot be manipulated. The analysis routine which will analyse the digital images will also be applied across all paved sections and thus free of localised manipulation. In case of quality issues, one can always go back to the original survey data. It is thus deemed that this technology could potentially improve data quality.

The disadvantage of the digital imaging is the high investment cost and the complicated maintenance. It is thus highly recommended that a maintenance agreement will be signed with the supplier. One issue relating to maintenance and operation is the risk of equipment breakdown during surveys. Being a highly complex computer-based equipment, it is not likely that the equipment would be reparable in the field. Thus, there is a risk of losing significant survey time, if the equipment is not stable and durable.

If this equipment based approach is chosen, it can be recommended that a laser beam is added to the vehicle, ensuring that the roughness and rutting also can be measured at the same time. This would mean that the roughness equipment in the provinces would be redundant and could be used for measurement of other road networks (e.g. provincial roads and/or urban roads).

It is deemed that two to three vehicles would be needed to cover the network in accordance with the proposed road monitoring framework. It should be realised that even with this pool of equipment, it will not be possible to reach all islands. Thus, on the more remote islands, manual approaches will still be needed.

International experience shows that data collection costs[46] is about 15-20 USD/km.

6.6 DATA COLLECTORS

The re-engineering of the survey framework also includes a change in the currently decentralised organisational setup. Adopting equipment based approaches also means that data collection should be centralised, in order to make sure the equipment is put to maximum use, and to ensure that the organisation with which the equipment rests, is capable (technically and economically) of maintaining the equipment and operating it. Several of the items proposed in the revised framework are highly complicated equipment. It is thus proposed that IRE would acquire the equipment and be contracted to undertake the data collection. Such contracts should cover a minimum of two to three years of surveys.

The IRE is already managing several equipment used for road and bridge surveys, and will have the capability to operate and maintain the proposed digital imaging equipment.

However, it should be stressed, that the involvement of IRE should be based on contractual arrangements (as if the work had been through a procurement process), in order to overcome the problems of in-house approaches.

At central levels, focus will need to be on contract management (the contract with IRE), which includes contracting, tracking of progress, supervision of data collection and quality assurance of

[46] Includes: operation costs, data processing and amortisation costs

received data (which would include spot checks on site). It is important that IRE will undertake their own quality assurance programme, and the results of this will be made part of the data submission from IRE to DGH, in order for DGH to ensure that the quality assurance processes agreed to are also adhered to.

6.7 QUALITY ASSURANCE

Independent of any approach to data collection, quality assurance is vital and absolute necessary if quality data is to be achieved. It is thus highly recommended that strict data quality assurance processes are adhered to. Such processes would include:

Stage	Main Activities
Before data collection	Calibration of surveyors (if manual surveying is part of the approach). Calibration and validation of *all* equipment adopted. Data collection demonstration test of at least 100 km representing the variety of the road network (to verify that the surveyor logistically can collect the data to the requested quality).
During data collection	Continual monitoring and supervision of surveyors.
After data collection	Data validation and verification, including field spot check of data.

For each quality process it should be clearly identified who would be responsible for undertaking and documenting the quality assurance. This should be described in a Quality Assurance Manual, which should also include relevant check lists. As part of this, it is important that the role of the IRMS staff in terms of *data verification of all data received* will be enhanced to include data spot check of received data. This will include significant field visits to compare received data with the actual situation on the ground. Moving to an equipment based approach for the surface condition will reduce the needs for data verificationas, if the demonstration tests (which is part of the calibration tests) show successful results, there would be no grounds for doubting the rest of the data (though the surveyor should always adhere to continues documented quality assurance processes).

6.8 SUSTAINABILITY MECHANISMS (GENERAL)

In order to make the proposed strategic direction sustainable, the following general and overall recommendations are provided for consideration:

- Management will need to clearly show their commitment to the IRMS. This includes the use of output, provision of budgets and training.
- The IRMS staff shall receive continual training in Indonesia and abroad.
- Clear and explicit IRMS planning and programming schedule developed with clear deadlines of and correlation between main tasks.
- Clear and explicit business processes should be developed, which clearly shows where the IRMS output feeds into.

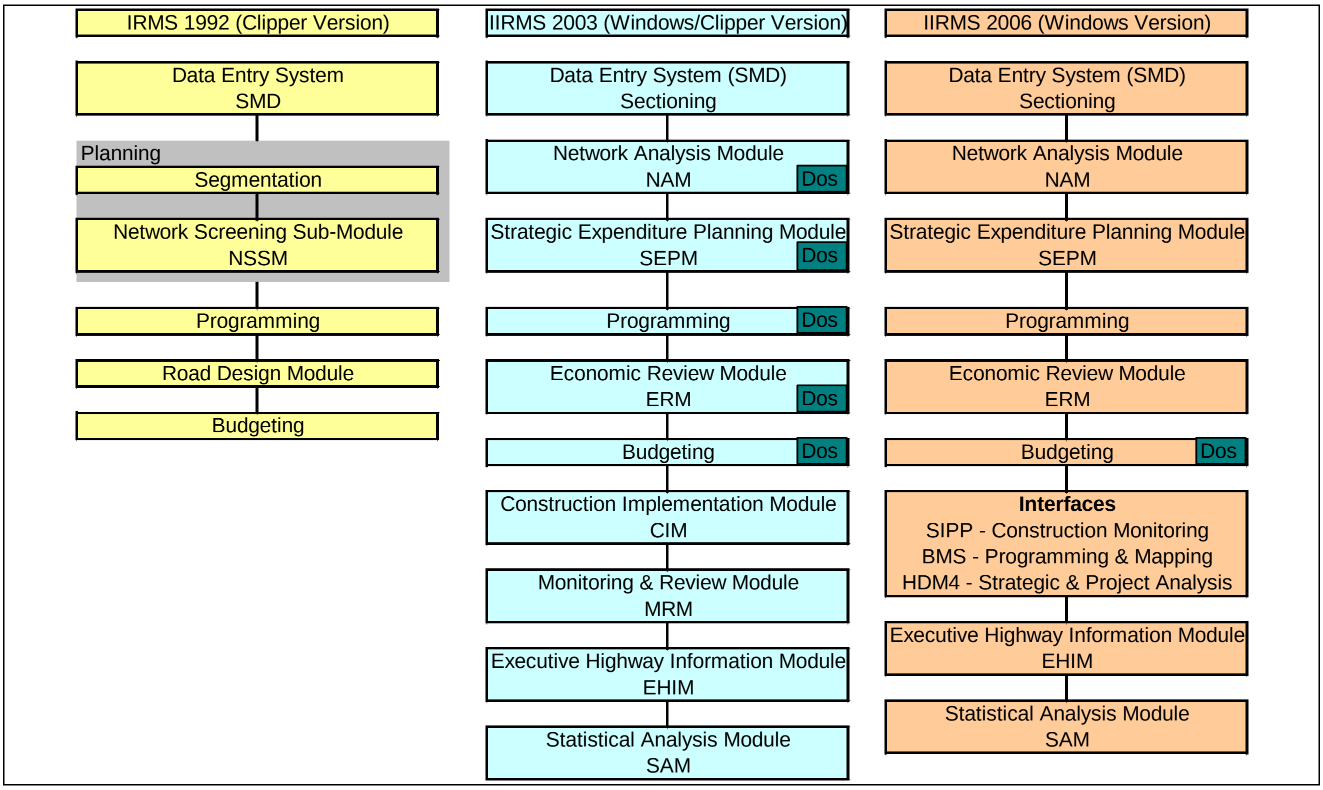
- Annual business reports should be prepared using direct input from the IRMS. This should include specific and realistic key performance indicators.
- Regular briefings should be given to high ranking officials on the importance of asset preservation and what is being done to make sure that asset presentation is dealt with satisfactorily.
- Have policies and procedures in place for data collection and for quality assurance.
- Technical auditing (internal and/or external) should be carried out on data and systems, and recommendations acted upon.
- A programme of continual quality improvement is critical (no system is static).
- There should be a specific organisational unit established with specific responsibility of the IRMS.
- The IRMS staff should have clear job descriptions, and should be provided with continual training.
- There should be specific budgets allocated for IRMS operation, maintenance, training and data collection.
- The IT department should be involved in the IRMS maintenance. The IT department should also develop an overall IT strategy, on which future developments of the IRMS should adhere to.
- Computers and other related IRMS equipment should be updated and upgraded as appropriate.
- The future development of the IRMS should be driven by DGH and fit into the overall development strategy for DGH.
- An awareness campaign should be considered in order to create more knowledge of the IRMS in the Ministry of Public Works (MPW), counterpart ministries and among development partners. This aims at increasing the role of the IRMS in the MPW in general.
- Only data needed to support the business processes should be collected.
- Data policies and procedures should be formalised.
- Strict data quality assurance procedures should be adhered to.
- Continual improvement is necessary on all aspects of data collection, quality assurance, and data management.

ANNEXES

ANNEX A: OVERVIEW OF IRMS

The IRMS has been under development in various forms over the last fifteen years or so, although its origins extend to the early 1980s. The latest major upgrade was implemented between 2003 and 2006 under the Planning Programming and Budgeting Procedures Project (PPBP)[47] and under the current project (mostly bug fixing). The scope of the IRMS is shown in Figure 2.1 and summarised below. A comprehensive description of the IRMS is given in DGH (2006) and accompanying reports and electronic media.

Figure 3: IRMS (1992), IIRMS (2003) and IIRMS (2006)



The component parts of the IRMS (DGH 2006) include:

- a *Database* and accompanying *Data Entry System* (SMD) for storage of data related to National and Provincial roads.
- a *Sectioning module* which processes available information and generates a set of homogenous physical sections of road for analysis (or segments), from which two further sets of sections are produced - sublinks, which comprise non contiguous homogenous sections within the same link which are used for annual works programming, and Replinks which comprise non-contiguous sections for a single province or group of provinces and are used in strategic analysis.

[47] Adapting planning, programming and budgeting procedures to Indonesia. DGH/IBRD Technical Assistance Project under EIRTP-1, Loan no 4643 IND.

- a *Network Analysis Module* (NAM) which takes the output from the sectioning stage and applies Road Deterioration and Works Effects (RDWE) models and road user effects and cost models to determine future agency costs and economic ranking for maintenance and betterment works. Based on a pre-set group of 23 treatment strategies, comprising a user defined base case and periodic maintenance and betterment options which can be applied in any of the 11 years, the NAM provides input to SEPM and the Programming Module. It is also used to model user defined options for the ERM.
- a *Strategic Planning Expenditure Module* (SEPM) which selects the optimal treatment for a single set of treatment strategies for selected road sections or to select an optimum set of strategies from investment alternatives representing National and Provincial roads (IRMS), Urban roads (URMS), Kabupaten Roads (KRMS) and Bridges (BMS). It is simply the degree of detail and the geographic or administrative scope of the strategies being optimised that may differ. A SEPM analysis is performed on a scenario – a user-specified set of annual budgets and parameters governing network scope, calculation of benefits and the optimisation process through budget availability. A solution is offered for each section, chosen to maximise the total NPV.
- a *Programming Module* produces annual, three and five year works programs based on the outputs of SEPM analysis. After SEPM optimisation, three processes are run automatically, namely i) Treatment Allocation; ii) Treatment Aggregation; and iii) Link Program Assignment. The aim is to produce indicative programs at a link level. Whilst the analysis is primarily intended for roads programmes, BMS outputs can also be subject to the same analysis.
- an *Economic Review Module* (ERM) which is used to both, evaluate projects on IRMS links or to carry out feasibility studies on roads not in the IRMS database. It was originally conceived as a tool for confirming the economic viability of periodic maintenance and betterment projects both, before and after the design and bid preparation stage of project implementation. Whereas the network analysis function of NAM uses existing data, system default costs and treatment and surface type selections to do a 'best-fit' treatment analysis; after detailed design and design review, the costs and treatments may be different and a user specified analysis is required.
- a *Budgeting Module* which takes the outputs from NAM/SEPM and presents them for annual budgeting purposes.
- a number of *Interfaces to Independent Tools*, including: i) SIPP[48] - to access information on the implementation of works from contract signing to hand over and then incorporate them in the IRMS works history table in order to integrate ongoing and future within the planning process; ii) BMS – for SEPM analysis, programming and mapping purposes; iii) HDM-4 – for exporting the results of the sectioning analysis for further processing in version 1.3 of the international investment tool owned by PIARC (Kerali 2000); and iv) the Local Roads Management System (LRMS) – a spreadsheet tool for determining works programs using a set of simplified RDWE and RUC models, including prioritisation using NPC/C (a Cost Effectiveness Indicator) and Social Points Score.
- an *Executive Highway* Information *Module* (EHIM) which is a GIS-based reporting and display tool. Maps created outside the IIRMS or updated from the centreline feature of the data entry module, can be interrogated showing various forms of data for links. In addition, thematic maps of roads and bridge data can be made, including i) Multiyear Programs Group; ii) Single Year Programs; iii) Condition; iv) Serviceability; v) Historical Works; and vi) Bridges.
- a *Statistical Analysis Module* (SAM) which stores a set of pre-determined road and bridge statistics which can be displayed in single and multiyear reports and graphs, including time-series data for five

[48] A system used for construction monitoring

data items (roughness, surface type, pavement strength, road width and traffic) for each km for each link each year. The display mechanism allows the user to choose which years to display in the graph. Management of the SAM data should be done once a year before the next year's survey data is inputted; otherwise the original data is overwritten and effectively lost.

As indicated in Figure A1, the majority of the modules exist in MS Windows. A number of modules and models were either updated or added to provide additional functionality. More importantly, the entire IRMS suite of programs underwent a major refurbishment as a result of a major upgrade and normalisation of the underlying database structure using a new common database written in *Powerbuilder*, a widely used database software.

ANNEX B: SUCCESS FACTORS FOR RMS SYSTEMS – AN OVERVIEW49

The successful implementation of a computerised road management system (RMS) depends on the interaction of three fundamental components: Processes, People and Technology. If any of these components are lacking, the system will not be successful. The best technology in the world will ultimately fail if implemented in an environment where there are no people to run it, or where the processes are not in place to utilise it.

In 2005 the World Bank hired consultants to conduct interviews in 21 different road agencies in 16 countries, to gauge their experiences in implementing RMS. A standard questionnaire was completed for each agency. The agencies were chosen to represent a cross-section of experience (with regards to RMS) in different continents. National road agencies were primarily chosen, although some large provincial and state agencies were also interviewed.

What is apparent from the study is that agencies that are successful in their implementations have built strong foundations in all of the fundamental components over a number of years. First and foremost, they have developed an 'asset management mindset', that is, they explicitly and conscientiously implement policies that are geared towards managing their highway infrastructure as an asset whose value must be maintained and improved. Their executives and management promote asset management principles in order to ensure that funding and budget are allocated to appropriate areas. They are explicitly committed to the RMS, in the sense that it is built into their processes and procedures. They ensure that sufficient budget is available for data collection, for upgrades and maintenance of the systems, and for staff training and progression.

If there is no 'asset management mindset' in place, if there is no organisational unit with specific responsibility to implement the system, or if the results of the system are not validated and utilised, then the system can be regarded as a failure. Unfortunately, most agencies were found to have failed in one way or the other.

There are several key recommendations made, based on this study:

- Prior to planning or implementing an RMS, the agency (with assistance from donors if necessary), should review its business processes, people and technology. The resulting project specification document or Terms of Reference (TOR) must focus on all areas. Too often in the past, TORs focused almost exclusively on the technical components (*i.e.* the computer system or the technical aspects of data collection) while paying scant attention to the organisation in which it sits and how it would be used.
- Key elements of institutionalisation that must be reviewed and explicitly addressed are business plans, budgets, and policies.
- Staff positions must be filled with proactive, involved individuals who are committed to the implementation, and who have the requisite management skills and initiative to drive the system.
- In the area of Information Technology (IT), an RMS cannot be implemented in isolation from the IT policies or IT infrastructure of the agency. Many agencies need particular support in this area, and some fundamental policies and procedures often need to be addressed, including IT architectures, IT

[49] Extracts from 'Success Factors for Road Management Systems', The World Bank, 2005

budgeting, IT procurement, IT replacement strategies, outsourcing of key areas such as computer network support or systems administration, and general IT support and training. Many organisations struggle in these areas, and this can have a major impact on the success of the RMS.

- This study recommends that road agencies should try to adopt the COTS software wherever possible. Custom developed applications have often proved difficult and expensive to sustain.
- The study includes a set of key functional requirements for RMS that, along with technical requirements, should be used as the basis for any RMS specification. There are several good products in the marketplace that address most of the functional requirements listed.
- If an agency has any concerns about its ability to operate and maintain specialist data collection equipment in-house (in terms of staffing skills, budgeting for spare parts, equipment calibration *etc.*), then the agency should seriously consider outsourcing data collection. Road agencies around the world are littered with expensive equipment that has proved impossible to maintain/sustain, and in some cases have never been used. However, this decision also has repercussions on staffing within the agency. Outsourcing surveys requires strong management and quality assurance policies and procedures. Training of agency staff to manage outsourced contracts must be provided in this regard. This study also includes key principles that should be included for all data collection contracts.

Finally, and most importantly, no system is static. The most successful agencies are always looking for room for refinement and improvement in data collection procedures, quality assurance, road deterioration modelling *etc.* Many agencies that start off with a simple system rapidly start to understand that an RMS is a major on-going investment. Technology continues to move forward in a number of areas – IT, data collection, road maintenance treatments *etc*. Staff must keep themselves abreast of developments and look for opportunities to improve the system and its uptake. Organisational planning and budgeting should take this into account, and agencies should be aware of the long-term impact of implementing RMS.

Below is a summary of the key recommendations from the study:

Processes
• **Funding:** Have annual budgets in place for data collection and operation of the RMS. Even if this initially requires donor funding support, there should be a phased increase in local budgeting to ensure that the RMS is self-funding within a given timeframe. • Introduction of an RMS by itself is not a guarantee that it will be used, or that it will be successful. The agency must also follow basic asset management principles. Strong involvement of executives and managers prior to and during the implementation of the system is ***absolutely necessary***. • Clear and explicit RMS planning and programming cycle/schedule developed with clear deadlines of and correlation between main tasks. • Annual Reports/Business Plans should be prepared, using 'Asset Value' and other Key Performance Indicators derived from the RMS. This is an executive and managerial responsibility. It also helps put focus on the RMS itself, since it provides the data and improves the chances that budget and funds are available to run the system. • Institutional support, consisting of high ranking decision-makers fully-committed to the asset management/asset preservation 'philosophy'. • Regular briefings should be given to ministers and other high government officials on the importance of asset preservation, and what is being done to make sure that the preservation of the road infrastructure is dealt with satisfactorily. • Have specific and realistic key performance indicators, targets to measure asset value and to preserve/enhance that value. Monitor those targets, and assess at the end of each year whether they have achieved them or not, and take appropriate action. By publishing this information in Annual Reports, they are accountable to it.

- Have policies and procedures in place for data collection, and for quality assurance of that data.
- Technical (internal and/or external) auditing must be carried out on data and systems, and the recommendations acted on.
- A program of Continual Quality Improvement is also critical. No system is static. All systems can be improved.

People

- There should be an organisational unit established with specific responsibility for the RMS.
- There should be a budget for the operation of the system, including all staffing, equipment, data collection (contracted or in-house), field travel, quality assurance etc.
- There should be clear job descriptions for the various activities, and a career path for those in the unit.
- There should be a continual training and development program (and budget) for staff to deal with staff turnover and re-training where necessary. This should potentially include Master's or other post-graduate degrees which will increase the attractiveness of working in this area.
- There should be training materials available. For bespoke systems the copyright should reside with the agency.
- Jobs should be filled with appropriately qualified personnel, with good management skills, and with access to and control over their budget.
- Job responsibilities should explicitly include:
    - Management of the Road Network Referencing System – control, verification, education and dissemination to other stakeholders.
    - Data Collection – planning, management, supervision and coordination.
    - Data Quality Assurance – verification and checking of all data.
    - Management Reporting – reporting and presentation to management.
- Strong contract management skills are necessary, especially for agencies that contract out portions of data collection.
- The agency should follow good basic management principles, covering procedures, records, auditing etc.
- There should be a commitment to Continual Quality Improvement.

Information Technology

- There should be an IT Division.
- TORs should explicitly reflect the IT support in the agency; they should not implement a system in isolation from the IT strategy of the agency. If necessary, assistance must be provided to define an IT strategy and to implement it.
- Road agencies should consider outsourcing/external hosting of their systems where possible, given their local environment and according to their overall organisational policies.
- Any sizeable organisation procuring IT should have a Technology Architecture, or explicit technology standards and directions. This is important to avoid a profusion of different infrastructure software (operating systems, databases, GIS etc.) with all the attendant support issues; it is also important in helping to define a replacement/upgrade strategy for hardware and software. There are also distinct economies of scale that can be achieved through centralised procurement of hardware and system software.
- All IT implementations should use COTS products wherever possible.
- For any future implementation of an RMS, a set of functional and technical requirements should be drawn up. Functional requirements should include the functions that the software should perform. From the wealth of experience available, it is relatively easy to determine generic functional requirements of an RMS, to suit a road agency of a given size. Technical Requirements should describe the technology environment within which the RMS will fit (i.e. hardware, operating systems, databases, GIS, and other applications). This should relate to the agency's Technology Architecture.
- TOR requiring 'integration' to other applications, such as HDM-4, with an RMS should be more precise, to raise client awareness of the issues, and will enable the consultant to get a clearer understanding of the client's needs prior to bidding.

- Agencies should develop and adhere to a long-term IT budget strategy that includes costs of hardware and software maintenance agreements (in addition to hardware replacement strategies). One of the comments from a case study in Asia was "*The system has not been upgraded since its initial installation (in 1996) and it shows its age. It was the first MS Windows-based version of this system and is not very user friendly*". This is a classic case of what can happen if there is no long-term IT strategy.
- The real requirements for web-enabling of systems should be more carefully assessed, and explicitly stated in TOR. The client also needs to make sure that their IT infrastructure (including hardware, systems software, databases and GIS) is able to support what they wish to do with a web-enabled system.

Data Collection

- Data collection equipment and approaches should be tailored to the capacity of the road agency.
- Only the key data that are required for use in decision-making should be collected and stored in the RMS.
- Data should be collected at the minimum level of detail with the most appropriate data collection technology given the constraints and capabilities of the agency.
- Data collection policies and procedures need to be formalised and should be readily available.
- If the agency has concerns about operation and maintenance of specialist data equipment in-house, then consideration should be given to outsourcing of the relevant surveys.
- Outsourcing surveys require strong management and quality assurance of the contractor. There should also be liquidated damages in the contract in the event the contractor fails to provide quality data in a timely manner.
- Key principles for data collection contracts should be included in TOR.
- Strict data quality assurance procedures should be adhered to so that all system users have confidence in the data and analysis provided to them.
- GIS data needs to be managed in a more detailed manner than other road data since it is likely to be used by many parties outside the road agency.
- Continual improvement is necessary on all aspects of data collection, quality assurance, and data management.

Key Functional Requirements for an RMS

- Terminology and Local Language: All screen labels, menu items, and reports should be configurable to the client conventions in the local language.
- Road Network Referencing: Different network referencing schemes should be supported. These should include linear distance from the start of the road section, linear distance from the start of a road, as well as distance from known location referencing points.
- Road Network Numbering Rules and Conventions: Network Numbering Schemes particular to the client should be able to be enforced by the RMS.
- Network Editing: Should permit splitting and joining of road sections, also modification of road section lengths, while preserving integrity of all data stored against the affected sections[50].
- Network Auditing: Any changes to the road network definition should be audited, and the RMS should allow review of these changes.
- Multi-Media Storage and Display: Should allow storage and display of multi-media objects (*e.g.* photographs, video clips etc.) as attributes of inventory items.

[50] This is one of the most often overlooked features of RMS and can lead to excessive maintenance efforts by the agency. Roads change over time and the system must be designed to automate the process of maintaining and updating the data to a very high degree.

- User-Defined Items and Attributes: Should allow the user from the GUI (Graphical User Interface) to define the types of inventory/condition data to be stored, and to define what attributes are to be stored against each type of inventory. There should be no restriction on the number and type of items or their attributes.
- Data Level Security: Allow security setup so that users may only have update privileges for sub-networks in different geographical or administrative areas. Also, for different users to have different levels of access depending on the type of data.
- Function Level Security: Allow security setup so that different users may have access to different application modules.
- Staging Area for Data Loading: Should permit data to be loaded into a temporary staging area for verification of data, prior to making it available to other users within the application.
- Reporting: Reporting should be flexible, and the interface must enable the user to define his own reports from the GUI without reprogramming of the application.
- Integration with GIS: The RMS should integrate with GIS to allow display of inventory and condition data against maps of the road network. The exact type and method of integration can vary widely, from embedded GIS in the application front-end, to simple ability to export data for manipulation in an external GIS.
- Automatic Sectioning: An automatic sectioning function to collate and summarise data for analytical purposes. The user should be able to define the sectioning criteria using any of the key inventory or condition data.
- Data Transformations: Sectioned data need to be transformed to the automatically generated sections using different criteria.
- Trend Analysis: Should allow production of reports/graphs showing trends in average condition (or any attribute of any database item) over time, for part of a section, a whole section, part of a route, or a whole route.
- Template Survey Forms: Should allow production of template forms for use by the client for performing surveys. These template forms should be based on actual network inventory.
- Schematic Line Diagrams: Should allow production of schematic line diagrams showing selected sections and inventory items with selected attributes.
- Purging of Data: Should allow purging of historical inventory and condition data to an archive database, and subsequent retrieval of that data if required.
- Audit Trail: All data changes should be audited, including time of change, username responsible for making the change, and value of previous data item.
- Application Programming Interface: Allow other applications to retrieve data from the RMS via a programming interface. Ideally, this should not take place through direct database access.
- Other Asset Inventory: Should permit storage of, or cross-references to, other major assets such as bridges and other structures. If bridges and other structures can be accommodated, then all above functional requirements should also apply to these assets.

Key Points for Implementation of a GIS

- Agree to the policies, standards and accuracies with internal stakeholders and with external stakeholders from other relevant agencies. Mapping data is much more likely to be shared, and taken out of context, than most other road data.
- In particular, agree on policies for updating the geographic representation of the road network, taking into account whether the agency has the ability to collect its own GPS data, or whether it needs to hire GPS contractors. There is also the possibility of getting road construction contractors to provide as-built drawings and/or GPS coordinates of new roads, although this does not help in the case of road conversions.
- Metadata [51] standards should be agreed on and implemented.
- Data quality standards should include data cleanup procedures, snapping of lines, closing of polygons etc. as well as domains of values for attribute data.
- Consideration should be given to versioning of data to allow historical spatial analysis.

[51] Metadata provides information about the content, quality, condition, and other characteristics of data.

Basic Principles For Data Collection Contract Management
• Require the contractor to survey a validation network (minimum 100 km) prior to the full survey. This will help the contractor to sort out logistical and technical issues early on and before the full survey commences. This validation survey data should be completely processed and imported to the RMS where it is verified as suitable. This will (i) confirm that the data processing steps are in place to use the data, and, (ii) ensure that the client can review the submitted data on a timely basis. • Require every data collection team of the contractor to perform the validation survey. If there are different teams, different vehicles, and different equipment, then all should be tested. • Require the contractor to produce his own Quality Assurance Plan prior to the start of the contract. This should be approved by the client. • It may also be useful to ask for the contractor's Quality Assurance Plan as part of the proposal, and include evaluation of the Quality Assurance Plan in the technical evaluation. • Require documentary evidence of calibration prior to, and during, the surveys. • Require data to be *submitted* within a short time period after collection (less than two weeks if possible, and certainly not more than one month). • Pay only for data approved, not for time, and not for data submitted. It will be necessary to agree upon the time-frame for approving data (usually 30 days or less) and to ensure that the client's staff are allocated sufficient time to check the data. • Have a liquidated damages clause in the contract which can be used in the event of late submission or continued submission of poor quality data.

ANNEX C: RENSTRA AND IRMS

The table below has the detailed Renstra objectives/targets listed and indicated how the IRMS could be adjusted to support these objectives.

Objective	Target	Role of IRMS
Improvement of the planning quality of the development of public works and settlement infrastructures, and control of the spatial utilisation in order to realise a sustainable development (including adaptation and mitigation of climate changes).	Implementation of an integrated, sustainable, and environmentally sound road operation with a percentage of accomplishment of 100 percent.	IRMS will support this through providing information for road operations as needed and requested. In particular, the IRMS can help in determining a need based distribution of budgets between provinces, which technically would provide a much more effective allocation distribution as compared to current distribution models[52].
Improvement of quality and quantity of road usage through preservations and improvement of road capacities.	Increased level of road usage on national road links into 91.55 billion vehicle-km per year.	IRMS could be enhanced to output estimated vehicle-km per year based on the link lengths and AADT figures.
	Decrease of average travel time between national centres of activities by 5 percent.	The IRMS RUC models could be used to estimate travel time based on road condition and road capacity.
	Percentage of national road networks in stable condition increased to 94 percent.	The IRMS could be enhanced to: (i) analyse the budget needs for achieving this target; and (ii) output historic and predicted development in the stability of the road network under different budget scenarios. This would involve a new objection function in the NAM.
	Increased capacities of national roads to 19.370 Km.	The IRMS can assist in identifying the roads with capacity problems.
	Increased lane-km on national road links by 13.000 lane-km.	
	Increased capacities of national roads with highway specifications by 400 km.	The IRMS could provide the data (in a separate report) for screening the national road network to identify where they do not meet highways specifications[53].

[52] IRMS Screening and Provincial Budget Analysis for future EINRIP Work Programs, EINRIP, November 2006.

[53] It should be noted, that this screening, as well as the similar screening for sub-standard national roads, would be done on the road data in the database only. It is assumed that the standards would include requirements for which data is not available in the database (for instance the horizontal and vertical road alignment). Such information could be analysed using a GIS system and the IRMS road alignment data.

Objective	Target	Role of IRMS
	Percentage of completion of road width improvement on four Main Highways into the minimum width of 7 m on Eastern Trans-Sumatra Highway and Northern Coast Highway, and 6 m on Southern Trans-Kalimantan Highway and Western Trans-Sulawesi Highway increased to 100 percent.	The IRMS could, as an analysis option, be enhanced to include forced widening for the corridors if current width is less than the target width (currently, widening is controlled by a combination of AADT and current width).
	Percentage of decrease in length of sub-standard national roads by 10 percent.	The IRMS could be enhanced to output a list of road sections where the road standard is not meeting current standards required (road width). If the IRMS is enhanced to include forced projects in the programme analysis, projects from this target could be included in the programme (by user selection).
	Decrease of the number of accident-prone locations related to road conditions by 150 locations.	No support possible (unless location and number of accidents were to be stored in the database)
Improvement of the length of national road networks with highway specifications	Additional highway networks constructed of 700 km.	The ERM can assist in evaluating feasibility of road improvements.
	Improvement of preparation of highway development in order to support ASEAN sub-regional economic cooperation by 75 percent.	If the NAM analysis is enhanced with an improved road/data selection filter, the ASEAN network could be analysed separately. Alternatively, these roads could be given higher priority in the MCA.
Improvement of preservation and capacity improvement of roads and bridges in strategic areas and underdeveloped regions as well as post-disaster functioning of road links.	Implementation of preservation and capacity improvement of roads and bridges in strategic areas (border areas, outer/ front most islands) and underdeveloped regions of 1,378 km.	It is recommended that this would be handled through the MCA analysis.
	Percentage of re-functioning of road links struck by disasters of 100 percent.	No support feasible. However it is suggested that the GIS mapping tool would be enhanced to show the relevant sections and the status of these. This would provide an overview of the situation, and how these links could be tied in with the MTEF.
Improvement of coordination support of regulation, guidance and supervision of road management and facilitation of regional road operations effectively and efficiently.	Improvement of coordination support of regulation.	The IRMS could be enhanced to include Key Performance Indicators on a regional level, in order to indicate the effectiveness of the road operations. This could include development in road conditions compared to the funding provided.
	Percentage of facilitation of regional roads of 70 percent.	-

ANNEX D: INFORMATION QUALITY LEVELS

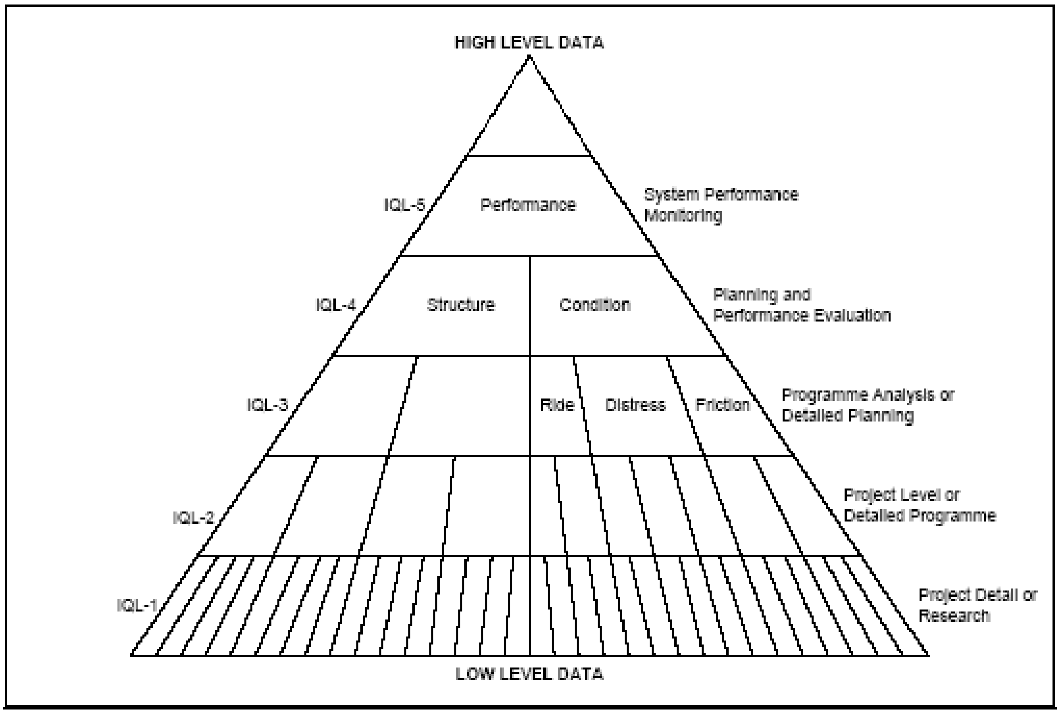
In road management, five levels of data have been identified as given below[54]:

Information Quality Level (IQL)	Precision/Detail
1	Most comprehensive level of detail, such as would be used as a reference benchmark for other measurement methods and in fundamental research. Would also be used in detailed field investigations for an in-depth diagnosis of problems, and for high-class project design. Normally used at project-level in special cases, and unlikely to be used for network monitoring. Requires high level of staff skills and institutional resources to support and utilise collection methods.
2	A level of detail sufficient for comprehensive programming models and for standard design methods. For planning, would be used only on sample coverage. Sufficient to distinguish the performance and economic returns of different technical options with practical differences in dimensions or materials. Standard acquisition methods for project-level data collection. Would usually require automated acquisition methods for network surveys and use for network-level programming. Requires reliable institutional support and resources.
3	Sufficient detail for planning models and standard programming models for full network coverage. For project design, would suit elementary methods such as catalogue-type with meagre data needs, and low-volume road/bridge design methods. Able to be collected in network surveys by semi-automated methods or combined automated and manual methods.
4	The basic summary statistics of inventory, performance and utilisation, of interest to providers and users. Suitable for the simplest planning and programming models, but for projects is suitable only for standardised designs of very low-volume roads. The simplest, most basic collection methods, either entirely manual or entirely semi-automated, provide direct but approximate measures, and suit small or resource-poor agencies. Alternatively, the statistics may be computed from more detailed data.
5	Represents a top level such as key performance indicators, which typically might combine key attributes from several pieces of information. Still higher levels can be defined when necessary.

The levels can also be graphically presented by a pyramid.

[54] See HDM-4 Documentation, PIARC 2000

Figure 4: Information Quality Levels



ANNEX E: IRMS MODELS

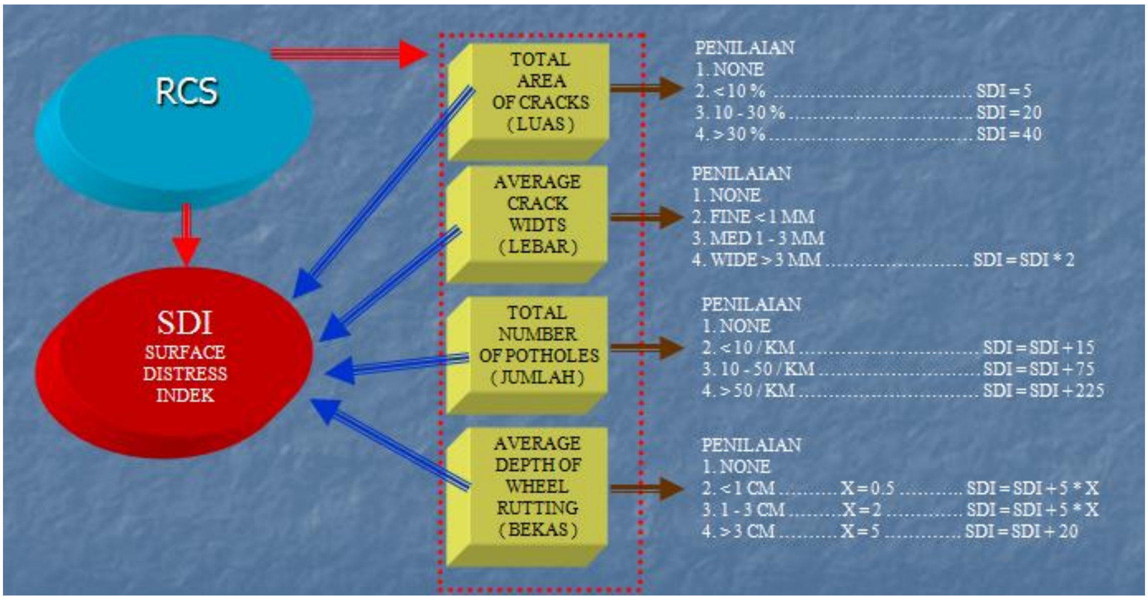
It has been reported that the IRMS did not focus sufficiently on preventive maintenance. It is deemed that in order to achieve a better balance in the IRMS between preventive maintenance and betterment works, the current models need calibration, rather than remodelling.

Below are inserted three of the main sub-models which is deemed to lead to the current focus on betterment works.

Surface Distress Index

The SDI is calculated based on: total crack area, average crack width, total number of potholes and average rutting. The model is shown below[55].

Figure 5: SDI model



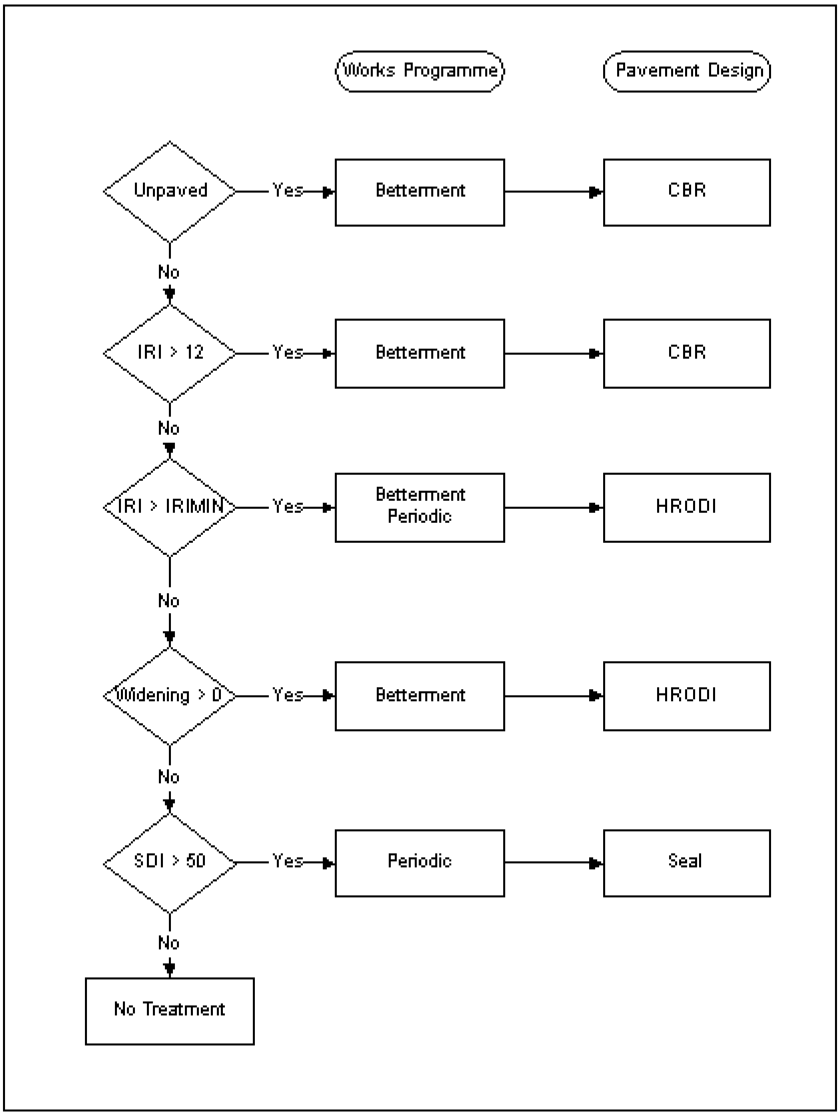
As can be seen, cracks, especially fine cracks, are not dominant in the estimated SDI. Assuming that cracks are an issue on the road network, it would be sensible to adjust the model to make cracks take a more prominent role in the calculated SDI. This can easily be done by increasing their weights.

Treatment Decision

The decision on treatments (periodic maintenance or betterment works) is done through a treatment decision model[56], which returns the work type and the design method to be applied.

[55] SMD-RSC Presentation (part of IRMS Training), ARRB, 2004
[56] NAM Technical Manual, 2000

Figure 6: Treatment Decision Model



As can be seen, periodic maintenance (preventive maintenance) can be triggered either by roughness or SDI. If the roughness trigger value is set too high, the design method will return betterment (thick payment layers) rather than thin preventive measures (thin overlays). By adjusting the IRIMIN downwards, more preventive maintenance would thus be expected.

If the road surface is still smooth, preventive maintenance can be triggered by SDI. However, as mentioned above, the SDI is controlled by number of potholes, and if there are a high number of potholes, also the IRI would be high (and the road treatment would then be trigged by the IRI criteria). Two options are available to catch preventive maintenance for cracked roads: (i) increasing the weight of cracking in the SDI calculation (see section above); or (ii) reduce the SDI threshold in the treatment decision model.

With the current threshold, a road with more than 30 percent fine cracks or with 10-30 percent wide cracks (and no other distresses) would not be selected for preventive maintenance.

Bina Marga Model – Link Level Programming Criteria

When the treatment analysis has been carried out for each road section, the Bina Marga model is applied to give a programme label for the link. The model is shown below[57].

Figure 7: Bina Marga Model

	Link programme
If in first year	
B + P = 0k	R
If the first 3 years	
B + P > 50% and B > 15k or B + P > 80% and B > P	B
If in first 2 years	
B + P > 20% or B + P > 5k or B > 1k	P

Again the model can result in lost preventive maintenance treatments. For instance, if a 25 km road link has up to 20 percent needs for periodic maintenance, it would not be selected by the model in the maintenance programme. It is highly recommended that DGH reconsiders the application of the Bina Marga model, and instead develop the programme from the treatment by sections. Alternatively, the trigger values in the Bina Marga Model model should be revised.

The revision of trigger values mentioned in the sections above would need to be based on an in-depth analysis of the data in the database.

[57] Programme Technical Manual, 2000