INFORMATION STRUCTURE FOR INTEGRATION OF FACILITY PROJECTS AT OPERATIONAL AIRPORTS

Facility projects at operational airports

J.P. NEEDHAM
Doctoral Student, Department of Engineering Management, The George Washington University, Washington, DC; Civil Engineer, Metropolitan Washington Airports Authority, Ronald Reagan Washington National Airport, Arlington, VA.
E.L. MURPHREE, Jr.
Professor of Engineering Management, Department of Engineering Management, The George Washington University, Washington, DC.

Durability of Building Materials and Components 8. (1999) *Edited by M.A. Lacasse and D.J. Vanier*. Institute for Research in Construction, Ottawa ON, K1A 0R6, Canada, pp. 2224-2233.

Abstract

Airport Organizations are faced with the increasingly complex task of integrating facility development projects with operational airport systems. Computer network systems present promising opportunities for meeting this challenge. The goal of improving the integration of airport systems is similar to the goal of computer-integrated construction in the Architectural, Engineering, Construction and Facilities Management (AEC/FM) industry. In the AEC/FM industry, researchers are applying object-oriented, graphical models as a basis for data exchange. In this research, an information structure for the relationship of facility projects with airport management and operations is formulated using graphical modeling. The purpose of this model is for application as an airport facilities and construction management, information reference and retrieval tool. A prototype implementation based on this work is located on the Internet at: http://www.host.trueserver.com/needham.

Keywords: airports, construction, facility management, information retrieval, information structure, graphical modeling, systems integration

1 Introduction

Airport Organizations that own, operate, develop and manage large commercial airports are responsible for integrating a complex set of inter-related systems and resources. Effective-and-efficient utilization-and-coordination of these systems and resources continues to gain importance given increasing levels of commercial aviation, the high cost of infrastructure improvements, and barriers to the expansion of airport facilities. Opportunities for improving the effective and efficient implementation of airport functions exist in the use of information management technologies. These opportunities are particularly evident in computer network

systems and associated communications, whose use in business applications is growing rapidly.

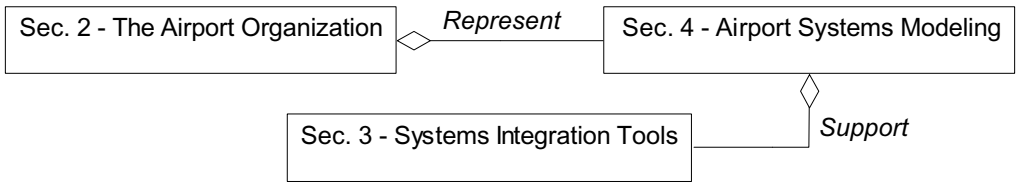

Fig. 1: Graphic model outlining the organization of this paper

The application of information management methods to classify and structure information required for the integration of facility projects at operational airport is the topic of a dissertation research project at The George Washington University, School of Engineering & Applied Science, Department of Engineering Management. Goals and objectives of this research are as follows:

a. Develop an information-structure representation for airport facilities and systems to improve information accessibility and integration of systems;
b. Identify and demonstrate a mechanism for detailing subject information;
c. Identify and demonstrate a mechanism for identifying subject relationships;
d. Provide a mechanism to assist in the identification of pertinent information;
e. Demonstrate an information management application prototype based on this research work; and
f. Identify methods that can be used within the developed information structure to improve organizational efficiency and effectiveness.

The organization of this paper parallels the methodology followed in the research effort: in Section 2, the airport organization's domain is described; in Section 3, systems integration tools are discussed; and in Section 4, the development of a systems model for airport organizations is presented. At the conclusion of the paper, pertinent findings of the research are summarized, and the status and location of the Internet-based, prototype implementation is given. Figure 1 outlines the organization of the body of the paper. The graphical models illustrated in this paper were developed using Rational ROSE-Student Edition, which is an object oriented software-engineering product of the Rational Software Corporation.

2 The airport organization

2.1 Business environment

Airport Organizations are one of three central business components that make up the operational portion of the United States commercial aviation industry. The other two are the commercial airlines and the Federal Aviation Administration (FAA). The ownership of airport organizations differ from the airlines and the FAA in that airports are traditionally owned by state and local agencies, whereas airlines are corporate entities and the FAA is part of the United States government. Numerous additional organizations and businesses are associated with or operate in support of commercial aviation. In North America *aviation activity has grown steadily*. From 1982 to 1992, growth was approximately 4.5 percent-per-year for passengers and 6.8 percent-per-year for cargo. (Kapur 1995) Forecasts are for

aviation activity to continue to grow, with rates estimated at 4.0 percent-per-year for domestic U.S. travel and 5.3 percent-per-year for international travel for the period from 1996 to 2007. (FAA 1996) Increased congestion at many airports has resulted from these increasing levels of activity. In response, *numerous airport development programs* are planned and being implemented across the U.S. in order to improve facilities and increase capacity. These programs, save a few exceptions, have been restricted by various physical, social, political and financial constraints to the expansion and improvement of existing airports. (Rutner et al. 1997; Inamete 1993) The implementation of facility projects at operational airports is complicated by the need to integrate the development with ongoing operations and existing systems. The airport organization as owner, operator, developer and manager of an airport facility holds the primary responsibility for implementation of airport projects.

2.2 Principle functions and locations

The *three principle functions* of an airport organization are: provision of traffic handling systems; provision of commercial services; and provision of operational services. (Ashford and Wright 1992; Kapur 1995; Wiley 1986) Airport functions can also be generally *classified based on their location* as follows: on the public or landside of the terminal; in the terminal and aviation service facilities; or on the airfield operating area (AOA). *This research* focuses primarily on the interface of facility development projects with the airport functions located on the landside of the terminal facilities. Airport landside traffic handling systems include roadways and traffic control, way-finding information, pedestrian routes, on-airport transportation, terminal curbside facilities, and employee parking. Landside commercial activities include parking, curbside services, taxi-service, car rentals, and off-airport transportation. Landside operational services include site management, maintenance, utility services, police, fire and rescue. The implementation of facility development projects will typically affect many of these airport functions.

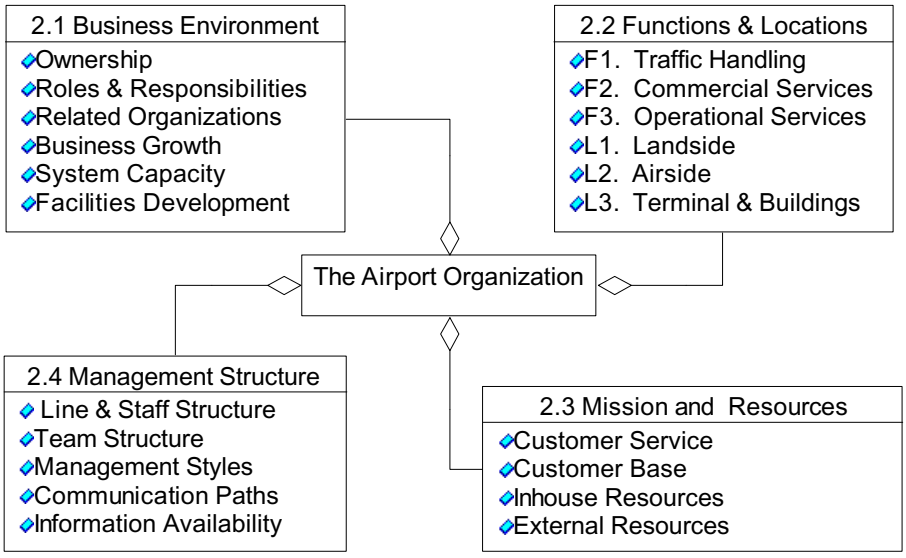

Fig. 2: Graphic model outlining the organization of Section 2

2.3 Organizational mission and resources

Provision of safe, efficient and responsive *customer service* is representative of a typical airport organization's mission. The *customer base* can be classified as consisting of passengers, senders, greeters, visitors and employees. A complicated mesh of in-house resources and contracted resources must be coordinated to meet customer demand. *In-house resources* are typically used for tenant management, management of business concessions, plant operations, facility project operations, maintenance operations, and for police and fire protection. Internal support is provided in the areas of human resources, finance, business services, engineering, public affairs, legal counsel, telecommunications and information systems. An *extensive array of resources external to the airport organization* is also required. Examples of external resources include: airline and cargo handling tenants; parking management and rental car business concessionaires; janitorial and landscaping service contractors; equipment vendors and material suppliers; and a variety of utility companies, engineering consultants, and construction contractors. Additional external resources include: federal agencies, such as the FAA and Postal Service; local public services, such as, public transportation, and water and sewer services; and a variety of interest groups and trade associations

2.4 Airport organizational management and communications

Formal communications and control within an organization are defined by the organizational structure and management style. The *line and staff structure* is commonly used by airport organizations. (Wiley 1986) This structure emphasizes vertical organizational relationships and is geared for stable business environments. (Moody and Premeaux 1993) The direct communications and rapid decision-making capabilities characteristic of line authority are combined with specialized staff that advise and assist the line function. There is a high degree of management flexibility and specialization, but internal conflicts between managers are likely. Effective communications and good working relationships can help minimize conflicts. The vertical structure is indicative of an autocratic or 'consultive' management style. (Miles 1975) These *styles* focus on work methods, and are characterized by formal communications that follow the chain of command in the form of directions passed down and feedback passed up. Information sharing between departments is permissible, although formal lateral communications at the lower levels of the organization are absent. Two-way communications can be utilized by management to help gain employee support for organizational objectives. In contrast, *organizational team structures*, such as the project and matrix structures, emphasize both vertical and horizontal organizational relationships. Team structures are geared towards more turbulent business environments. (Moody and Premeaux 1993) The inclusion of the horizontal structure is indicative of a human resource management style. (Miles 1975) This management style focuses on objectives, and is characterized by full availability of information, direct communication with lateral groups, and short feedback loops. Program and construction management consultants hired by airport organizations are likely to utilize a team structure. (Hendrickson and Au 1989) Within a large organization a variety of sub-structures and management styles are likely to be utilized and to change with time, which complicates the management process and the delineation of communications.

3 Systems integration tools

3.1 Systems integration

An Airport Automation Survey of computer systems was conducted by the Airports Association Council International, North America (AACI-NA) in 1992. Thirty-one U.S airports and two international airports were included in the survey. Results for three-of-the-five survey categories are summarized in Table 1. The two categories not shown here are financial management and hardware systems. It can be seen from the table that airport organizations use computer systems for a wide variety of applications. And although the trend for computer systems in general has been toward greater connectivity and interoperability, much work remains. The on going convergence of computing and communications, particularly in the area of network systems, however presents promising opportunities for increasing organizational effectiveness and productivity (Alter 1996; Laudon & Laudon 1996). The goal of improving the integration of airport systems through the use of information technologies is similar to the Architecture, Engineering, Construction and Facilities Management (AEC/FM) industry goal of computer-integrated construction. And in fact, there is a significant overlap of the airport industry and the AEC/FM industry, especially in the area of airport facility projects. Review of research directions and methods utilized within the AEC/FM industry shows compatibility and applicability to airport facilities work and to the overall airport organization.

Table 1: Airports with automated systems-33 surveyed (AACI-NA 1992)

Office Automation		Facilities Management		Operations Management	
Word Processing	33	Activity Statistics	24	ID Badges/Security	30
Spreadsheet	32	CAD/Engineering	23	Access Control	28
Database	28	Fire Alarm	21	Flight/Bag Information	21
Desktop Publishing	21	Building Energy Mgt.	20	Human Resources	15
Statistical Analysis	19	Lease/Property Mgt.	18	Incident Tracking	12
Electronic Mail	16	Maintenance Mgt.	16	Police Interface	10
Group Scheduling	16	Vehicle Maintenance	13	Airfield Lighting	9
Records Management	9	Construction Mgt.	11	Noise Complaints	9
Disaster Recovery	7	Fuel/UST Sensing	10	Baggage Handling	7
Document Mgt./		Travelers AM Radio	10	Police/Fire Dispatch	7
Imaging	6	GIS	8	Gate Scheduling	4
Executive Information	3	Central Plant	7	Vehicle Tracking	4
		Custodial Control	5	Taxicab Control	3

3.2 Systems integration research in the AEC/FM industry

The AEC/FM industry is characterized as a fragmented industry consisting of a large number of specialized firms and organizations. Vertical fragmentation exists between project phases, while horizontal fragmentation exists between the specialists within a phase. (Howard et al. 1989) In an effort to reduce this fragmentation, extensive research into the development of computer integrated systems has occurred. Examples of this research include overall strategies for computer integration (Teicholz and Fischer 1994). While work in specific areas includes the integration of cost and schedule data (Abudayyeh and Rasdorf 1991), the integration of design

information with construction planning (Parfitt et al. 1993), and integration of construction product and process information (Stumpf et al. 1996). Larger-scaled, integration research and development projects include: RATAS (Bjork 1994); COMBINE (COMBINE 1998); COMMIT (COMMIT 1998); STEP (ISO STEP 1998); and the International Alliance for Interoperability's - Industry Foundation Classes (IAI IFC's 1998). A central theme in these integration research studies is the need for common conceptual models upon which to base data exchange. Modeling related research includes the primitive-composite approach (Howard et al. 1992), construction process information models (Froese 1996), and construction methods modeling (Froese and Rankin 1998).

3.3 Graphical modeling

The purpose of conceptual modeling is to develop a logical view of a system's structure. In database design, conceptual modeling is an important part of the information level design process, which precedes the physical level design process. (Pratt and Adamski 1994) While both lexical and graphical conceptual modeling techniques are available, graphical modeling was chosen for use in this work based on the strength of the visible representations produced. (Schenck and Wilson 1994) Graphical models are able to capture organizational structure, detailed subject information and subject relationships, which are three of the goals of this work. The two principle modeling techniques, which are similar in nature, are the entity-relationship model and the object-oriented model. The entity-relationship technique is formally defined and is used by designers of relational databases. The object-oriented model has not yet achieved a comparable level of conformance in practice, but has gained popularity based on its strength for matching data objects to real world components and processes. (Ryan and Smith 1995; Reingruber and Gregory 1994) Primarily for this reason, the object-oriented Unified Modeling Language (UML), a part of Rational ROSE, was chosen for use. In addition, student edition software and ample documentation is available, and it is likely that UML will become an industry standard. (Rational Software 1998)

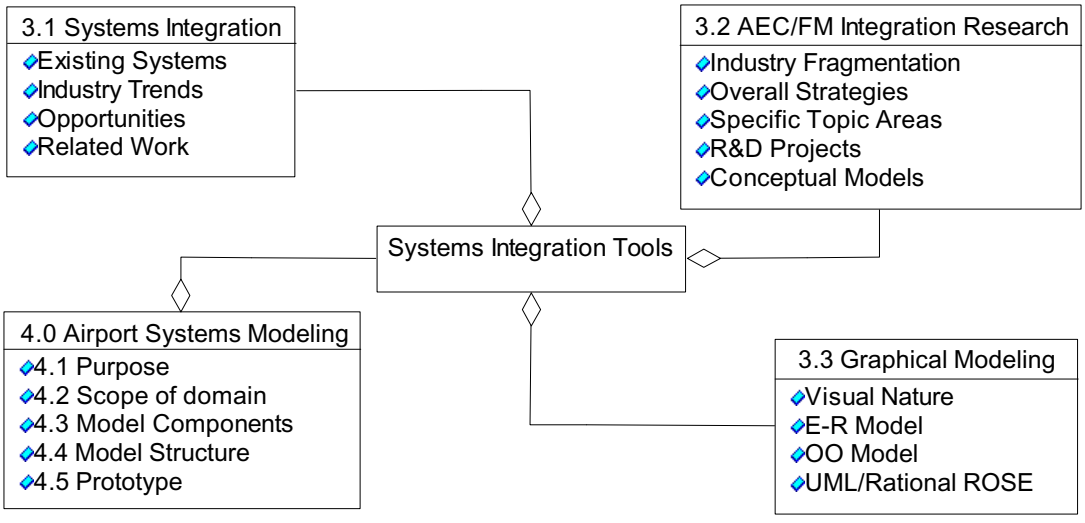

Fig. 3: Graphical model outlining the organization of Sections 3 and 4

4 Airport systems modeling

4.1 Model purpose

The *purpose* in preparing a graphical model of an airport organization's domain is for use in the development of an information reference and retrieval tool. The *underlying premise* is that representation and network computer implementation of subject and subject inter-relationship information used in facilities and construction management can be used to improve the quality of project implementation by reducing variations in operational, administrative, contractual and technical processes and products. The *objective* is to improve the organization's ability to identify and access pertinent information. The *aim* of the information model is for inclusion in the airport organization's Intranet system.

4.2 Model scope - the domain

Facility projects and project management at operational airports are subsets of the overall facility and organizational management structure, respectively. Therefore modeling of the overall information system structure is necessary to attain the full potential for improved systems integration. In other words, facility operations personnel, project development personnel, and management can reduce variations in work, and thereby improve organizational efficiency and effectiveness by improving the information set which they share. Accordingly, Figure 4 is a graphical representation of 'Level 1' of the information system model. The primary subject area being developed within the model is the interface of airport landside projects with operational airport facilities. A pedestrian tunnel project is being used to depict specific instances with which to validate and further refine the model.

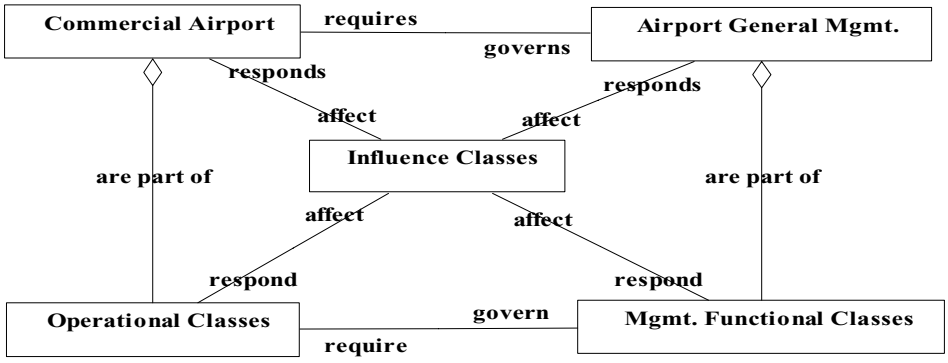

Fig. 4: Airport systems model - Level 1

4.3 Model scope - the model components

The components included in the modeling of airport systems include object classes, relationships, attributes and sample class instances. Types of relationships used in the model are associations, aggregations, and generalizations. Several 'use case diagrams' are also included as part of the systems modeling effort to illustrate specific organizational process interactions, along with the participating 'actors'. Modeling components not included in this research project include sequence diagrams, class operations and object behavior.

4.4 Model Structure

The model structure is partitioned in a hierarchy of model groups as follows:

Level 1- Model of the overall airport system;

Level 2- Models of the top level systems represented in Level 1;

Level 3- Models of the major classes represented in Level 2;

Level 4- Models of the object classes represented in Level 3; and

Level 5- Instantiation of model classes (Pedestrian Tunnel Project Example).

Object classes, objects, object instances, attributes, and object relationship are depicted graphically by the model. As an example, the 'Project Management Functional Class- Level 2' model is shown in Figure 5.

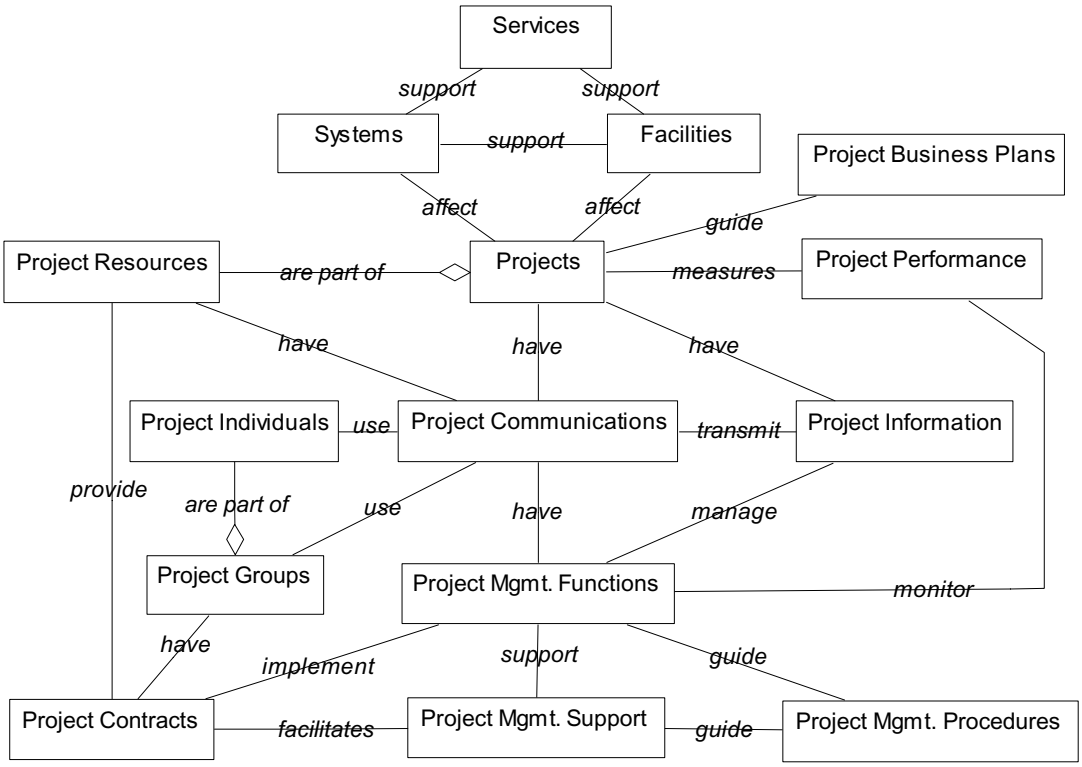

Fig. 5: Project management functional class model - level 2

4.5 Prototype implementation

A web-based prototype is being implemented which uses the model structure as the 'site map' for navigating and locating information. The site was developed using Microsoft FrontPage 98 and is located at: http://www.host.trueserver.com/needham. The size of the model partitions and corresponding web pages have been controlled so that each 'model page' can be viewed with relative convenience using a web browser. The web pages were developed by 'pasting" the model partitions and adding hyperlinks. The prototype illustrates the use of a web browser as a means for activating graphical models, however it is limited in that the model is only partially developed and a database for instantiation of the model has not yet been developed.

5 Discussion

The goal of this research is to develop an information reference and retrieval tool that can be used by Airport Organizations to improve the project information management process. The research has focused on two aspects: first, the development of a conceptual information structure; and second a prototype implementation of the information structure. The background for the information structure was gained through research and experience with airport development projects. The top-down approach was taken in developing the model structure, however it is not expected or necessary that the entire model be detailed. Rather, the portion of the model of interest is that related to project operations and management, and the associated relationships with general management and other functional management areas. Three keys to validating the model are: ensure the scope of model is complete; check that object categories are appropriate and correctly detailed; and check that relationships are accurate and complete. A long-term, on going airport 'Pedestrian Tunnel' project is being used to help detail and validate the model. This amounts to a bottom-up approach for checking and detailing the model. The next step for validation of the model is for a sample group of the airport project personnel to review and critique the web-based prototype. The prototype is to have two primary features: first, the graphical components of the information structure are used for site navigation; and second a test-database for instantiation of objects. The navigational feature of the site is operational and demonstrates the general organization of the information structure developed. However, before operational testing by the sample group can begin the addition of a test-database is planned. The research methodology being followed does appear to hold promise given current opportunities with the development of organizational Intranet and Internet sites, and further development and testing is on going. Comments regarding the web site are welcome and can be made using the Email form available at the site: http://www.host.trueservercom/needham.

6 References

Abudayyeh, O. and W.Rasdorf (1991) "Design of Construction Industry Information Management Systems", J. of Construction Eng.&Mgt, Vol. 117, #4, Dec. 1991.

Airports Association Council International, North America. (1992) "Airport Automation Survey," Washington, D.C., June 26, 1992. pp. 3-5.

Alter, Steven (1996) Information Systems, 2nd ed., The Benjamin/Cummings Publishing Company, Inc., Menlo Park, CA. pp. 23-25.

Ashford, N. and P.Wright (1992) Airport Engineering, 3rd ed., John Wiley & Sons New York, NY.

Bjork, B (1994) "RATAS Project-Developing an Infrastructure for Computer-Integrated Construction", J. of Computing in Civil Eng., Vol. 8, #4, Oct. 1994.

COMBINE (1998), 'Computer Models for the Building Industry in Europe', http://erg.ucd.ie/combine.html.

COMMIT (1998), 'Construction Modeling and Methodologies for Intelligent Information Integration', www.salford.ac.uk/iti/projects/commit/commit.html.

FAA (1996) Federal Aviation Administration-Aviation Forecast 1996 - 2007, www.faa.Gov /APA/INTERCOM/1996/MAR19/COMM.HTM.

Froese, Thomas (1996) "Models of Construction Process Information", Journal of Computing in Civil Engineering", Vol. 10, #3, July 1996.

Froese,T., and J.Rankin (1998) "Construction Methods in Total Project Systems", Proceeding of the 1998 ASCE International Computing Congress, Boston MA.

Hendrickson, Chris and Tung Au (1989) Project Management for Construction, Prentice Hall, Englewood Cliffs, NJ.

Howard, H., R.Levitt, B.Paulson, J.Pohl and C.Tatum (1989) "Computer Integration: Reducing Industry Fragmentation in AEC Industry", Journal of Computing in Civil Engineering, Vol. 3, #1, Jan. 1989.

Howard, H., J.Abdalla and D.H.Phan (1992) "Primitive-Composite Approach for Structural Data Modeling", J. of Computing in CE, Vol. 6, #1, Jan. 1992.

IAI IFC's (1998), International Alliance for Interoperability-Industry Foundation Classes, http://iaiweb.lbl.gov/enduser.htm.

Inamete, Ufot (1993) "Key Elements in Managing Airports", International Journal of Public Sector Management, Vol. 6, #5.

ISO STEP (1998), International Organization for Standardization, Standard for Exchange of Product Data, www.nist.gov/sc4/step/parts/part106

Kapur, Anil (1995) Airport Infrastructure, The World Bank, Washington, DC.

Laudon, Kenneth, and Jane Laudon (1996) Management Information Systems, 4th ed., Prentice Hall, Upper Saddle River, NJ. pp. 365-366.

Miles, Raymond (1975) Theories of Management: Implications for Organizational Behavior and Development, McGraw-Hill Publishing Company, NY, NY.

Moody, Wayne and Shane Premeaux (1993) Management: Concepts, Practices and Skills, 6th ed., Allyn and Bacon, Needham Heights, MA.

Parfitt, M.K., M.G.Syal, M.Khalvati and S.Bhatia (1993) "Computer-Integrated Design Drawings and Construction Project Plans", Journal of Construction Engineering & Management, Vol. 119, #4, Dec. 1993.

Pratt, Philip and Joseph Adamski (1994) Database Systems Management and Design, 3rd ed., CTI, Cambridge, MA. pp. 245-247.

Rational Software (1998) http://www.rational.com.

Reingruber, Michael and William Gregory (1994) The Data Modeling Handbook, John Wiley & Sons, Inc., New York, NY, pp. 342-343.

Rutner, Stephen, Ray Mundy and Jonathan Whitaker (1997) "Alternatives for Reducing Delays at the United States' Busiest Airports", Transportation Journal, American Society of Transportation & Logistics, Spring 1997.

Ryan, Nick and Dan Smith. (1995) Database Systems Engineering, International Thomson Computer Press, London, UK, p. 388.

Schenck, Douglas and Peter Wilson (1994) Information Modeling the EXPRESS Way, Oxford University Press, New York, NY, p. 28.

Stumpf, A.L., R.Ganeshan, S.Chin, L.Y.Liu (1996) "Object-Oriented Model for Integrating Construction Product and Process Information", Journal of Computing in Civil Engineering, Vol 10, #3, July 1996.

Teicholz, Paul and Martin Fischer (1994) "Strategy for Computer Integrated Construction", J. of Construction Eng. & Mgt, Vol. 120, #1, March 1994.

Wiley, John (1986) Airport Administration and Management, Eno Foundation for Transportation, Inc., Westport, Connecticut.