eProject Management Information System (ePMIS) requirements for Railways' Design Build Operation and Maintenance (DBOM) Projects

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Introduction

ePMIS is a proposed high level management and diagnostic tool which can be used for the complete and integrated project management, and FFCS of a mega project. ePMIS should store all the key information, and a website should allow access to common information. This will enable KPIs to be tracked and measured on a regular basis which further will provide essential management information for tracking the project. In this manner modern control systems will be introduced in order to facilitate rigorous monitoring of the project.

ePMIS should be established and implemented by every project team of contractor and/or owner of a railway project. ePMIS should be tailored to the requirements of the project's participants. Through ePMIS the project management team in conjunction with the ePMIS controller can establish a highly effective system of project control. ePMIS should be based on graphic tools, where the proposed system will gather all the relevant information and then present them in the form of monthly reports. Each month the graphs and tables will be updated so that the follow-up and control are used in the most diligent manner.

1.0 Work schedules

A number of separate construction schedules should be created by the contractors at the outset of the railway project. There will be updated throughout the duration of the contract. Each schedule has its own function, but all must be inter-related for continuity and conflict avoidance.
Each railway contractor should develop his own proposed construction schedule prior to starting work. These schedules will be reviewed independently by the project management and the ePMIS controller to ensure logic and continuity. In addition the project management in coordination with the ePMIS controller should provide an analysis of progress on weekly basis. This analysis should be provided to the client and be discussed during weekly management progress meetings. The schedules should include but not be limited to:

- Labor and resource schedules
- Material delivery schedules
- Manpower availability programs

Any client requirements and milestone activities must be incorporated into the main schedule by the project management and the ePMIS controller prior to approval in order to ensure validity and keep the overall project on schedule. These external constraints and considerations include but are not limited to:

- Anticipated client approval schedules
- Land acquisition and rights of entry programs
- Utility relocation schedules
- Equipment procurement period

The scheduling, management and performance of the construction work remains the contractor's responsibility. These schedules will present details such as:

- The contractor's planned mobilization
- Planned construction schedule taking into account traffic/safety measures
- Planned construction methods
- Estimated quantities to be constructed
- Planned procurement and storage of materials
- Planned work organization and sub-contracting arrangements

The project management in conjunction with the ePMIS controller should review the contractor's proposed schedules and work methods and provide comments as required. It is particularly important to verify the planned phasing of works. Upon completion of this review the contractors will be required to revise or adjust their schedules when necessary. Revisions are required when it is apparent that the submitted schedules are not realistic, create conflicts with other project components or are contrary to the client or contract requirements.

The contractors and the construction supervision teams will discuss revisions to the contractor's construction, if/when required. After agreeing on the methods of resolving any discovered schedule conflicts discovered, or realizing they need to adjust contract schedules to meet completion deadlines, the contractors will make revisions to their individual schedules.

ePMIS scheduling program should track the progress of individual projects and the total contract to date, and should identify areas of potential scheduling conflict whenever updates are created. Actions can then be taken to resolve these conflicts before potentially major problems occur.

Once the schedules have been finalized and approved at the outset of the contracts, they should be set as "baseline schedules". As the work progresses, the "baseline schedule" should be updated to show actual progress. Critical activities, potential delays or necessary acceleration can then be identified by the parties.

Two principal types of schedules are normally employed in the management and tracking of major projects. One is based upon "work task assignments" of the contractors and the other on the "critical path" of the project or contracts.

- **Gantt chart**: The work task assignment method is usually depicted in a "Gantt" chart format. It illustrates the various work activities to be accomplished according to a stated time sequence, with the anticipated duration of tasks graphically shown. Actual progress is measured as percentage of work completed against the duration of scheduled time expended
- **Critical path method**: The second method of scheduling a major project is through the use of critical path method (CPM). It defines which activities must be completed in the sequence shown

to ensure the success of the contract. The activities that lie on the critical path are those that, if delayed, will consequently delay the project's completion date.

The scheduled activities must include stated "milestone" dates that highlight proposed dates by which certain staged completion points in the work should be accomplished. Milestone dates divide complex, extensive projects into manageable segments of work that can be manipulated to meet intermediate goals in the construction installation program. There are many software packages that can be adopted for the purpose of ePMIS. For example, the Primavera software package can be used as a reliable ePMIS version. Below, I analyze the main considerations, functions and parameters of Primavera as ePMIS.

2.0 Primavera computer software

Primavera provides centralized, timely and accurate access by multiple users to all project information from KPI to detailed work assignments for individual team members. This program combines the power of windows desktops with the simplicity of the internet.

An interactive browser interface allows the various project participants to see the specific information they need to carry out their tasks and duties effectively. This browser allows access anywhere and anytime to the project data without needing to install special software on desktops. This facility enables team members to:

- Update actual progress
- Identify constraints
- Modify relationships
- View schedule and cost issues in order to establish project performance
- Access current issues
- Highlight project milestones and critical activities
- View project reports
- View project risks

A particularly useful feature is that project engineers and field staff can use the package directly to update actual progress on site via a mobile hand-held PDA. Examples of the packages that someone can adopt on a railway line project include:

2.1 Primavera Expedition

Primavera Expedition allows projects, people and programs to be managed efficiently. In turn this enables control of the project's schedule, budget and deliverables to ensure a successful project outcome. This is not an easy task, particularly on large complex projects where unbudgeted changes or schedule delays may result in increasing costs, risk and claim exposure.

Efficient communication between the project management members is vital. This powerful computer based tool can increase efficiency and speed, whilst reducing costs, schedule delays and risk. It can enable the project management to immediately respond to questions, issues, changes and daily events. Project management members can have instant and easy access to the latest, most accurate project information including drawings, minutes of meetings, answered requests for information (RFI), and approved changes.

Primavera Expedition provides job cost management, comprehensive change management, powerful reporting, and a clear understanding of who is accountable. This enables a rapid response and provides an accurate history of events to assist with claims resolution procedures.

The program's layout and format can be customised to enable project specific key data to be clearly and prominently displayed. In addition, Primavera Expedition can easily be integrated with other project management packages. Overall the key features of the Primavera Expedition can include:

- **Management of multiple projects in multiple locations**: Primavera Expedition enables the project management to establish consistency and efficiency across multiple projects and multiple locations. Primavera Expedition places all data into one, central and secure database which allows inefficient patterns and unfavorable trends to be more easily identified
- **Role based project control**: Primavera Expedition facilitates team interaction. Role-based views display information relevant to each project participant. Action lists, alerts, and turnaround graphs can help the project management immediately identify the source and impact of any delays and establish whether they will affect the budget or schedule
- **Improved clarity of information**: Primavera Expedition provides accurate and up-to-date information which is easily accessible for all project participants. Primavera Expedition's powerful reports provide the visibility needed to control large complex projects. For example, budgets, cost variances and project changes from multiple project components can be analysed and compared to establish trends and cause effect among projects. This enables efficiency to maximize whilst minimizing project costs, risks and safety issues
- **Change management**: It is clear that change is inevitable on mega projects. The key to a successful project outcome is to manage change efficiently. Primavera Expedition provides change management power to assure changes are resolved, payment is made and claims are avoided. This reflects the impact on costs or schedules of any change on the project and identifies the effect. Primavera Expedition enables the user to prepare for the unexpected and have the power to negotiate cost and schedule details to final resolution
- **Forecast costs and simplify contract control**: The cost worksheet element within the program automatically collects and summarizes detailed cost elements from contracts, requisitions, invoices, changes and purchase orders, and dynamically displays this in one easy to read form. This enables the user to calculate actual project costs and establish final budgets

2.2 Primavera (P3)

Primavera project planner (P3) provides project management and schedulers with control in order to effectively manage the project. The project management can use this package to schedule works, track resources, control costs, and produce graphics and reports.

Primavera P3 is specifically designed to handle large-scale, highly sophisticated and multi-faceted project components within a mega project. The program can organize projects up to 100,000 activities. P3 allows an unlimited number of resources and target plans to be input. This sophisticated tool allows huge amounts of data and activities to be organized, filtered and sorted effectively. Different layouts can be created to analyze the project from different perspectives.

Primavera P3 allows the project management and the rest to manage multiple projects in a multi-user environment. A single database solution provides simultaneous access to project files by multiple users throughout the project whenever and wherever required. Internet web features also help the whole project management team to be kept in the loop.

A PERT view enables a schedule's critical path to be analysed. Activities can be viewed based on their time sequence rather than relationship only.
Primavera P3 enables powerful scheduling and resource leveling options, including backward resource leveling, smoothing and the ability to level selected portions of a project. Float for single activities and the project as a whole can be calculated. In addition, the effect of progress can be shown against the remaining work.
Historical or post completed reporting and analysis, to assist with claims resolution, can be carried out by storing weekly or monthly records of actual previous resource assignments, costs and earned value for selected periods.

2.3 Primavera engineering and construction

The components within this latest "cutting-edge" package are similar to the Primavera P3 and Primavera Expedition packages outlined above. However, the Primavera engineering and construction program benefits from standardization scheduling and represents the latest technology. The program allows the project management and the rest to efficiently control project costs, schedules, procurement, contracts and changes. The project's true financial position can therefore be established. Access to the data can be achieved via a web browser, desktop or remote. One centralized database will store and manage all the relevant data. This package enables the project management and the rest to:

- Obtain an early warning of project risks
- Forecast schedule completion date and costs
- Improve collaboration between Team Members

The program includes flexible planning and scheduling analysis including critical path scheduling, baselines, Gantt charts and trace logic. Advanced reporting and analysis features should be adopted by the project management team.

Further, the program allows users to plan and control large projects efficiently. The project management should create and analyze optimum project plans, identify the activities located on the critical path, locate activity predecessors and successors, establish the float on any activities, confirm correct schedule logic, optimize working patterns, and plan holidays. The project management can also use the program for:

- Improved understanding of project performance
- Forecasting cost to completion
- Accurately estimating the project's actual completion date
- Improved team collaboration
- Flexible planning and scheduling including critical path scheduling, baselines, Gantt charts and trace logic
- Advanced reporting and analysis
- Accountability management
- Efficient resource management to effectively plan labour, equipment and materials
- Integrated cost management to help forecast profit, carry out earned value analysis, compare estimates and integrate with accounting
- Contingency management to analyse and identify risk

PERT scheduling and diagrams enable the activities, relationships and project workflow to be easily viewed. Driving relationships will be focused on and analysed. The predecessor and successor logic will be assessed and modified.

The integrated risk management features enable the project management to identify, quantify and mitigate risks such as late materials, adverse weather or sophisticated installation procedures. Risks are categorized and control plans documented as part of the overall project plan. The resource simulation engine enables the schedule and cost exposure of project risks to be established. The project management can therefore identify project risks and plan the necessary response.
The Primavera engineering and construction program enables the project management to carry out effective management of costs and earned value analysis.

3.0 Risk analysis module

ePMIS should include a powerful and widely used risk analysis module.
Risk analysis module should assist with the decision -making process by considering all possible outcomes and scenarios, and estimating how likely they are to occur. On mega projects, perfect information is rarely available. However, there are risk analysis modules that can enable the decision maker to have the most complete picture possible. An informed decision can then be made concerning which risks to accept and which ones to avoid. While, no software package can predict the future, a reliable risk analysis module should enable the best strategy to be selected based on the available information. The following four steps are required to carry out a risk analysis using risk analysis module.

1. **Prepare model –** Define the problem or situation in Excel or Microsoft Project, depending on the application
2. **Identify uncertainty –** Determine the inputs in the model that are uncertain, and represent these using a probability distribution function
3. **Analyze the model with simulation –** Run the simulation to determine the range and probabilities of all possible outcomes for the outputs specified
4. **Make a decision –** Having obtained the risk analysis results, a well-informed decision can be taken

4.0 Presentation of information and reporting

The amount of information issued to participants should be targeted and remain relevant. Providing groups or individuals with excessively detailed information that they do not require, nor have the time to digest, is a waste of the participant's time and poor utilization of the project engineer's efforts. Based on experience, I strongly believe that an effective method of presenting summary information on project is to show this data in a graphical format.

ePMIS's scheduling program should make full use of a wide range of customizable graphical displays that will be used to depict summary information to interested parties.
At the same time, summaries of the developments and status on each of the individual contracts should be included in the client's regularly transmitted informational package.
Preparation of clear and concise reports ensures all parties are able to receive and analyse information in an efficient manner.

The types of graphic usually prepared reporting include:

- Location map showing progress of works. The localization plan uses a color code to show the boundaries of the building site according to the various phases of construction
- Overall project schedule and construction schedule summary. This graph illustrates the comparison between the planned activities and the real situation

- Overall summary of major components activity. The table allowing the comparison between the amount of work actually carried out and the work projected for the period
- Cumulative progress chart. The graph compares, for each type of work, the evolution of work to the initial work plan (concrete Cast-in-place, embankment construction, bridge piling, track construction, etc.)

4.1 Coordination

ePMIS controller should ensure constant coordination and management of the numerous project and component interfaces. Often, there are cases where coordination in mega railway projects is also required outside of the railway construction contracts. ePMIS coordination will not only have to address completion dates, it must also coordinate the railway construction inside the project limits. In some other occasions there is need to coordinate, for example, the import of track construction materials through new port facilities. With respect to ePMIS internal coordination, minimising the number of these interfaces is a key part of any contractor's contracting strategy which usually is outlined in his proposal document.

The main aim on a multi-contract project is to construct all segments of the work and to place the system into service within a specified time span. The smooth integration and implementation of all the elements comprising a system into a unified functioning facility is paramount. In order to do this, individual segments must be constructed to fit harmoniously together to create a total unified project.

Total project coordination is the transfer of information from one source to another and should be accomplished through established ePMIS channels of communication. These channels should be identified, opened and maintained by the ePMIS controller. The preparation and issuance of organizational charts, distribution and contact lists are vital to maintain effective communication. This applies both to those seeking information or those issuing it.

Mega-project contracts require coordination between all the project participants throughout the duration of the contract. ePMIS controller should ensure that effective coordination can be established and maintained between the parties of the project. Based on prior experience in supervising and managing complex mega-projects, the ePMIS controller should be in a position to anticipate technical, coordination problems before they occur, and to resolve these coordination conflicts, from beginning to end, and before they affect the progress of the contract.

ePMIS controller should be able to ensure that the construction supervision teams have complete access to current and detailed information concerning the scheduling and progress on other components within the contract, as well as on overall. It is the project management's responsibility to keep all supervisory management groups informed concerning all facets of the contract during the project life. This can be done by tailoring the information to specifically address the interests and concerns of the various management groups.
Individual construction supervision teams should be active in the development and the review of their individual projects.

Further, it is vital to ensure that all relevant parties receive prompt distribution of the updated schedules. This will allow corrective action, to be taken as required, at the earliest opportunity. The schedules should therefore contain clear and concise information.

Based on experience I propose to maximize use of the internet for communication purposes, while the Primavera program allows users access to the latest schedules.

4.2 Progress meetings

Regularly scheduled management, progress and update meetings are a vital part of the coordination process. ePMIS controller should be able to initiate and organise the joint management and progress meetings with the contractor.

It is anticipated that a whole series of different meetings should be held between the combined management staff from all relevant representatives including the various construction supervision teams, contractor's management and client representatives. The meetings should be scheduled to follow each update of the contract's schedule or as requested by the participants.
Further, ley issues should be identified and advice given on resolution of technical and contractual matters. The purpose of the meetings is to:

- Review progress to date
- Discuss problems encountered during construction
- Discuss and resolve administrative and communication problems
- Discuss and resolve technical issues or problems
- Discuss and resolve contractual issues or problems
- Discuss plans to avoid and to mitigate current or potential delays
- Discuss general planning for the forthcoming month
- Prepare of an outline for the following monthly work schedule
- Address any other pertinent business

In order to keep the meetings as brief yet effective as possible we should encourage only the key decision makers to be involved. I believe that meetings involving dozens of participants can become ineffective and a waste of time for the people involved.

ePMIS controller should be able to prepare the agenda and distribute the minutes of the meeting for record purposes and commenting by all parties. If comments are not received within the stated timeframe (i.e. 7 days) it will be deemed that the minutes are agreed. Any comments received will be distributed to all relevant parties and discussed and agreed upon at the following meeting.

4.3 Monitoring progress of work

ePMIS monitoring should be performed during the fabrication, construction, and installation phases. Throughout the entire contractual period, usually the ePMIS controller should actively seek to ensure delays do not occur. However, if and when delays occur, then ePMIS controller should identify and evaluate remedial measures by which the contractors can remedy the situation. The circumstances surrounding and causing the delay, together with the project engineer's recommendations as to resolution, should be communicated to the client. All stages of the engineering, fabrication, construction, and installation should be tracked by the ePMIS with a critical eye towards anticipating, minimizing, eliminating and resolving delays. The ePMIS controller should keep the management and the client fully informed of its delay minimizing activities and the results achieved.

The proper monitoring of work schedules must be based upon an agreed baseline schedule against which actual progress can be measured. This schedule should be prepared by the contractor and include all activities including construction, testing and commissioning. These schedules should demonstrate how the contractors will complete their activities within the stated time constraints.
ePMIS controller should create a useful graphical aid known as an “S” curve at this stage. The initial agreed baseline schedules should be fixed and remain unchanged throughout the project duration. All updated schedules can then be compared against the agreed “baseline”.

The contractor’s actual progress on site is measured by observations, reports, and the progress payment requests submitted by the contractors for work completed, as reviewed and approved by the construction supervision team. Throughout the construction, testing and commissioning phases, the ePMIS controller should receive data from the project engineers and project management who will perform site inspections to verify that the work reported in the contractors' progress statements has been performed in compliance with the provisions of the contract as documented in the relevant testing reports. In addition, work under progress can be estimated by the construction supervisors and, after comparison with projected accomplishment milestones, be included in the schedule revisions to give a more accurate picture of the work completed during the assessment period.

4.4 Variation orders

As provisioned within the contract documents, variation orders may be approved during the course of the work which will increase or decrease the amount of work required to be constructed by the contractors. These changes may not require a change be made to the original contract schedule.
However, they must be shown in the revised work task and ePMIS’s CPM schedules to properly reflect the total amount of work that must be done within the original time frame of the initial schedule. These changes to the periodically revised schedules must be made to reflect the true progress being achieved by the project participants.
Should the variation result in an extension of time, the management information system developed by the project management has the flexibility to incorporate the associated changes into the ePMIS schedule.

5.0 Inventory control

ePMIS should include an inventory control system module for all materials procured during the project, to be turned over to either the operator or to the client at the end of the project. To do this, the ePMIS controller should select and procure a widely-used and commercially-available software. For materials to be turned over to the operator, the inventory should at a minimum be sub-divided by major departments and further subdivided as required. A separate inventory should be kept for assets to be turned over to the client at the project’s end. The ePMIS inventory can be made available to the client at any time during the contract and will be used as one of the official vehicles to turn over assets from the project engineer, contractor or client to the selected operator.

6.0 Financial forecasting and control

Also, ePMIS should include the necessary modules in order to perform the financial forecasting and at the same time establish a reliable control system for a railway mega-project.

6.1 Payment approval

The quantities approved for payment or completed during the payment period and approved by the construction supervision teams should be input only once, into the model according to the procedures designed and agreed by the project management and in conjunction with the ePMIS controller. The project's schedule should be automatically updated by the contractors' management information systems based upon the quantity information supplied.

6.2 Costs and cash flow control

There are several ways to control the project costs, one of the best of which is to focus on getting the work done in the most efficient manner possible and ensuring that the completion date is met without having to allow for a time extension.
This means that variation orders must be kept to a minimum, particularly those affecting the critical path. Excluding changed conditions that cause a re-design can often be accomplished by a supervision engineer/contractor team approach to keep the work running smoothly.

Other methods that can be used in controlling costs include the use of a computer based system for processing of the contractor's billings and keeping a check on the balance of the remaining quantities during construction.

The overall financial management during the project should aim to provide the following services:

- Reviewing the contractor's monthly quantity reports for work executed and comparing this to the BoQ
- Keeping a record of statements of work done and materials onsite and materials used
- Reviewing interim payment certificates to be forwarded to the client
- Reviewing draft variation orders, if required
- Periodic checking of remaining quantities and cost estimates
- Managing general financial aspects of construction supervision
- Preparing final payment certificates and completion certificates

6.3 Accurate preparation of contractor's payments

In the case of implementing railway mega-projects a large portion of the project funds are disbursed by means of the payment certificates, therefore they must be prepared with accuracy. The project management in conjunction with the ePMIS controller should ensure that care is taken to ensure this. All measurements will be recorded on standard quantity agreement sheets for each pay item.

6.4 Periodic checking of remaining quantities and cost estimates

Throughout the construction period, the project management in conjunction with the ePMIS controller should periodically review and check the remaining quantities and cost estimates for all items of work to be constructed, and should constantly update the status of the estimated balance of works to be completed. The project management in conjunction with the ePMIS controller should also review and update the disbursement schedule periodically in line with the actual work progress as well as any change in the work schedule.

6.5 Certification of works

At the end of each month, the contractor should be asked to submit the quantities of all items of the works executed. The project management in conjunction with the ePMIS controller should check the correctness of each item of work completed and accepted.

Typical cross-sections should be prepared by the contractor. The project management in conjunction with the ePMIS controller should establish the quantities of the works and materials on site, by checking and examination of the records and drawings, and by verification survey as required, in accordance with the specifications, contract clauses and other related documents, and will approve only the correct amount.

Based on the quantities agreed between the project management and the contractor, a monthly payment certificate showing quantities of works and also the amount of money to be paid to the contractor, incorporating deductions and adjustments in the billing that may be due to repayment of advances, non-acceptance of part of the work or other similar reasons, should be prepared.

The cumulative amounts of both quantity of works and amount of money paid should be shown in the monthly payment certificate to reflect the status of works every month. The billings should be supported by such items as inspection reports with photographs (when necessary), surveyor's quantity measurement sheets and quality control test results. The monthly payment certificate should be signed by the authorised representative and submitted to PIF for final approval and payment.

At the end of the construction contract, the project management in conjunction with the ePMIS coordinator should recheck all items of works performed and verify the final calculations of work quantities and amount of works performed on each contract, based on which, the final payment certificate should be prepared.

6.6 Disbursement schedule

Once the contractor's schedule of works is agreed, the project management in conjunction with the ePMIS coordinator should review the planned disbursement schedule. This should be updated at least every quarter in accordance with standard practice. The schedule should indicate the essential information - price and completion date - on a single graph (schedule) or table, showing the actual and anticipated expenditure against time, giving explanations of any major changes in price on an accompanying sheet, together with reasons for any change in completion dates.

The schedule should comply with any reasonable specific arrangements for financial control that the client may have. In the absence of any further specific instructions from the employer, the project management considers that the following should be adopted as the minimum requirements for budgetary control:

- A graph of payment against time showing original contract sum compared with anticipated final total
- A statement in the form of the summary of the BoQ showing tender prices, current amounts certified and anticipated final amounts
- A summary of variation orders and anticipated claim amounts, plus any liquidated damages or bonuses payable, culminating in a forecast of the total contract price with explanations of all changes from the previous review
- An overall program showing key dates plus extensions of time
- Breakdown of cost into foreign and local currency (if appropriate)
- Monitoring of financial status

6.7 Disbursement schedule monitoring

The project management in conjunction with ePMIS controller should prepare graphs to assist the monitoring of payments. An example is the variation of cumulative payments for each of the following:

- Project costs
- Approved interim payment certificates
- Authorized bank withdrawal orders
- Loan disbursements, etc.

Gaps between the planned and actually realized curves would be indicators of bottlenecks in the payment system. The objective should be to keep the gap between the projected cost curve and the loan disbursement curve to a minimum.

The project management in conjunction with the ePMIS controller should review the disbursement progress schedule based on the scheduled progress of works. Furthermore, during the implementation of works, the project management in conjunction with the ePMIS controller should periodically review and check the scheduled disbursement versus the actual disbursement progress. In order to enable the project management to check on the actual disbursement progress, copies of the bank withdrawal orders must be made available to the project management and ePMIS. Reporting on the scheduled versus actual disbursement progress will enable the relevant parties to be kept fully informed of the project's financial status.

6.8 Evaluation of unit rates

Due to contract variations, original unit rates may become subject to revision. Furthermore, additional unit rates for any unscheduled items of work may be required. In such event, the project management should instigate negotiations with the contractor to arrive at an agreement on acceptable unit rates. The project manager in conjunction with the ePMIS controller should carry out the analysis of unit rates by reviewing information on prevailing material costs, wage and equipment rates.

6.9 Certification of works

The standard general conditions of contract and specifications for works are often based on unit rate payments with periodic measurement of quantities. At the end of each calendar month, the project manager in cooperation with the ePMIS controller should prepare and submit his monthly payment claim for works completed and for which he is entitled to be paid. The contractor's monthly request must be substantiated along with all supporting data such as quantity measurements and quality control test results.

The project management in coordination with the ePMIS should verify the quantities claimed for payment by referring to their own records of quantity measurements carried out earlier during the works.
In the event of any discrepancy between the contractor's monthly invoice and the project management’s checking, then the project management with the assistance of the ePMIS controller should only approve payment for works which are complete, complying with test results obtained and the works approved. At the end of the project the project management in coordination with the ePMIS controller should prepare final payment certificates and completion certificates.

6.10 Work review, contract variations and claims

Modifications or alterations to the design and the technical specifications may become necessary during the works. The project management with the assistance of the ePMIS controller should carefully examine such possible alterations and determine the effect on cost and timing for issue to the client. Once approved the project management should prepare contract change orders and/or addenda, which are necessary to legally cover any alteration to the original contract and scope of work.

If necessary the project management in conjunction with the ePMIS controller should resolve any dispute arising out of a particular contract by preparing and submitting a special report with the project management's comments and judgment on any such particular claim.

The project management in conjunction with the ePMIS controller should examine and evaluate such contractual claims with regard to cost and/or time implications. In addition they should study thoroughly all matters related to a particular claim by referring to the official records, contract documents, progress schedules and other pertinent data and information. The project management should then prepare recommendations as to the validity of the claim and submit its recommendations to the client for consideration.

The cumulative construction costs, and expenditures (cash-flows) graphs should be supplemented with text in order to facilitate the analysis of the results appearing there. Additional text, such as a summary of the contractor's field reports, can also be integrated when necessary. Moreover, an analysis made by our experts will enable delays to be anticipated, or the strong and weak points observed during the period to be highlighted.

There are many advantages to the graphical display used for control reports, such as:

- The ease of reading and integrating data
- Overall understanding which makes it possible to establish the links between the various elements considered
- Anticipation of potential difficulties at the time of realizing the work
- Follow up of cash-flows expenditures

8.0 Quality assurance

ePMIS should include a QMS module for all design, construction and materials procured during the project, to be turned over to either the operator or to the client at the end of the project.

8.1 Quality management system

The project management should prepare a QMS based on ISO 9001:2000 to comply with the requirements specified in the ToR. The standards should encompass project management in addition to administrative tasks. The development and implementation of standards translates into a superior execution of projects by ensuring that compliance to the procedures is carried throughout the project.

The ISO standards provide an assurance that quality should be met according to the agreed set procedures. They are recognised internationally and used in more than 90 countries. The ISO certification is an international recognition that attests that the company is committed to quality. The project management support the development of powerful procedures which can minimise the risk of errors or omissions and facilitate project follow-up and control. This philosophy, combined with the elimination of

administrative burdens, allows the respect for deadlines and budgets and facilitates communication with the clients.

The QMS will be one more ePMIS module which should be integrated into the total system for handling the quality and the environmental management. The QMS should consist of the following three levels:

- The quality manual and general project procedures
- Project quality plan
- Specific procedures for each component and supporting activities

8.2 Quality manual

The quality manual is the central document in which the QMS should be described. The quality manual should give an overall description of the project management and ePMIS quality policies as a whole and specify the requirements each employee must comply with.

The requirements should be formulated in a number of process descriptions, which will be divided into:

- Project processes for obtaining and solving the assignment
- Management processes for quality related management tasks
- Supporting activities for project and management processes

Workflows for each process should be described in procedures which reflect desirable work routines.

8.3 Quality policy

The project management's objective is to provide competent services at a high level of expertise, thereby ensuring that value is added to the DBOM as well as to the client's organisation. The project management should generate quality by complying with the following principles:

1. Every employee has a role to play in generating quality
2. All employees must be fully aware of how they will add value to their external and internal clients.
3. All employees should confide in their superior if they feel uncomfortable about performing the task in question
4. The line manager should make sure that the employees are familiar with, understand and comply with the quality and environmental management system
5. The project manager should ensure that the project complies with the quality and environmental management system
6. All departments within the project management's organisation should seek, apply and exchange "best practices"
7. All departments within the project management's organisation must stipulate goals and actions in order to improve quality and develop competence

8.4 Policy for sustainable development

The project management in conjunction with ePMIS should take into consideration environmental and social aspects in connection with the tasks which should be performed during the various DBOM stages. I consider this a fundamental obligation for the implementation of any railway project.

The project management should consider the adherence to local legislation and international conventions of course. ePMIS can further contribute to sustainable development through constant improvement of its service modules, and through dialogue and cooperation with the world around the project.

ePMIS should fully support the recommendations in "sustainable development in the consulting engineering industry – a strategy paper" (2000) by FIDIC.

8.5 General project procedures

The general project procedures should cover the following processes:

- Project management
- Planning of the project
- Project execution
- Errors and complaints
- Project completion
- Quality and environmental management related activities
- Tools management
- Management reviews

8.6 Project quality plan

The project management should prepare a project quality plan module describing the specific quality assurance activities to be used within the frames of the overall QMS and at the same be applicable to the ePMIS. The quality plan should be implemented in the project organisation by presenting the content of the plan to the project staff in separate meetings. The quality plan should continuously be kept up to date on the basis of experience, auditing, quality inspections, evaluation of failure reports and management reviews.

The participants working on components such as contracts and/or signalling and telecommunication should establish special procedures in accordance with the requirements in the overall QMS. The project quality plan will be prepared and based on the general project procedures. An outline of the proposed quality plan is given below.

General Introduction - The introduction should describe

- The purpose of the quality plan
- How the document will be maintained
- The quality requirements
- How the document will be distributed

Requirements regarding confidentiality – A description of special requirements concerning confidentiality should be included.

Organisation, responsibility and authority - This part of the quality plan should contain an organisation chart with indication of key personnel, their responsibility and lines of communication. The responsibility and authority of each key person should be described. The quality manager should report to the project manager and should have direct access to the ePMIS. Sub-contracators and their assignments should be listed in the ePMIS too.

Interfaces - Identification and control of internal and external interfaces including determination of the responsibilities of the involved parties should be listed and described in the ePMIS.

Technical and additional support – ePMIS list and description should be provided concerning how to coordinate and use the resources of other project components for providing technical support throughout the project.

Communication and coordination – ePMIS communication and coordination inside the project organisation and with the client, management group and other interested parties should be described. In addition, this section should contain a description of the meeting structure, and a schedule of fixed meetings should be established.

Public relations – The project management in coordination with ePMIS controller should set up a module in the ePMIS to facilitate public relations, to provide project information and to deal with approaches/inquiries of any kind.

Project success criteria – A description of the main conditions to be fulfilled and achieved, in order for successful project outcome should be included in the ePMIS. The ePMIS key aims of the project should be detailed.

Project basis – ePMIS should include descriptions and other outlines of how to establish and maintain the basis for the work, for instance previous studies, authority regulations, maps and standards should be used.

Scope of work – Reference to the scope of ePMIS work should be included.

Clients' contribution – A description of services supplied by or inputs to be received from the client including deadlines should be included. Possible milestones with connection to the overall time schedule should be determined.

Project risk - Potential problem areas and project risks (e.g. technical, cultural, economic, organizational etc.) should be identified and described together via ePMIS with the action foreseen to resolve such problems.

Detailed time schedule – A description should be provided detailing how to prepare, update and distribute time schedules. Further descriptions concerning essential deadlines should be included.

Financial management - The breakdown of the project into well-defined activities should be described including budget evaluations, estimation of progress and determination of outstanding works.

Progress reporting – The methods and procedures for evaluating project status and progress should be described.

Health, safety and environment (HSE) - The project should be categorised and substantiated in terms of HSE. The environmental screening describes the HSE relations of the project.

Execution of the project – Preparation and check of project documents – This part of the quality plan should describe:

- How to carry out the specific activities
- How to check the outcome
- How to correct errors, if any, and check the corrections

- Determination of the extent of the documentation wanted for the activity that has been carried out.

All conclusive and verifying documents and all basic documents should be checked and approved. The system should operate with distinctive levels of verification.

Specific procedures and plans – The contents of specific procedures and plans should be laid down.

Procurement procedures – Procurement of goods and services should be described in this part of the quality plan.

Operating and safety – Guidelines for preparing station working rules and the train operating manual should be included.

Maintenance manual – Guidelines for preparing the maintenance manual for track works, bridges, equipment maintenance, signalling and rolling stock should be included.

Technical facilities – Technical equipment used within the project such as computer facilities and measuring equipment should be described.

Information management and document and data control – A document management system ensuring that all documents are marked in an unambiguous manner should be established. The preparation, check, approval, distribution, application, correcting and filing of documents should be managed by the means of a document management plan.
A system for the management of electronic data should be established to ensure:

- Access rights
- Structuring of data
- Unambiguous identification of files
- That data can be located in an efficient manner
- That transfers to clients and others take place in a controlled manner

This section of the quality plan should include descriptions of:

- Procedures for control of the technical facilities used on the project
- System for handling of the correspondence must be described
- System for central and decentralised filing of digital data, documents and correspondence

Document layout and numbering – A system for document layout and numbering covering all types of documents should be described.

Change, errors, corrective actions – This section should describe how changes/corrections should be handled. It would be ensured that:

- A written proposal is prepared and formally agreed before the change is implemented
- The consequences of the change are estimated by everybody influenced by the change before the change is implemented
- The work encompassed by the change is subjected to the same quality control activities as the first scheduled work.

Errors and omissions, corrective actions – This part of the quality plan should describe how errors and omissions are handled and how corrective actions are implemented.

Audits – Internal audits should be carried out in order to ensure that the quality plan is implemented and functions according to the purpose. This part of the quality plan should describe how audits are planned, carried out, reported and followed up. A proposed procedure for auditing contractors and suppliers should be included.

Management reviews - The purpose of the management review is to assess the continuing suitability and efficiency of the quality system. A procedure for conducting these reviews should be included.

Specific procedures for each component and supporting activities – In this section the content of every component should be evaluated. The quality manager should manage the preparation of procedures covering these issues in cooperation with the organisation in each component.

Administrative procedures – Procedures concerning specific administrative activities should be included in a separate volume titled "administrative procedures." The administrative procedures often include specific procedures concerning resources, activity and progress, setup in the ePMIS.

9.0 Document control (please see eDIMS paper)

10.0 Communication system

Computer network - ePMIS should deploy a LAN and WAN in order to support project activities and deliverables.

Wiring – ePMIS's IT system will consist of a CAT5E wired Ethernet local area network (LAN). The network should operate over the TCP/IP (Internet) protocol and should extend throughout the work environment. All workstations should be connected by wire to a server room and then via a switch to a central file server. The network architecture is usually a fully switched star topology. All workstations should have access to shared facilities on the network. Facilities include printers, plotters and other peripheral devices. Any IP device including Microsoft servers and workstations, Linux and Mac systems, voice over IP communications (VoIP), should be capable of communicating over the network.

Servers – The file servers should run Windows 2000 Server NOS, Exec backup software operating to a tape subsystem connected to the server by a SCSI interface. Server disk storage should use redundant RAID storage technology built into the server to prevent data loss in the event of disk failure. The file server should be used for live, active storage of documents and materials developed during the project. This should include email, active reports, schedules, and other works in progress.

Network area storage (NAS) – NAS devices should be installed where required. These devices should be used to store archive and reference materials used by the project. The purpose of NAS is to reduce the storage load on the main file server. Completed documents, purchased documents and maps, archive materials, project photos and other items which are not under development should be stored by the ePMIS controller as read only documents. These will be available on line but will not require the same level of backup or security as the active file server.

Wide area network (WAN) – Wide area networking is the connection of two or more local area networks such that some or all of the facilities are shared across the networks. Wide area network links are typically slower than local networking and there may be limitations to access across the WAN.
WANs usually eliminate broadcast traffic between LANs so that network facilities on connected LANs (servers, printers) may not be easily identified without prior knowledge of the facility. However, with proper IT assistance, the facilities (including file servers) may be accessed securely across the WAN.
Typically, WAN traffic is routed between LANs through a series of internetworking routers. Where facilities exist, the WAN could be implemented over leased line or frame relay. However, where public communications infrastructure is limited, WAN traffic may be carried over wireless connections or through the public Internet via virtual private networking (VPN). The ePMIS controller in coordination with the IT staff should select from available technologies when implementing wide area networking.

Wired WAN – Frame relay or leased lines are commonly used in the USA for wide area networking. Where this service is available, WAN traffic is routed through a private network provided by a service provider, usually the telephone company. This is usually the easiest, most cost effective, and most reliable methodology for wide area networking. The service provider takes responsibility for maintaining the connection. However, where a communications infrastructure is not available, other methods may be employed.
Private satellite bandwidth may be purchased and it will function in the same way as a wired network. The cost of satellite bandwidth, combined with the lack of other infrastructure associated with the choice of satellite utilization, usually makes VPN by satellite to the
Internet a more desirable alternative when satellite bandwidth is the only available alternative. If security is an overwhelming concern, point to point satellite connectivity is a viable, but expensive solution.

Radio Linked WAN – ePMIS may implement WAN by a dedicated, proprietary radio link which routes traffic in a meshed network via radio between LAN locations. This link typically operates at 11 to 56 mbps (megabits per second), making the link nearly transparent to the user. There is a distance constraint for wireless links which are usually limited to not more than 5 kilometre, line of sight. However, distance may be extended with more powerful radios and specialized antenna configurations. Using publicly available radio channels, line of site is usually a requirement unless a repeater systems implemented.

Virtual private network (VPN) – VPN technology uses the public internet as a conduit for WAN traffic. Through encryption and tunneling technology, the link appears to be a wired, routed connection and the traffic visible on the public Internet is inaccessible to systems along the way. VPN requires additional processing power at both ends to encrypt and decrypt the data stream in real time, and is usually implemented with VPN appliances at one or both ends of the connection. VPN requires additional configuration and maintenance skills in the IT staff and requires additional maintenance of access accounts and security conditions.

Private satellite bandwidth Internet connection – ePMIS requires high speed internet connectivity. Main office installations must support 20-50 individuals utilizing email and web information systems, and transferring report and design files, pictures and other data, occasionally in excess of 20mb per transmission. Smaller installations, supporting 1-4 personnel may also be required.

Wired solutions – Where dial up facilities exist, this is a viable connection for email and other low volume data transfers. The existence of dial up service implies the availability of voice communications infrastructure and ordinary telephones may be used for voice.

Where the communications infrastructure exists, a wired connection to the internet is desirable. Wired connections come in a variety of service offerings including:

- Digital subscriber line (DSL)
- Cable (via TV cable)
- Partial T1 (E1 in some countries)
- T1

DSL and cable are primarily residential solutions where the internet connection rides an existing facility like the phone line of cable TV. Bandwidth in these connections is typically highly oversold because residential services make the assumption that each user will use only a small fraction of the actual capacity. While this is true of residential use, business use often overstresses these facilities, resulting in traffic bottlenecks and slowdowns which are often unacceptable to the business where larger shared access or high volume traffic is the norm.

T1 (E1 in Europe) is a standard business solution in developed countries and, where available, is a reasonable choice. These come in many varieties which allow for economic configurations, appropriate to the needs of the users. Above T1 all the way to fibre are a number of solutions where high bandwidth is an absolute requirement and is usually employed where the primary business requirement is the movement of large quantities of data.
Wired solutions consist of a vendor provided connection (usually Ethernet) which connects to the network firewall. All maintenance beyond the firewall is usually provided by the service provider at no cost to the user. Equipment cost is low.

Satellite service – Where there is no communication infrastructure to provide reliable Internet connectivity, satellite service may be implemented. This requires the purchase and installation of a satellite teleport, and the purchase of satellite bandwidth as a monthly recurring cost. Both in initial investment and in monthly service cost, satellite service is far more expensive than wired services. Though not requiring excessive maintenance once operating, a fairly high degree of expertise is required for setup and for reliable service.
If no wired service provider can be identified, the project management should install independent satellite teleports where required. In the absence of a wired carrier, it is likely that voice services are also unavailable. Therefore, the satellite service will have the capability to carry voice as well as data.

A typical teleport installation consists of a satellite dish, LNB, amplifier, BUC (transceiver), modem, router. Depending on the technology employed, components may vary. In some cases, the above equipment is combined into multi-function components.

The ePMIS controller in coordination with the IT staff should deploy a teleport which is capable of carrying data and voice. Equipment should be installed enabling the connection to carry data, VPN, inter-office voice (intercom) and external voice (telephone) services. Each office should have connectivity to the project management's other local offices, smaller remote offices and the home office.

Due to the high bandwidth, low latency requirements of voice, and the high data transfer rates required for consulting services, a premium SCPC system will be selected.
Typical SCPC installation capable of carrying voice and data:

- Channel master 2.4M dish
- Codan LNB, 20W amplifier/BUC

- Combination modem/router
- Dedicated 512mbps symmetrical space segment

Hybrid internet connection – In some locations where there is no communications infrastructure, ISP (Internet Service Provider) companies' spring up and sell bandwidth on a single satellite dish. Access to the service is provided via radio link as in WAN implementations. My experience with these services is that the excessive overselling of bandwidth causes service to deteriorate quickly to unacceptable levels.

Low capacity solution – Where only 1-4 individuals need temporary support, and no communications infrastructure exists, then the ePMIS controller in coordination with the IT staff should deploy portable satellite phones and portable satellite internet services. Such facilities support voice and the transmission and retrieval by email of normal email text and moderately sized reports and photos. Some training may be required to enable individual users to deploy the Internet solution locally.

Power – Electric power is a fundamental requirement. Reliable power means uniform voltage and frequency, uninterrupted 24 hours per day continuously.

Public power supply – Where reliable power is available from a service provider, the ePMIS controller in coordination with the IT staff should subscribe to public power.

Generated power – Where power is unavailable, intermittently available, unreliable or unstable, the ePMIS controller in coordination with the IT staff should purchase and deploy generated power. A typical generator for an office of 20-40 staff, capable of powering lighting, air conditioning, heating, computer equipment, office equipment and miscellaneous electrical items consists of a diesel engine correctly sized for a 160-200KVA generator, housed in a sound proof enclosure, mounted on a concrete slab. Since the generator requires maintenance and periodic service, a backup generator of equal capacity should be deployed.

It is possible to realize a cost saving by deploying a smaller backup generator and, perhaps, running the smaller unit at low usage times. In this case, the backup is not a suitable substitute for the main unit in the event of a failure, resulting in a need to curtail usage of electric power. Mismanagement of this function may damage the backup unit resulting in a secondary failure or requiring staff to work without heat or air conditioning.

As the actual cost of lower capacity units is often comparable to higher capacity units, right sizing or matching the generators is advisable. Adequate, reliable power also eliminates the need for UPS installation either globally or at each workstation, limiting UPS deployment to critical items such as satellite equipment, routers and servers.

Workstations – All workstations should be based on the Wintel platform. This consists of Intel or compatible processors running at or near the highest speeds available. Major brands should be selected for reliability and ease of service. Typical workstations may be configured as follows:

- CPU, Intel P4 operating at 2.4GHz (or equivalent AMD Processor)
- Hard disk, ATA 40GB single drive
- Memory, 512mb of high speed RAM, compatible with motherboard
- Graphic subsystem, 64mb display memory, high resolution
- Flat panel (TFT) screen, 17inch, natural resolution 1024x768 or more, 24 bit color

- USB 2.0
- Keyboard with optical mouse
- DVD writer

All workstations should run with Windows operating system. Also, each workstation should be provided with the Windows operating system. Professional suite of software for general office productivity and Norton or McAfee anti-virus should have access for live update for protection from computer viruses. In addition, all workstations should have installed Win-Zip, Adobe Acrobat Reader and other commonly used utility software, along with all software necessary to operate attached peripheral equipment. Some workstations should be equipped with additional productivity software (Microsoft Project, Adobe Acrobat and others) as necessary to perform project tasks. Depending upon project requirements, the latest versions of the following software may be included:

- Microsoft project
- Primavera project planner (P3)
- Primavera Expedition
- Autocad LDD3, civil design
- ArcInfo

Several workstations may be dedicated to CAD or other computationally intensive functions. These workstations should be specified separately and should be provided with increased speed, higher level graphics, increased storage and faster internal components. Thus, appropriate software should be installed. A number of workstations may require specialized equipment such as scanners and local printers to be attached and configured for exclusive use.

Miscellaneous network facilities – Networked devices such as printers and plotters should be deployed by the IT staff in coordination with the ePMIS controller as should be required by the project participants. High speed laser printers capable of report size (LTR, A3) and oversize (B, A3) with large quantity trays, and automatic selection of paper should be installed on the network. Queues should be installed on the server to facilitate rapid release of printed documents from source computers. Both color and black and white printers should be installed. For larger format paper products large format roll feed inkjet plotters should be deployed as network plotters. These should be shared on the network.

UPS – Uninterruptible power supplies (UPS) should be installed to support critical items on the network. These items include servers, routers, radio links, satellite equipment, PBX and other shared equipment. Typically, a 1500KVA UPS should support a file server and surrounding devices. UPS for satellite teleport should be sized by the vendor to be appropriate to the unit.

Air quality and environment control – Critical IT equipment should be kept in a controlled environment. A room should be selected to isolate and seal off the equipment. The environment should be fully air conditioned for low temperature and low humidity. If necessary, filter systems should be installed to reduce dust and other contaminants.

Security – Computer systems, especially servers and other networking equipment should be installed in a closed environment with access limited to authorized personnel.

Staffing and support – IT staffing usually consists of the following:

- IT Director – Responsible for the development of requirements, interaction with project principals, selection and procurement of equipment, deployment of initial installation, selection and hiring of support staff, initial training and orientation
- IT Manager – Responsible for the day to day operation of the network, operation of backup systems, selection, supervision and training of subordinate staff, help desk operations. Responsible for maintenance of servers, WAN, satellite connection and other networking equipment. Responsible for maintenance of network
- IT staff – Responsible for workstation maintenance, help desk responses and day to day trouble shooting for individual user problems on the network. IT staff should assist in maintenance of network equipment and operation of backup systems.