Management Information System: An Innovative Tool to Monitor and Control of All Corporate Processes Related With the Construction of the New Railway in Greece

Stavros E. Stavrinoudakis

Depatrtment of Information Technology and Infrastructure, Ergose S.A., Athens, Greece
ststavrino@ergose.gr, ststavrino@gmail.com

Abstract

The Ergose's Management Information System (MIS) objective is to assist the decision support functions in almost all corporate processes related with the implementation of the new railway construction in Greece. The MIS main scope is to organize, standardize, control and monitor the majority of the corporate central processes such us programming, design, land acquisitions, tendering, construction, procurement and quality control. The system was implemented through several project phases with a common methodology, the definition of the scope and the project team, gap analysis, system design, functional requirements, software development, acceptance test, user training, system operation and the evaluation of results. The core of the MIS is based on a database management system, an application development framework, an internet site for online reporting and multidimensional statistical analysis and a Document Management System. The operation of the system resulted in the improvement of the data quality and flow, the reduction of the time and manpower needed for monitoring and controlling several corporate processes, the assistance in the decision support and risk management processes and the improvement in the collaboration with third parties. The key benefit of the system is the significant improvement of the corporate project management effectiveness, efficiency and maturity.

Keywords

Management information system, Decision support, Document management, Project management

1. Introduction

Ergose S.A. (Ergose, 2009) is a subsidiary of the Hellenic Railways Organization OSE (OSE, 2009), founded in 1996 in order to undertake the management of the organization's investment programme projects and in particular those co-funded by European Union programmes. The main aim of Information Technology (IT) and Infrastructure directorate in Ergose is the design, development, installation, operation and maintenance of important and innovative Information Systems, in order to organize and improve corporate project management effectiveness and efficiency. It is important to state that a MIS should not be the only IT system in a company. Usually the upper level managers believe that a MIS will provide the "magical" solution to all their issues, but this is not the case. MIS is the most important IT system for the top level managers, but at the same time the installation and operation of several other IT systems that have on-line and batch interfaces with the MIS can highly contribute to the efficient support of all the corporate processes and procedures. In this aspect several Information Systems have been developed, customized, installed and are in operation the recent years (2003-2008), such as: (a) Primavera Project Planner Enterprise P3 for monitoring the time plan of design and construction projects; (b) Enterprise Resource Planning (ERP); (c) Human Resources Management System (HRMS); (d) Business

Plan Monitoring System for the control and monitor of the corporate business plan with the concept of balanced scorecard and key performance indicators (Kaplan and Norton, 1996); and (e) Geographical Information System (GIS) (Tomlinson, 2003), in cooperation with the Land Surveying Design department of Ergose, with Spatial Database Engine (SDE) technology (Peters, 2008) and Linear Reference System (LRS) approach (Buttler, 2008). GIS monitors and displays: the railway network and the progress of designs and constructions projects, based on orthophotomaps and satellite images. Ergose's GIS received honors for exceptional work using GIS technology, a "Special achievement in GIS" award in the 2006 international GIS conference by ESRI (ESRI, 2009).

The most important and innovative Information System in Ergose is the MIS. The system was designed by the Information Technology directorate of Ergose and developed in various phases during the recent years (2003-2008). MIS covers almost all corporate processes (programming, procurement, design, construction, land acquisition, finance, document management etc.) and has on-line and batch interfaces with the rest of the Information Systems (ERP, HRMS, GIS, Business Plan, Primavera etc.). MIS main scope is to organize, standardize, control and monitor the data and the information flow of the main corporate processes. MIS resulted in improving the company's project management effectiveness as well as assisting substantially in various areas of important and vital decision making processes.

In the paper the MIS objectives are defined, taking into account important considerations that a MIS project manager should be aware off prior to the design of the project. Further on, the MIS project methodology and the software packages that are used in the design and implementation of the MIS are presented. Finally the results of the MIS operation and the corporate benefits are analyzed.

2. MIS Objectives

"No tool has ever aroused so much hope at its creation as MIS, and no tool has proved so disappointing in use" (Riley, 1981). This is a statement that we took in serious consideration when starting to define the objectives of the corporate MIS. The objectives and the scope of an MIS system should be "clear" and feasible. The deliverables and the expectations of the system should be defined and approved in detail by the upper level management at the start phase of the project. Usually upper level managers have great expectations from a MIS, such as instant solutions (dare to say even "magical") to their decision making problems. Undocumented and not feasible expectations cause disappointment at the end of the project. It is important to document clearly the system objectives (what you hope to accomplish by implementing this project) and the scope (what is included and what is excluded in this project).

Starting to define Ergose MIS objectives, we transformed the company's strategy set and mission to MIS strategy set and mission (Riley, 1981). So the company's aims (maximize absorption of Greek and European Union funds and ensure that the new railway network structures will be delivered to Hellenic Railways Organization OSE on time and at an acceptable cost and quality) became also MIS aims. In order to satisfy these aims we needed to clarify the MIS objectives and scope. The system objectives followed a top down approach starting from the needs of the upper level management and going down to the needs of middle and lower level management (Riley, 1981).

The MIS objective is to assist the decision support functions on almost all corporate processes, such as: programming, procurement, design, land acquisition, construction, document management, finance, quality control, quality assurance and health & safety.

The MIS scope is to:

(a) Organize, standardize, control and monitor the data and the information flow of the main corporate processes.

(b) Centralization of data storage.
(c) Categorization and coding of data.
(d) Data safety and security.
(e) Multidimensional real time data analysis (Thierauf, 1997).
(f) Powerful, easy, flexible and fast in development decentralized reporting, that would require from the managers as less effort as possible (Riley, 1981).
(g) Open architecture always expandable and adaptable to new functional requirements.
(h) Exclude functional requirements that are covered through other information systems, such as: ERP, HRMS, GIS, Business Plan and Primavera.

Another important conceptual task was to identify the MIS constraints (Riley, 1981) and these were:

(a) The national and European legislation.
(b) The corporate ISO system, the relevant information flow and the predefined reports that were mandatory to be supported.
(c) The need for interfacing with other IT systems (ERP, HRMS, GIS, Business Plan and Primavera) in order to extract data from their databases and synchronize them with the MIS data.
(d) The time plan and the budget: the upper level management needed urgently the development of the MIS, so the initial system was implemented within a year and in line with the budget.
(e) The lack of experience within the management group for sophisticated information systems.

Finally, we had to take seriously into account and perform a plan of actions, for each one of the following important considerations (that could lead in drawbacks and issues during the development and operation phase of the MIS):

(a) Psychological disposition of the users due to their resistance to change, propensity to utilize ego defenses and apprehension toward the system (Riley, 1981).
(b) Resistance of the users for sharing the MIS data due to their "data ownership" attitude. Prior to the MIS the storage of the data and the control of the information flow were decentralized, meaning that each organizational unit was "holding" and controlling it's own data, giving to middle and lower level managers a feeling of organizational power and authority. The operation of a modern MIS results in the centralization of data storage and control of the information flow, the middle and lower level managers should adapt in this new situation and "their own" data should become "corporate data".
(c) With the MIS the access in data and the retrieval of information is easy and fast, so the upper level management can visualize instantly the progress of several tasks and realize the corrective actions that should be taken. The middle and lower level managers, who feel that their work and their possible wrong decisions are easily feasible to the upper level management, react (in not predictive ways) in the operation of the system, trying to minimize the appreciation of the upper level management to the MIS.
(d) The operation of the MIS requires robust corporate processes. The employees, who are not focused in following the processes, resist in the operation of the system, as it places them in a strictly formed environment of workflow.
(e) Communication between the project team is a vital part for the project success, especially when a series of middle and lower level managers should cooperate for the same purpose.


3. MIS Methodology and Tools

3.1 Methodology

The MIS Methodology was based on a strategic planning framework with a medium range plan in order to satisfy the short term (2-5 years) company's needs but at the same time a long range plan in conceptual

terms for future needs (McLean and Soden, 1977). The medium range plan was based on several MIS sub-projects according to the upper level management priorities. Each one of the sub-projects corresponded to a "MIS project phase". The time plan for each MIS project phase was about 6 months to 1 year (Figure 1).

The Information Technology directorate of Ergose was performing the project management and relevant administrative tasks of the MIS project. The rest of the project team consisted of several middle and lower level managers, responsible for relevant corporate processes, such as: programming, procurement, designs, construction, land acquisition, finance, quality assurance, quality control and health & safety. The characteristics of the selection of the middle and lower level managers who participated in the 1st phase of the MIS project team where the following: (a) they had knowledge of the operational processes of their organizational units that participated in the medium range plan of development; (b) the MIS was contributing to their self-interest with important benefits to their work; (c) they were receptive to changes and new technology; and (d) their opinion and their system evaluation had important influence in almost all the levels of company hierarchy (upper, middle and lower level management).
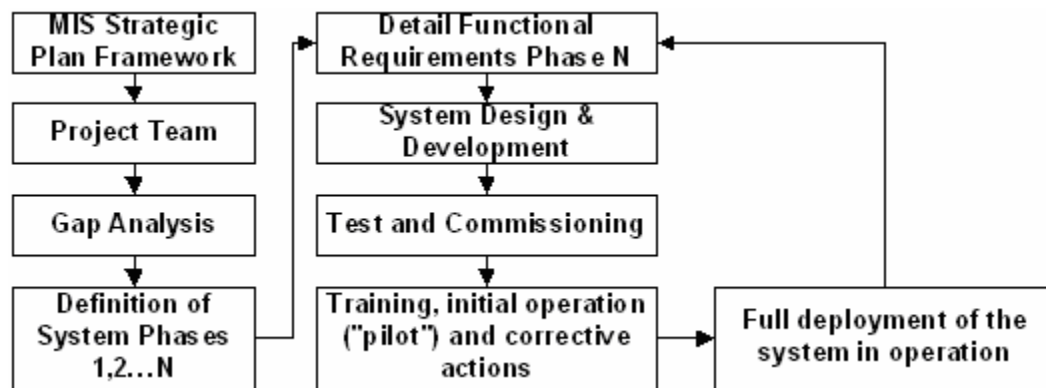
Figure 1: MIS Project Methodology

The tasks of the relevant middle and lower level managers were: prepare the functional requirements of their operational units, monitoring the progress of development of the system, testing and acceptance of the deliverables, assist in the operational deployment of the system.

Following the project team definition, we performed a Gap analysis of "where we stand" and "were we want to be". The "where we stand" status was:

- Important information and the relevant data where scattered in hundreds of individual files (MS Excel spreadsheets, MS Word documents, MS Access databases etc.) in all over the company, spread out to all organizational units.
- The same information and data elements where stored and maintained in parallel by several organizational units, with different coding, different categorization and even more important different meaning.
- The retrieval and manipulation of information in order to perform even a simple daily or monthly reporting task, was a very time consuming process that needed great resources and manpower (in order to compare the data between the several sources, find out which data are the more accurate, correct the data, transform the data in the needed structure, present the data in the right form etc.).
- The decision support processes needed accurate information that occasionally was not possible to be retrieved and formed in specific time frames (via MS Excel spreadsheets). Therefore, decisions were not always based in proper and accurate data.

For the "were we want to be": the MIS objectives and scope were detailed enough in order to proceed in the definition of the various project phases (sub projects) that we should follow.

The 1st Project Phase consisted of:

- The design and development of the system architecture.
- The installation and customization of the appropriate hardware and software.
- The development of software modules for the control and monitor of the procurement and the design related corporate processes.
- The development of an intranet/ internet site for powerful reporting, with On-Line Analytical Processing (OLAP) and multidimensional data analysis capabilities (Thierauf, 1997).

The next MIS project phases (2nd and 3rd) focused on the implementation of additional software modules for monitor and control the rest of the corporate processes, such as: construction, document management, land acquisition, finance, quality assurance, quality control, health & safety and interfaces with other IT systems (ERP, HRMS, GIS, Business Plan and Primavera).

3.2 Tools

The software packages for the core of the system are: Sybase ASE 12.5.4 database server, Power Builder 10 with foundation classes (PFC) for the application development framework, Power Designer 12 for the design of the central database, Business Objects 6.5 for the MIS intranet/internet reporting site with multidimensional data analysis capabilities, CITRIX presentation server 4.5 for accessing client server data entry system modules via internet.

For specialized statistical analysis (such as: descriptive and inferential statistics, correlation analysis, principal component analysis, cluster analysis, association rule mining, Bayesian data analysis, missing value analysis, factor analysis, reliability analysis, correspondence analysis and regression analysis) data are extracted from MIS database, imported and manipulated with the following software packages (Marques De Sà, 2007): MATLAB, SPSS (Field, 2005), R programming language (Crawle, 2007).

The system hardware: (a) for the database server a HP ML350G3 rack mounted server with 2 Xeon 2.4GHz CPU, 4GB Ram, 2x36GB Raid-1, MS-Windows 2000 Server with SP4; (b) for the Application Server & MIS Reporting Site HP ML350G3 rack mounted server with 2 Xeon 2.8 GHz CPU, 2GB RAM, 2x36GB Raid-1, MS-Windows 2003 Server with SP1 and IIS 6.0; and (c) for the data storage HP Storage Area Network (SAN) Modular Smart Array with 7 Terra Bytes (TB) capacity.

4. Results

The results of the Ergose MIS project are:

(a) A central Relational Database Management System (RDBMS) that consists of more than 600 tables, with high-end data safety and security mechanisms.
(b) A Storage Area Network (SAN) of 7 TB for data storage and control purposes (Figure 2).
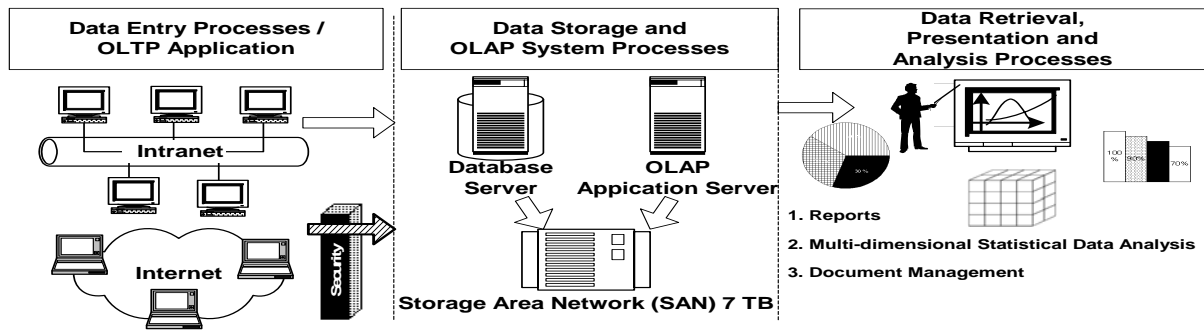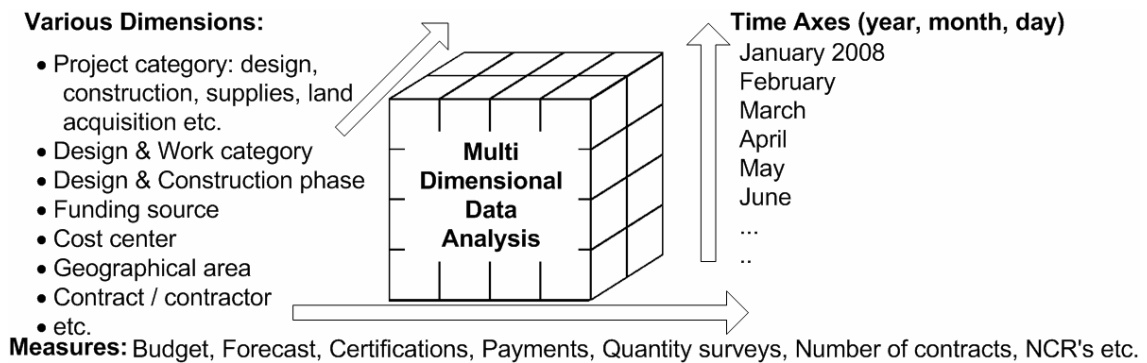
Figure 2: System Architecture

(c) The corporate data are categorized and follow logical data concepts: entities, attributes and relationships (Davis and Olson, 1984) with multidimensional approach (Thierauf, 1997).

(d) Each data element is entered in the system only once by an authorized user, is stored in a specific database table and retrieved by authorized users only.

(e) An object oriented application development framework for fast and robust development of data entry software modules with On-line Transaction Processing System (OLTP) approach.

(f) A modular system (OLTP) for data entry purposes with integrated workflow functions, which controls the following main corporate processes:

- Programming: tendering planning, budget control, funding etc.
- Procurement: procurement plan, procurement processes etc.
- Designs: progress per design category (structural, architectural, land surveys etc.) and physical structures (tunnels, bridges, cut & covers etc.), electronic submission of payment certifications to the Finance directorate, change orders etc.
- Constructions: progress per work category, physical structures (tunnels, bridges, cut & covers etc.), pre-measurements, quantity surveys accompanying each billing process, electronic submission of payment certifications to the Finance directorate, recapitulation tables etc.
- Supplies (rails, ballast etc.).
- Land acquisition.
- Finance: payments certifications, billing, budget, forecast etc.
- Quality Assurance (QA)/ ISO (audits, findings, open/close items, Non Conformance Reports NCR's, suggested improvements etc.).
- Quality Control (QC) (material controls, laboratory controls, concrete plant controls, NCR's etc.).
- Health & safety in the construction sites (audits, findings, NCR's etc.).
- Document Management System: corporate correspondence, library, standards and technical specifications, technical document archiving (contracts, designs, as built drawings etc.).

(g) A web-based reporting site (installed on a dedicated application server) with OLAP functions (Thierauf, 1997), with the following characteristics:

- The predefined reports are categorized and accessed by authorized users.
- Ad-hoc reporting for new reports (or modification on existing).
- The reports are easily used by upper, middle and lower level management (via an Internet Explorer browser).
- Users can perform on-line queries with dynamic filters, extract data in various ways (tables, charts, crosstabs etc.), slice-n-dice data and drill down / up / across in a multidimensional data environment (Figure 3).

- Users can perform statistical analysis either directly through the MIS internet site, or by using specialized third party software (such as: SPSS, MATLAB, R etc.) on extracted MIS data or directly connected to the database.

Various Dimensions:
- Project category: design, construction, supplies, land acquisition etc.
- Design & Work category
- Design & Construction phase
- Funding source
- Cost center
- Geographical area
- Contract / contractor
- etc.

Multi Dimensional Data Analysis

Time Axes (year, month, day)
January 2008
February
March
April
May
June
...
..

Measures: Budget, Forecast, Certifications, Payments, Quantity surveys, Number of contracts, NCR's etc.

Figure 3: Data Drilling in a Multidimensional Environment

(h) A high-end sophisticated and flexible data security mechanism: each user accesses (write or read) only the information and relevant data elements that he/she is authorized.
(i) On-line and batch interfaces with other IT systems (ERP, HRMS, GIS, Business Plan and Primavera) in order to extract data from their databases, synchronize them with the MIS data, analyze and present them through the MIS OLAP reporting site (Poe *et al.*, 1997).
(j) An open architecture system, easily expandable to new functional requirements and adaptable to modifications in existing system processes.

The majority of the company employees are users of the MIS. They can access the system through the corporate data network and via Internet (Athens, Thessaloniki and construction sites all over Greece). Apart from the corporate users the MIS is accessed also by third parties (external authorities): (a) The Greek Ministry of Transportation and Telecommunications; and (b) The Managing Authority for transportation projects.

With the operation of the MIS a lot of issues regarding the monitoring of the corporate projects progress have been solved, such as:

(a) The frequency of the management reports: prior to MIS the management reports where mainly produced quarterly and in the best case scenario monthly via batch procedures (off-line/not interactive). With the MIS the reports are available daily and on-line.
(b) The data quality: prior to the MIS the data quality was limited due to the fact that data was scattered in hundreds of Excel files between different departments of the company. With the MIS the quality of the data is almost excellent due to the centralization of data and several automated data control mechanisms.
(c) The reporting capabilities where limited in the past and very time consuming. With the MIS the management have "unlimited" options/alternatives for data analysis (multidimensional data environment etc.) and is able to take important decisions in a short time.
(d) The forecast capabilities were limited and the prevention of issues mainly concern the excess in the budget of a project were almost impossible. With the MIS we have dynamic forecast control (with relevant software modules) and at the same time we are in position to take preventive actions in order to eliminate issues due to upcoming future excess in budget of projects (by analyzing MIS data related with the quantity surveys and pre-measurements per work category and physical structure).

5. Conclusion

The most important lessons learned from the MIS project are:

- The efficient cooperation between middle and lower level managers of different departments within the company, working for a common goal like the implementation of the MIS, does not only impacts significantly the results of the system, but at the same time motivates the managers to solve diachronically operational issues mainly related with lack of communication and cooperation of their departments.
- The MIS is not the only IT system in a company, various other IT systems must be installed and operate prior to the development of the MIS (like ERP, HRMS etc.).
- A feasible, understandable and acceptable by the top level management MIS target and scope is mandatory.
- A step by step approach is substantial for such an important and difficult goal, so as to: primary have intermediate results in a short period of time, furthermore get the experience from the system operation in order to design more efficiently the next system phases and be able to absorb the new technology and the new processes more effectively.
- The system should have "open" architecture, always adaptable and expandable to new features and new processes. At the same time the IT directorate of the company must be able not only to support but also to expand the system with new modules, reports etc.
- The design of the schema of the system database and the OLAP processes must have multidimensional capabilities in order to analyze operational data by every needed approach.

The corporate benefits from the MIS operation are:

a) Minimization of time and efforts needed for managerial and operational reporting.
b) Best decisions, based on easy and fast accessed consolidated, categorized and accurate data.
c) Improvement of programming and forecast capabilities based on statistical analysis in historical data.
d) Improvement of the construction quality of the new railway structures based on: better evaluation of designs, better monitoring of construction projects and faster identification of possible drawbacks that may occur and require preventive actions.
e) Improvement of communication and information flow between the various organizational units and with third parties (governmental authorities, European Union, Prefectures, Municipalities, contractors etc.).
f) Improvement of employee job performance and effectiveness through a well tuned workflow environment with less effort needed for controlling their daily tasks.
g) Improvement of the corporate capability to achieve positive results in several National and European audits, regarding the proper and effective management of the Investment Programme.

The key benefit of the system is the significant improvement of the corporate project management effectiveness, efficiency and maturity.

6. References

Buttler, J.A. (2008). *Designing Geodatabases for Transportation*, ESRI Press, California, USA, pp.143-160.
Crawle, M. (2007). *The R Book*, John Willey & Sons Ltd, West Sussex, Great Britain.
Davis, G.B., and Olson, M.H. (1984). *Management Information Systems: Conceptual Foundations, Structure and Development*, 2nd ed., McGraw-Hill International, Singapore, pp. 95-130.
Ergose Company Internet Site. (2009). Company Profile. On line at http://www.ergose.gr. Accessed on January 5, 2009.

ESRI Company Internet Site. (2009). ESRI International User Conference 2006. On line at http://events.esri.com/uc/2006/sag/list/index.cfm?fa=pr&SID=499. Accessed on January 5, 2009.

Field, A. (2005). *Discovering Statistics Using SPSS*, 2nd ed., Sage Publications, London, Great Britain.

Kaplan, R.S., and Norton, D.P. (1996). *Translating Strategy into Action: The Balanced Scorecard*, Harvard Business School Press, Boston, USA, pp. 1-42.

Marques De Sà, P.J. (2007). *Applied Statistics Using SPSS, STATISTICA, MATLAB and R*, 2nd ed., Springer, NY, USA.

McLean, E.R., and Soden, J.V. (1977). *Strategic Planning for MIS*, John Willey & Sons, NY, USA, pp. 23-27.

OSE (Hellenic Railways Organization) Internet Site. (2009). Company Profile. On line at http://www.ose.gr. Accessed on January 5, 2009.

Peters, D. (2008). *Building a GIS: System Architecture Design for Managers*, ESRI Press, California, USA, pp. 51-68.

Poe, V., Klauer, P., and Brobst, S. (1997). *Building a Data Warehouse for Decision Support,* 2nd Ed., Prentice-Hall Inc., NJ, USA

Riley, M.J. (1981). *Management Information Systems*, 2nd Ed., Holden-Day Inc., San Francisco, USA, pp. 93-282.

Thierauf, R.J. (1997). *On-line Analytical Processing Systems for Business*, Quorum Books, London, Great Britain, pp. 3-131.

Tomlinson, R. (2003). *Thinking about GIS: Geographic Information System Planning for Managers,* ESRI Press, California, USA, pp. 1-199.