

## CHAPTER 5 - THE APPLICATION OF MANAGEMENT INFORMATION SYSTEMS IN THE CONSULTING ENGINEERING FIRM

### 5.1 Introduction

In Chapters 3 and 4 the external business environment of South African consulting engineering firms was described. The management of a consulting engineering firm should make strategic decisions based on its assessment of the firm's external business environment. Knowledge and understanding of the external environment is therefore central to successful strategic management. The management of consulting engineering firms must have suitable information systems to provide them with accurate information on their external environment so that they can make appropriate and effective strategic decisions in the best interest of their firms. This chapter explores the application of management information systems in the consulting engineering enterprise in order to put the characteristics of a suitable strategic environmental information system in perspective.

An information system is a set of people, procedures, and resources that collect, transform, and disseminate information in an organisation [9]. Information systems can play a vital role in business success. They can provide the information that a business needs for efficient operations, effective management, and competitive advantage [127].

### 5.1.1 System concepts

A system can be simply defined as a group of interrelated or interacting elements forming a unified whole, but a more appropriate definition for an information system is a group of interrelated components working together towards a common goal by accepting inputs and producing outputs in an organised transformation process [127, 188]. Such a system, also called a dynamic system therefore has the following three basic interacting components or functions.

- **Input**, which involves capturing and assembling elements that enter the system to be processed.
- **Processing**, which involves transformation processes that convert input into output.
- **Output**, which involves transferring elements that have been produced by a transformation process to their ultimate destination.

Two additional components are normally present in a self-monitoring, self-regulating or cybernetic system, namely

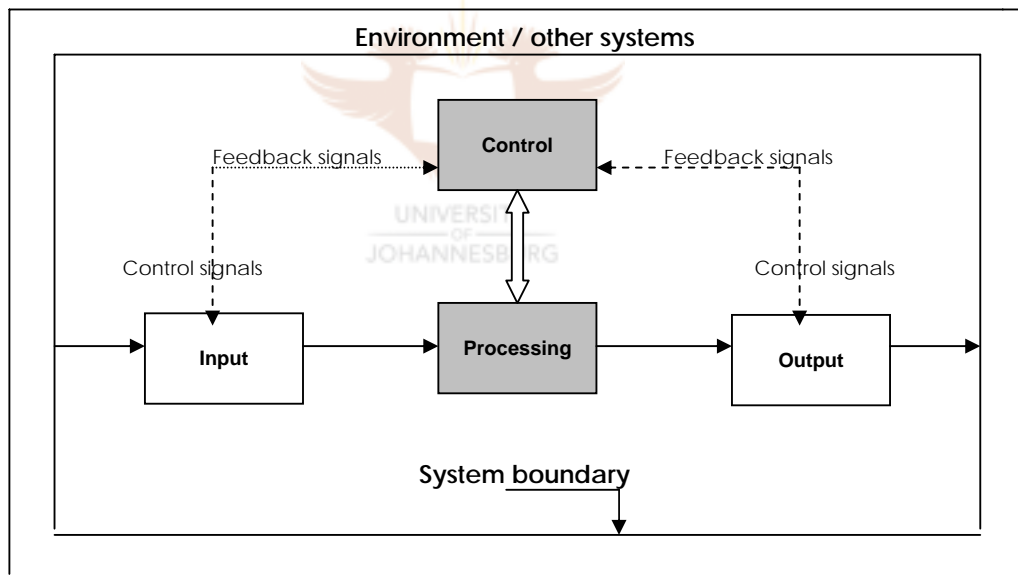
- **Feedback**, which is data about the performance of the system, and
- **Control**, which involves monitoring and evaluating feedback to determine whether a system is moving towards the achievement

of its goal. The control function is responsible for making necessary adjustments to a system's input and processing components to ensure that it produces proper output [127].

It should furthermore be kept in mind that a system does not exist in a vacuum. It exists and functions in an environment containing other systems as illustrated in Figure 5.1.

FIGURE 5.1

Fundamental components and characteristics of a system [127]



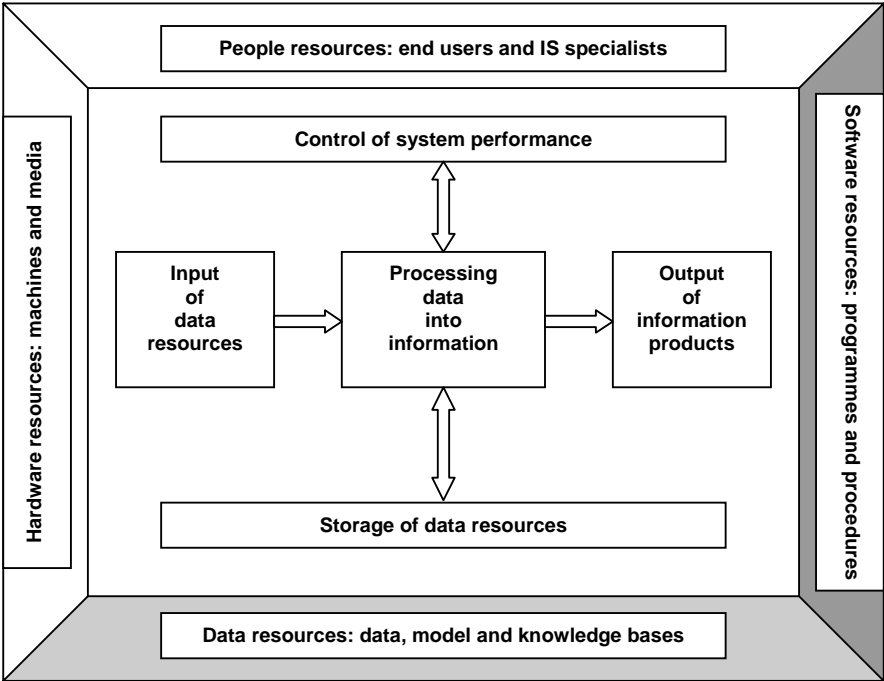
### 5.1.2 Information system components

The systems concepts can be used to understand how an information system (IS) works. Figure 5.2 illustrates such an information system model in which the system

uses the resources of people, hardware and software to perform input, processing, output, storage and control activities that convert data resources into information products.

FIGURE 5.2

The components of an information system [127]



5.1.3 The classification of information systems

Information systems can be classified using numerous classification systems, but for the purposes of this study, a simple functional classification by major role in a business was used. It should however be noted that information systems are typically integrated combinations of the several types of information systems

mentioned in this chapter. Information systems are functionally classified according to the three major roles they play in a business enterprise, which are:

- Supporting business *operations*
- Supporting *managerial* decision making
- Supporting the enterprise's efforts in gaining *competitive advantage* by producing specific information-based products, services and capabilities. These information-based products, services and capabilities can give the firm a strategic advantage over the competitive forces it faces in the global marketplace [139].

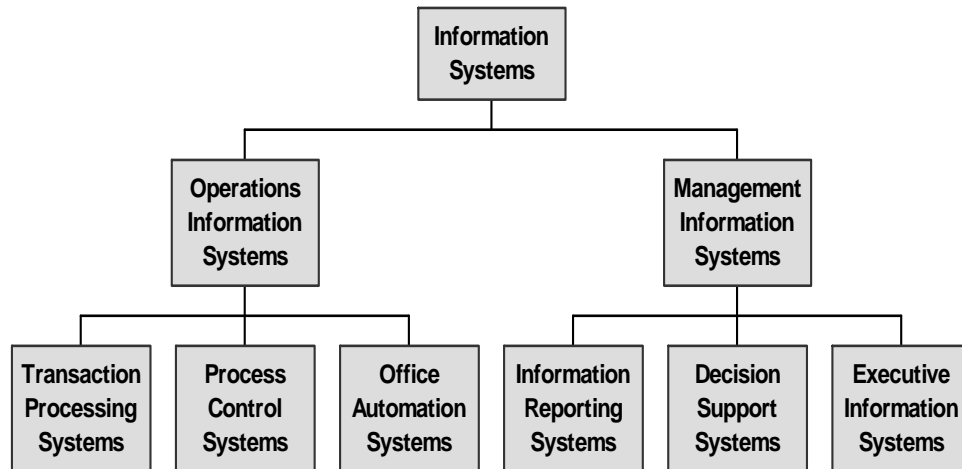


The *operations* and *managerial* classifications can furthermore be categorised into several conceptual classifications as illustrated in Figure 5.3 [87]. *Operations* information systems, which are systems that support business operations, include systems such as those that process business transactions, those that control industrial processes and those that contribute directly to office communications and productivity. *Management* information systems, which are systems that support managerial decision making, include pre-specified information reporting systems, interactive decision support systems and those systems that provide information for top management [188].

Further discussion in this chapter will focus on *operations* and *management* information systems (OIS's and MIS's). There will furthermore be specific reference to the application of OIS's and MIS's in South African consulting engineering firms.

FIGURE 5.3

Operations and management classifications of information systems [87]



## 5.2 Operations information systems

Information systems have always been used to process the data generated by and used in the business operations of consulting engineering firms. Such operations information systems are tailored to produce a variety of information products for use both inside and outside these firms. Operations information systems are different from Management information systems. They do not emphasise the production of specific information products for use by managers.

The role of a firm's operations information systems is to efficiently process business transactions, control industrial processes, support office communications and productivity and update business transaction-related corporate databases.

### 5.2.1 Transaction processing systems

Operations information systems include the major category of transaction processing systems (TPS). Transaction processing systems record and process data that result from business transactions [188]. The nature of the consulting engineering business dictates that business transactions are usually processed in batches, rather than by real-time or online processing. The following are typical examples of such TP systems in a consulting engineering firm.

- **Accounting systems**

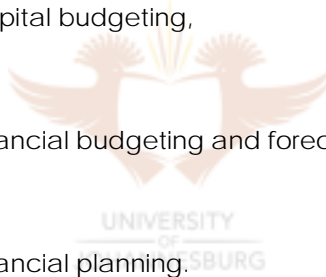
These systems accommodate the day-to-day business and accounting processes such as accounts receivable and payable (debtors and creditors), inventory control (work in process/ progress), payroll, debtor and creditor database management, general ledger and financial statements [206, 37]. Such systems typically produce:

- o invoices and statements to clients,
- o cheques or electronic payments to creditors,
- o debtors age analyses for debtor control,
- o employee salary cheques or electronic payments,
- o payments to maintain staff benefits (e.g. pension, medical aid, UIF etc.),
- o staff leave provision and administration records,

- o tax forms for individuals and companies,
  - o payments of taxes and levies (e.g. RSC and training levies) and
  - o financial statements (balance sheet and income statement).
- **Financial systems**

These systems attend to business processes such as:

- o cash and securities management,
- o capital budgeting,
- o financial budgeting and forecasting, and
- o financial planning.



### 5.2.2 Process control systems

These operations information systems make routine decisions that control operational (normally industrial) processes. Process control systems (PCS) are seldom, and then only on a small scale, employed in the operations of a consulting engineering firm. An example of such a small-scale application is an automatic inventory re-order system for computer peripheral consumables, which is in use in some large design offices.



### 5.2.3 Office automation systems

These systems involve the transformation of traditional manual office methods and paper communications media. Office automation systems (OAS) collect, process, store and transmit information in the form of electronic office communications. The automated systems rely on text processing, telecommunications and other information systems technologies to enhance office communications and productivity [127]. For example a consulting engineering firm may use word processing for office correspondence, electronic mail to send or receive electronic messages, desktop publishing to produce a company newsletter, website design and maintenance software to operate an electronic message board, teleconferencing to hold remote meetings, scheduling to set up and co-ordinate appointments, tracking systems to administer and record all data and information transfers, and specialist software to administer electronic brainstorming workshops.



### 5.3 Management information systems

Management information systems are information systems developed primarily to provide information and support for effective decision-making by managers [9, 188]. Management information systems originated in the 1960's when it became evident that computers were being applied to the solution of business problems in a piecemeal fashion, focusing almost entirely on the computerisation of clerical and record-keeping tasks. The concept of management information systems was developed to counteract such inefficient development and ineffective use of computers [127]. The MIS concept is regarded as vital to effective and efficient information systems in organisations for two major reasons:

- It emphasises information technology's (IT's) function of supporting management decision-making, not merely processing data generated by business operations.
- It emphasises that a systems framework should be used for organising information systems applications. Business applications of IT should be viewed as interrelated and integrated computer-based information systems and not as independent data processing tasks or operations.

### 5.3.1 The relationship between management information systems and operations information systems



Management information systems support the decision-making needs of strategic (top) management, tactical (middle) management, and operating (supervisory) management. Operations information systems support the information processing requirements of the day-to-day operations of a business, as well as some lower-level operations management functions.

Managers at different organisational levels in any enterprise will have different information needs in accordance with their respective management functions. The relationship of management information systems and operational information systems to business operations and the levels of management are illustrated in Table 5.1 [127].

**TABLE 5.1**

**The relationship of management information systems and operational information systems to business operations and the levels of management [127].**

<b>Management level</b>	<b>Information systems</b>	<b>IS type</b>
Strategic management	<ul style="list-style-type: none"> <li>• Executive information systems</li> </ul>	<b>Management Information Systems (MIS)</b>
Tactical management	<ul style="list-style-type: none"> <li>• Decision support systems</li> <li>• Information reporting systems</li> </ul>	
Operational management	<ul style="list-style-type: none"> <li>• Office automation systems</li> </ul>	
Business operations	<ul style="list-style-type: none"> <li>• Transaction processing systems</li> <li>• Process control systems</li> </ul>	<b>Operations Information Systems (OIS)</b>

### 5.3.2 Information reporting systems

Information reporting systems (IRS) are the most common form of management information systems. They provide managerial end users with information products that support much of their day-to-day decision-making needs. Information reporting systems can provide a variety of reports and displays to managers. Managers specify the content of these reports and displays in advance so that they can be customised to contain the information that managers need, presented in a way that suits the managers.

Information products provided to managers include displays and reports that can be furnished:

- on demand, that is instantaneously,
- periodically, that is to a predetermined schedule, or
- whenever exceptional conditions occur [9, 188].

Examples of information reporting systems in consulting engineering firms [82] are:

- Project accounting or project costing systems. These systems deal with all the management functions at a projects level, i.e. covering functions such as:
  - staffing/ resourcing (e.g. actual electronic timesheets against staff category and time allocations in project budget),
  - project progress (e.g. actual progress against programme and actual progress against budget cost expended),
  - financial progress (e.g. actual cost expended against budgeted cost),
  - profitability (e.g. income invoiced against direct and indirect expenses),
  - inventory control (work in progress/ process),
  - comparison of project unit costs to benchmark unit costs and updating benchmarking databases.
- Project management systems that deal with programming/ scheduling, resourcing and monitoring of projects. These systems are ideally integrated with the project costing systems, but deal with detailed project information (e.g. task scheduling etc.) to a much greater level of detail than the project costing systems.

- Human resource management systems, which often integrate leave management and availability systems, personnel databases (staff data, fields of expertise, project experience, presentation CV's etc.) and other human resource management aspects.
  
- Marketing systems, which can include inter alia:
  - client databases,
  - client (market) and service (product) type analyses by turnover and geographical location,
  - standardised marketing proposal frameworks,
  - firm's experience and expertise,
  - general marketing material such as firm's and discipline electronic brochure material, etc.



### 5.3.3 Decision support systems

Decision support systems (DSS's) are a natural progression from information reporting systems and transaction processing systems [127]. Decision support systems are interactive, computer-based information systems that use decision models and specialised databases to assist the decision-making processes of managerial end users. These systems are therefore different from transaction processing systems, which focus on processing the data generated by business transactions and operations. They also differ from information reporting systems, which focus on providing managers with prespecified information, in the form of

reports, which can be used to help them make more effective management decisions.

Decision support systems provide managerial end users with information in interactive sessions on an ad hoc basis. A DSS can provide managers with analytical modelling, data retrieval, and information presentation capabilities. Managers therefore use a DSS to generate the information they need for more unstructured types of decisions in an interactive, computer-based process. Information from a DSS is therefore different from the prespecified responses generated by an IRS. When using a DSS, managers can be exploring possible alternatives and receiving tentative information based on alternative sets of assumptions.

Consulting engineering firms, due to the nature of their professional services business, do not commonly make use of DSS's. Some of the larger practices do however use these systems, with input from their marketing and project costing IRS's as well as their financial and accounting TPS's [81].

#### **5.3.4 Executive information systems**

Executive information systems (EIS's) are management information systems tailored to the strategic information needs of top management. Top executives of consulting engineering firms get the information they need from many sources, which may include letters, memos, industry/trade and other publications, reports, meetings, telephone calls and social activities. Much of a top executive's information therefore comes from non-computer sources. Computer-generated information has generally not played a major role in meeting the information needs of top executives in consulting engineering firms.

The goal of computer-based executive information systems (EIS's) is to provide top management with immediate and easy access to selective information about key factors that are critical to accomplishing their firm's strategic objectives. EIS's must therefore be easy to operate and understand. Graphic displays must preferably be used extensively and it should provide access to external and internal databases. An EIS should provide information about the current status and projected trends for key factors selected by top executives.

### **5.3.5 Information and the levels of management**

The information needs of management depend heavily on the management level involved. Table 5.1 in section 5.3.1 illustrated the relationship of management information systems and operational information systems to business operations and the levels of management.



The activities of management can be subdivided into the three major levels of strategic management, tactical management and operational management, which can generally be related to the traditional management levels of top management, middle management and operating or supervisory management. This model of management was popularised by Robert N. Anthony [10] in the 1960's and relates the planning and control activities of a manager to his or her specific level in an organisational structure.

- **Strategic planning and control.** Top management has ultimate responsibility for long-range strategic planning, i.e. the development of overall organisational goals, strategies, policies and objectives. The top executives also have to monitor the strategic performance and overall direction of the organisation. [168]
- **Tactical planning and control.** Middle management develop short- and medium-range plans and budgets and also specify the policies, procedures, and objectives for sub-units of the organisation. They also acquire and allocate resources and monitor the performance of organisational sub-units, such as departments, divisions, and other work groups.
- **Operational planning and control.** Supervisory managers develop short-term production-related plans. They direct the use of resources and the performance of tasks according to established procedures and within budgets and programmed durations established for the work groups of the organisation.

Table 5.2 emphasises that the type of information required by managers is directly related to both the level of management and the amount of structure in the decision situations they face.

For the purposes of this study it is important to note that the strategic management level requires condensed, ad hoc, unscheduled reports, and external intelligence with a wide and forward-looking scope to support its more unstructured planning and policy-making responsibilities [127].



TABLE 5.2

Information requirements by management level and the amount of structure present in decision-making [127]

Decision structure	Management level	Information characteristics	
Unstructured (non-programmable)	Strategic management	Ad hoc Unscheduled Summarised Infrequent	Forward looking External Wide scope
Semi-structured	Tactical management		
Structured (programmable)	Operational management	Pre-specified Scheduled Detailed Frequent	Historical Internal Narrow focus



5.3.6 Information and decision-making

Herbert A. Simon, a well-known economist and scholar of management decision-making, divided the managerial decision-making process into three activity types, namely *intelligence*, *design* and *choice* [192]. Other researchers have emphasised that, since managerial decision-making is typically a problem-solving process, the *implementation* of a decision is as important to its success as the steps that lead up to it [73].

Figure 5.4 illustrates a four-stage decision-making model that incorporates both the three initiating stages and the implementation function. The model includes the ability to cycle back to a previous stage if the decision-maker is dissatisfied with the intelligence gathered, the alternatives developed or chosen, or the success of implementation activities.

FIGURE 5.4

A model of the managerial decision-making process [73]

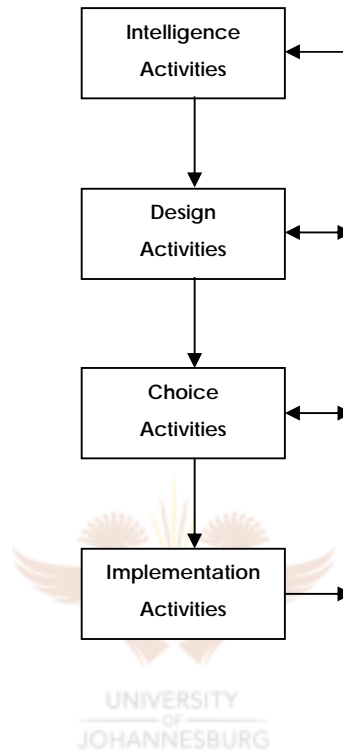


Table 5.3 illustrates how each of the four stages of managerial decision-making has unique information requirements and how information systems can support each stage of the process.

Table 5.4 provides examples of management decisions by the type of decision structure and by the level of management in a consulting engineering firm. The principles contained in the table are based on the work of Gorry and Morton [73].

**TABLE 5.3**

**Information systems supporting the decision-making process [127]**

<b>Decision-making stage</b>	<b>Activity</b>	<b>Support role of information systems</b>
Intelligence activities	Search for and identify conditions requiring a decision	Information systems should scan the internal organisation and the external environment and help identify problems and opportunities
Design activities	Develop and evaluate alternative courses of action	Information systems should help generate and evaluate decision alternatives
Choice activities	Select a course of action	Information systems should help emphasise and prioritise decision alternatives
Implementation activities	Implement and monitor the success of the decision	Information systems should provide feedback on the implemented decision



**TABLE 5.4**

**Examples of decisions by the type of decision structure and by the level of management**

<b>Decision Structure</b>	<b>Operational management</b>	<b>Tactical management</b>	<b>Strategic management</b>
<i>Unstructured (non-programmable)</i>		Work group/ project team reorganisation	New business planning Company reorganisation
<i>Semi-structured</i>	Cash management Credit management Project scheduling Daily work assignment	Work group performance analysis Employee performance appraisal Capital budgeting Project or programme budgeting	Service planning Mergers and acquisitions Office location
<i>Structured (programmable)</i>	Control of work-in-progress/ process	Project or programme control	

Structured decisions involve situations where the procedures, which need to be followed when a decision is required, can be specified in advance. Such decisions are therefore structured or programmed by the decision procedures developed for them. Structured decisions can be deterministic (algorithmic), i.e. the decision's outcome can be determined with certainty if a specified sequence of activities (an algorithm) is performed. A structured decision may also involve a probabilistic decision situation, i.e. enough probabilities about possible outcomes are known that a decision can be statistically determined with an acceptable probability of success [127].

Unstructured decisions involve decision situations where it is in most cases not possible or desirable to specify in advance the decision procedures to follow [127]. Most decision situations facing top management are unstructured because they are subject to many random or changeable events or involve many unknown factors or relationships.

#### **5.4 Conclusion and recommendations**

Information systems can be classified using numerous classification systems, but for the purposes of this study, a simple functional classification by major role in a business was used. It should however be noted that information systems are typically integrated combinations of the several types of information systems mentioned in this chapter.

The information systems classification method followed in this study define management information systems (MIS's) as information systems developed

primarily to provide information and support for effective decision-making by managers. Such information and support can be for the decision-making needs of strategic (top) management, tactical (middle) management, and operating (supervisory) management.

Executive information systems (EIS's) are management information systems tailored to the strategic information needs of top management. For the purposes of this study it is important to note that the strategic management level requires condensed, ad hoc, unscheduled reports, and external intelligence with a wide and forward-looking scope to support its more unstructured planning and policy-making responsibilities.

A model of the managerial decision-making process (Figure 5.4) and Table 5.3 indicate that, during the intelligence stage of managerial decision-making, management information systems should scan both the internal organisation and the external environment and help identify problems and opportunities.

This study emphasised management information systems that scan the external environment of a particular industry, namely the South African consulting engineering industry. The focus furthermore was on the provision of information to assist strategic management in the South African consulting engineering industry. Such assistance was primarily aimed at decision situations on large strategic management issues [168, 101] such as:

- New business ventures
- Major additions to the core competencies of a firm
- Closure of mature or undesirable market interests
- Long-term market and service development

- Development of human resources in a firm
- Restructuring or re-engineering a firm, including changes in corporate culture, to adapt and prepare for the future
- Range of services offered, e.g. movement from mature services into new and developing or growth services
- Mergers and acquisitions
- Geographical office location

The next chapter discusses the need for such an industry-specific strategic management information system (SMIS) and investigates the required characteristics of a suitable SMIS for the South African consulting engineering industry.

