

# MITOS: Multi-phase Integrated Automation System for Building Production Process

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## Summary

Building production process has a complex nature and fragmented structure due to the characteristics of project type productions, i.e., number of participants, various organizational patterns, multi-phased production etc. Some of the currently available information system solutions and models in both conceptual and practical dimensions try to provide an *integration* and *continuity* through the phases of building production process in terms of various management-related functions by integrating the components that correspond to these functions. This paper presents an *integrated* design of a *unified* computer-based office automation system, MITOS (Multi-phase Integrated Automation System for Construction Industry) that basically comprises three relational database models; ASAP (Automation System for Architectural Practices); ASCC (Automation System for Construction Companies) and ASCE (Automation System for Cost Estimation).

**KEYWORDS:** Architectural office, architectural practices, construction companies, information system, information technology, office automation, relational database, data warehouse, AEC firms.

## 1. Introduction

An increase in the scale and complexity of production requires a larger number of participants and a more efficient communication among them. Because of the fragmented nature of the construction process, construction organizations have always searched for new ways to integrate both inter and intraorganizational functions [1]. The idea of integrating the functional components of a construction organization and computer applications developed for construction is not new. Various research projects such as RATAS - Infrastructure for Computer Integrated Construction [2], SPACE - Simultaneous Prototyping for an Integrated Construction Environment [3], ICON - Intelligent Integration of Information in Construction [4], COMMIT - Construction Modeling and Methodologies for Intelligent Information Integration [5], ATLAS - Architecture, Methodology and Tools for Large Scale Engineering [6], COMBINE - Computer Models for the Building Industry in Europe [7] that attempt to solve the integration problem can be found in literature. However, they do not seem to contain a comprehensive model that use *unification* as a standardization tool in design of information system.

## 2. Definition of the Problem

Information systems (IS) utilizing the facilities provided by information technology (IT) are used as tools to integrate the phases of building production process and remove fragmented structure of construction industry. Integration may be achieved in *horizontal* or *vertical* direction. Horizontal integration deals with the management-related functions within organization and is based on

intranet applications mostly. Vertical integration tries to establish relationships among the components of information systems used by various participants in different phases of building production process. Due to the fragmented structure stated above, research projects that focuses on *integration* in IS solutions are encouraged in construction industry but integration is not the only tool to use. Although *unification*, which is known as the combination of more than one models into one unique model fulfilling the functions of each model combined, is another conceptual tool.

Unification studies should be extended to IS models. This tool that must be considered and focused in development of IS models does not seem to receive the attention it deserves yet. In order to determine the possibility of unification of models used in different phases of building production process, the similarity of the information organized in different models must be determined first. However, none of the IS models in literature seems to deal with this dimension of the problem.

### 3. MITOS: A Multi-phase Integrated Automation System

**MITOS** (Multi-phase Integrated Automation System for Construction Industry), a data warehouse model, was designed for solving the problem stated above. The initial conceptual structure of the model that suggests integration of the components is given in *Fig. 1*. The basic components of **MITOS** are:

- ASAP (Automation System for Architectural Practices),
- ASCC (Automation System for Construction Companies),
- ASCE (Automation System for Cost Estimation),

These basic components of **MITOS** use the same external components for certain functions. These components can be used individually and independently or can be integrated to these systems. The shared components are MS PROJECT (Project Planning and Programming Software), NEMETSCHEK (CAD Software), SIS (Suppliers and Input Items Information System), QIS (Quality Information System), AXIS (Academic eXternal Information System) Library Module.

As it can be seen in *Fig. 1*, the initial structure of the conceptual model of **MITOS** was containing basically three integrated components at the beginning of development studies. Through the development process it was explored that the functional modules in ASCC that does not exist in ASAP can also be used by ASAP and the models developed for the architectural offices (ASAP) and construction companies (ASCC) may have almost the same internal modules to organize the same sort of information; so they can be *combined* into one unique model that provides *unification* with minor changes and additions in detail. Thus, the same database objects can be used to save the same information for different type of projects, i.e., *design* or *construction projects* with few exceptions.

Although this sort of exceptions makes it difficult to use the same database objects and to *simplify* and *unify* the structure of combined model, most of the modules that exist in both models match each other. For example, ASAP contains *Engineering Offices Module* to organize the information related to engineering offices undertaking design of various subsystems of projects. As for ASCC, *Subcontractor Module* is one of the basic modules in the model. These two modules are completely similar to each other since engineering offices can be accepted as subcontractors of design projects. These two models was combined into one unique model as it can be seen in *Fig. 2*.

After the conceptual model was completed, MITOS was converted to a relational database software (*Fig. 3*). The database file was developed in *MS Access '95*, then converted to *MS Access 2000* and then the *help* and *content* files were prepared by *MS Access Help Workshop*. Finally, all the files were compiled and prepared for automatic setup process using *MS Access Developer Toolkit*. The software contains 95 tables, 218 queries, 87 reports, 373 forms and 400 macros.

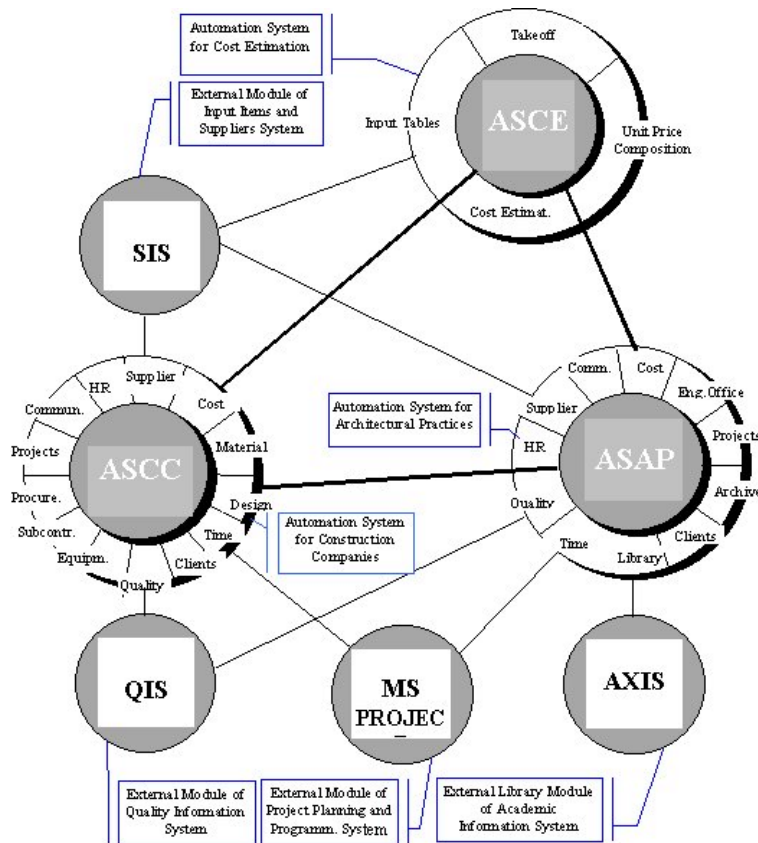


Fig. 1 Initial conceptual structure of MITOS (integration of components)

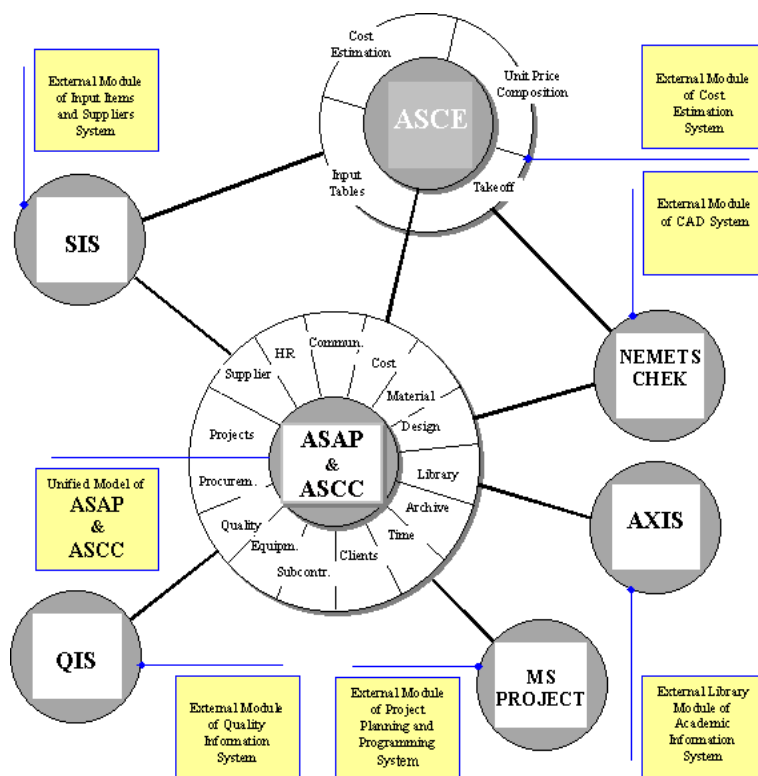


Fig. 2 Revised conceptual structure of MITOS (integration and unification of components)

MITOS was designed as an intranet application but it could have been developed for use as a web-based management tool. The current version of MITOS was developed using Access for Windows '95 that did not provide built-in tools to create web-based "html" screens. This sort of interfaces can be prepared by using some external software such as ASP (Active Server Pages) based software if desired. But, Access for Windows 2000 that appeared after the development of MITOS allows such interfaces to be added to the model. In other words, MITOS can be used as a web-based management tool with minor modifications after it has been upgraded to Access 2000. MITOS was not designed for the operational level transactions but as a data warehousing and data-mining tool. All transactions at operational level are carried out by external software packages and the documents including the detailed information are linked as OLE objects to the records in related modules of the model that contains summarized data.

Although integration provides facilities of electronic data flow and exchange, it carries the fragmented structure of construction industry to IS solutions. This type of an architectural solution sometimes may be something desired but sometimes may not. Users of the information system will face to hundreds of screens because of unnecessary duplication. Whereas it is possible to reduce the number of screens by half and remove the resistance of personnel that stems from the complexity of IS and volume of procedures to be learned. In addition to vertical unification of IS models, the architecture of the unified model should also be taken into consideration to minimize the number

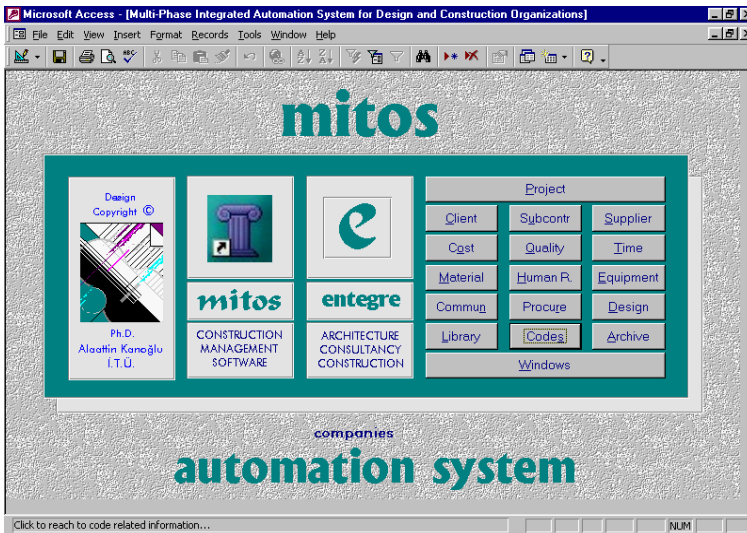


Fig. 3 Basic modules & start screen of MITOS

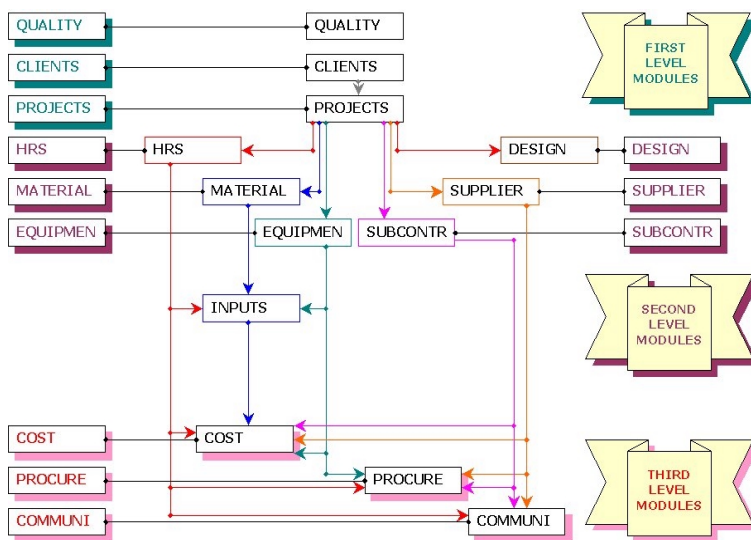


Fig. 4 Levels of modules and access to modules

of interfaces and simplify the transitions among them. MITOS tries to achieve this by suggesting a tree structure for the transitions that is too simple to learn and impossible to get lost in details. The structure and principals of these transitions are given in Fig. 4. As it can be seen in figure, the modules are grouped into three sequential levels. The modules at the third level, i.e., *Cost*, *Procurement* and *Communications* Management Modules, can be accessed by one (direct access), two or maximum three steps. Second level modules, i.e., *Hrs*, *Materials*, *Equipment*, *Design*, *Suppliers* and *Subcontractors* Management Modules are reached by one (direct access) or maximum two steps. First level modules, i.e., *Projects*, *Clients* and *Quality* Management Modules, can be accessed directly by one step. In each transition, selected entities such as project, personnel, equipment, material, supplier, subcontractor, etc., and their unique IDs are transmitted automatically to the succeeding modules as filter parameters. The same path followed forward is used backward and this is the simplest map for the users.

## 4. Basic Components of MITOS

### 4.1 ASAP: Automation System for Architectural Practices

Recent research studies seem to focus on conceptual and practical models organizing the information flow among project stakeholders. There are only few conceptual and practical models that were developed as a response to the needs in design stage. However, any comprehensive conceptual model especially designed for architectural offices could not be located in the literature. ASAP (Automation System for Architectural Practice) was developed for solving the information handling and management-related problems by taking into consideration the design process in architectural offices with a holistic look.

Information related to the drawing sheets, approvals of local authorities, required legal documents for projects can be organized in the model. Work hours of personnel, income-expense values and payment plans related to clients and engineering offices are defined for each project in related modules. Messages and meeting minutes recorded for each project can be accessed from the Projects Module. Engineering offices can be assigned to perform the design of subsystems and

contracts/specifications can be defined. The names of the components will be given in *Paragraph 4.2* as both model have same modules and use the same database objects, i.e., tables, queries, etc., after combining them into one unique model.

#### 4.2 ASCC: Automation System for Construction Companies

The model is the output of a research project [8] supported by TUBITAK (The Scientific and Technical Research Council of Turkey). The aim of the project was to develop a software model, i.e., management information system for construction firms. The model (ASCC) contains the basic components stated below. These modules are also basic modules for ASAP after unification.

- Projects Management Module,
- Clients Management Module,
- Subcontractors Management Module,
- Suppliers Management Module,
- Human Resources Management Module,
- Time Management Module,
- Design Management Module,
- Materials Management Module,
- Equipment Management Module,
- Cost Management Module,
- Communication Management Module,
- Quality Management Module,
- Procurement Management Module,
- Input Management Module.

#### 4.3 ASCE: Automation System for Cost Estimation

The variations in cost estimation sometimes may have remarkable values due to the effects of unforeseen factors related to basic parameters of *design* e.g., buildability or *construction* e.g., location of project, weather conditions and their effect on the productivity values of teams, problems related to procurement or availability of materials, labor and equipment in some locations etc. Any model should take into consideration the *construction* phase parameters in addition to *design* characteristics for more accurate estimating in design stage. Conceptual structure for the procedure of performance-based cost estimating systems is used for also *performance-based duration estimation* suggested for MITOS. Use of the same procedures and methods for different functions is another tool for *unification* at a different level. The module and its integration with the other modules are explained in detail in another study [9].

#### 4.4 External Modules

The external components stated in *Paragraph 3* undertake certain functions in the system and communicate with each other as illustrated in *Fig. 2*. MS Project and Nemetschek are commercially available software. The others were developed in the design process of MITOS.

### Discussion and Conclusions

This paper presents a relational database model (MITOS) that tries to achieve *unification* along with *integration* in development of the information systems of different participants, i.e., architectural offices and construction firms undertaking the roles at different parts of building production process. If it can be proved that the architecture of any IS model for the construction industry allows to achieve *unification* of information systems of different type organizations in a fragmented industry such as construction, this supports and serves to the *standardization* efforts that contains *unification* and *combination* dimensions in terms of IS solutions for the industry. MITOS proves that in a relational database environment that also provides data warehousing and data-mining utilities, *vertical unification* is also possible beyond the integration of IS models.

Combining the models developed for these organizations that seems to be different at first sight regarding to their basic functions, i.e., *design* and *construction*, begins to make sense when the

management-related functions in both type organizations and in both levels, i.e., *project* and *corporate* levels, are explored to be extremely similar with some minor exceptions. One of these approaches, i.e., *integration* and *unification* for the architecture of basic components of an automation system may be preferable in certain organizational patterns. Integration between these components is a common solution. What is new here is not *integration* but *unification* that means *combination* of the components into a unique model. Thus, same sort of information is possible to be recorded in one relational database object (table) instead of two, for *design* and *construction projects*.

In some organizational patterns such as “design and build,” *design* and *construction* functions are undertaken by separate departments of the firm. Management-related functions of the organization at project level should have horizontal (within any phase or organization) and vertical (between design and construction phases) relationships. This type of an organizational pattern can also be observed in partnering approaches. The pattern allows (and needs, as well) combination of information systems of an organization that undertakes the functions of two separate organizations. In other words, the combination of organizational functions is reflected to IS solution and the model presented in this paper (MITOS), proves that this claim is possible to be achieved in both conceptual and practical dimensions.

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