THE DESIGN OF AN INFORMATION SYSTEM FOR TECHNOLOGY COMPANIES' COMPLIANCE WITH ISO 9000 QUALITY STANDARDS

by

Yangsong Li

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Dr. Wallace Carlson Research Project Advisor

The Graduate College
University of Wisconsin-Stout
April 200

The Graduate College
University of Wisconsin-Stout
Menomonie, Wisconsin 54751

ABSTRACT

Li	Yangsong			
(Writer) (Last Name)	(First)	(Middle)	(Initial)	

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The need for information systems that assist management has been increasing due to escalating global competitive pressures, which make the process of production more complex and product cycles shorter. In addition, compliance to international standards (such as ISO 9000 quality standards) has become a requirement for more and more technology companies.

The purpose of this study is to design an information system for technology companies that will comply with ISO 9000 quality standards. The researcher will identify information system structure and the information needs for technology companies, and

then describe a development model for a technology company information system based on ISO 9000: 1994. For the purpose of this study, the researcher will address the application of the development model by using three ISO 9000 elements to analyze the requirements and develop logical designs. There are examples of the compliance to ISO 9000 elements provided.

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Chapter I

INTRODUCTION

Introduction to this study

The need for information systems that assist management has been increasing due to greater global competitive pressures, which make the process of production more complex and product cycles shorter. In a time when the fast-changing global market requires technology companies to adapt quickly, traditional paper-based information systems have found difficulty meeting this challenge. Paper-based information systems are difficult to change, requiring significant time and expense. For these reasons, responsive and adaptive information systems are the key solution for technology companies.

To meet the need of technology companies, the structure of an information system should be identified, and the most appropriate information system should be selected. It is very important to design an information system, which is cost effective and flexible to allow fast changes at low cost.

International standards compliance is also becoming a requirement for more and more technology companies. For example, the ISO 9000 series of quality system standards have been used by more and more companies to control the quality of products and services and has been increasingly required by many distributors. Many technology companies' customers expect ISO registration body certification. This study is to design an information system for technology companies which will be in compliance with ISO 9000 elements.

Statement of the study

The purpose of this study is to design an information system for technology companies which will be in compliance with ISO 9000 quality standards.

Needs for the study

This study will be beneficial to technology companies that are doing the following: evaluating information systems as effective management tools, considering changing from traditional information systems to more responsive and adaptive information systems, or evaluating information systems as a means of compliance with international standards.

Objectives

1. To identify information system structure.
2. To identify a technology company's information system needs.
3. To identify the types of information which technology companies require.
4. To describe a development model for a technology company's information system based on ISO 9000 quality standards.
5. To describe the application of the development model using three of the twenty elements of ISO 9000:1994 and give some examples.

Limitations of the study

1. Limited to the researcher's time and resources.
2. Limited to the available body of knowledge.

Assumptions of the study

The following assumptions underlie this study. It is assumed that:

1. Technology companies have identified the information system's structure.

2. Technology companies are evaluating a change of the information system's structure.
3. Technology companies have unique classes of information needs.
4. The information system identified in this study will assist technology companies in achieving compliance with ISO 9000 quality standard elements.

Definitions

E-Commerce – Electronic Commerce is the use of inter-networked computers to create and transform business relationships.

Enterprise Resource Planning (ERP) –An all-encompassing enterprise-wide information system that lets distributed data be shared throughout the enterprise.

ISO 9000 – International Organization for Standardization, founded in 1946, is a federation of more than 130 member countries that promotes the development of international standards to facilitate world trade. The ISO 9000 series identifies the basic disciplines of a quality management system that can be used by manufacturers, suppliers, distributors and end users. It specifies the national, regional, and international accepted procedures and criteria that are required to ensure that products and services meet the customers' requirements.

Information System – Any telecommunications and/or computer related equipment or interconnected system or subsystems of equipment that is used in the acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of voice and/or data, and includes software, firmware, and hardware.

Local Area Network (LAN) – Data communications network that connects workstations, peripherals, terminals, and other devices in a single building or other geographically limited area.

Logical Data Structure (LDS) – "A Logical Data structure, or LDS is a graphical data model- that is, a diagram depicting what kinds of data some person or group wants to remember." (Carlis & Maguire, 2000 p. 4). LDS is a tool for database logical design, serving as a bridge between the concepts that make up real-world events and processes and the physical representation of those concepts in a database.

Reengineering - The complete restructuring of an existing system that is the introduction of fundamental rethinking and radical redesign of processes to bring about dramatic improvements in performance.

Supply Chain - "A supply chain is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers." (Ganeshan & Harrison, 1995. Retrieved April 25, 2001 from the World Wide Web: http://silmaril.smeal.psu.edu/misc/supply_chain_intro.html). Supply Chain describes all the activities related to the acceptance of an order from a customer and fulfilling it.

Technology Company – A company that has a specific technology focus and expertise to produce or process its products to meet the customers' needs.

Wide Area Network (WAN) – Data communications network that serves users across a broad geographic area and often uses transmission devices provided by common carriers.

Chapter II

REVIEW OF LITERATURE

Introduction

This chapter reviews topics, concepts, and keywords relative to information systems and ISO 9000 quality standards. This information is provided to support the findings in chapter IV. This chapter is divided into four sections.

- The first section reviews information systems from the 1950's.
- The second section analyzes today's challenges of technology companies.
- The third section identifies the classification of information systems.
- The fourth section reviews ISO 9000 quality standards.

Information system from the 1950's

An information system is a specialized type of system and can be viewed in a number of different ways. One view is that an information system is a set of inter-related components working together to collect (input), manipulate (process), store and distribute (output) data and information to support decision-making and control in an organization (Turban, McLean, & Wetherbe, 1999). An information system contains three basic functions: input, process and output data. Data is collected and processed into information or knowledge by the information system, which is to support decision-making or to be shared by users. Data refer to the elementary description of things, events, activities, and transactions that are recorded, classified and stored, but not organized to convey any specific meaning. Information is data that have been organized so that they have meaning and value to recipient. Knowledge consists of data or information that have been organized and processed to convey understanding, experience,

accumulated learning, and expertise as they apply to a current problem or activity (Turban, et al., 1999).

Information systems existed long before the 1950's. Construction of the wonders of the ancient world such as the Chinese Great Wall and the Egyptian pyramids, must have been supported by information systems. However, information systems were significantly changed since the computer was invented in the 1950's, for the computer is an idea tool for the storage, process and retrieval of data. A computer based information system is composed of hardware, software, databases, telecommunications, people, and procedures that are configured to collect, manipulate, store, and process data into information or knowledge (Stair, 1992).

Computer based information systems can be traced back to the 1960's, while management information systems (MISs) were developed to produce reports such as a daily list of employees and their work hours or a monthly report of expenses as compared to a budget. In the 1970's, the early stage of office automation system (OAS) was developed to assist word processing and electronic communication. At about the same time, computers were introduced to manufacturing environments such as computer-aided design and manufacturing (CAD/CAM). In the 1980's, information systems were developed dramatically and used by government, industry, education, and even agriculture. It touched most aspects of the operation in a whole organization, from accounting and finance to marketing, manufacturing, and human resources management. The philosophy of Computer-integrated Manufacturing (CIM) was adopted by manufacturing companies at the same time. An integrated computer information system could be implemented to support all the functions of an organization. Along with new

management philosophies and emerging technology, Enterprise Resource Planning (ERP) was developed to provide a link between the new management philosophies and the information system technology. The ERP information system may provide a tool to unite the various functions within the organization into a whole effective organization striving to achieve the common goal with the same level of resources (Turban, et al., 1999).

In the 1990's, the Internet, a global network of computer networks that grew out of an experimental project of the Advanced Research Project Agency (ARPA) of the U.S. Department of Defense, linked the information superhighways and systems across all over the world and initiated the coming of the information age. The Internet eliminates the constrains of time and distance in operating a business, making company information available worldwide (Korper & Ellis, 2000). The information needed to transact business can flow freely anywhere, anytime, to customers, suppliers and trading partners. It is changing the way people do business and live. The World Wide Web, a vast collection of interconnected pages of information that are stored on computers around the world and are connected to the Internet, became the most extensive information source. Web based information systems were integrated into the ERP information system. Supply chain management (SCM) was developed in the late 1990's. Information systems in a technology company involve not only the company that produces the product or the service, but also its suppliers and customers worldwide. It reinvents the way technology companies do business by changing ways to distribute goods and collaborate within the company and with suppliers (Korper & Ellis, 2000).

Challenges for today's technology companies

A technology company is a broad definition, which refers to a company that has a specific technology focus and expertise to produce or process its products to meet customers' needs. For example, Cisco Systems Inc., the largest Internet hardware provider, has a mission of shaping the future of the Internet by creating unprecedented value and opportunity for their customers, employees, investors, and ecosystem partners (http://www.cisco.com). Amazon.com, the largest online bookstore, has a mission of using the Internet to transform book buying into the fastest, easiest, and most enjoyable shopping experience possible (http://www.amazon.com). General Motors Corp., the world's largest automotive corporation, has a vision to be the world leader in transportation products and related services (http://www.gm.com).

Technology companies are particularly and increasingly influenced by changes in business environment. To understand the challenges of today's technology companies, it is useful to review the major business environmental factors that create pressures on the technology companies. The business environment consists of many technological, social, economic, legal, physical, and political factors that all affect business activities. Significant changes in any part of this environment are likely to create pressures on technology companies (Turban, et al., 1999). In this chapter, changes in the following factors will be described: technology, society, and market, because information systems have been developed to assist technology companies to meet those challenges.

Technologies are changing. New and improved technologies improve productivity, increase efficiency, create or support substitutes for products, alternative service options, and superb quality. New technologies make product cycles shorter because the substitute

for the old products comes out faster (Turban, et al., 1999). Thus, technology accelerates competitive forces. Many technologies affect technology companies in areas ranging from materials and genetic engineering, to metallurgy and transportation. However, the technology with the greatest impact is information technology (Dertouzos, 1997). Information technology allows technology companies to store huge amounts of information in an easy-to-access yet small space. It can perform high-speed, high-volume, numerical computations, much less expensively than when done manually. It increases the effectiveness and efficiency of people working in groups in one place or in several locations when the information system is integrated with the telecommunication network. It provides high-speed, accurate, and inexpensive communication within and between organizations, and it allows quick and inexpensive access to vast amounts of information worldwide. For all these reasons, information technology becomes the major facilitator of technology companies. With the increasing amount of information available to technology companies from the Internet and other telecommunication networks, the accessibility, navigation, and management of data, information, and knowledge, which is necessary for managerial decision-making, becomes critical (Turban, et al., 1999).

Societies are changing. The impact of social pressures is on the increase. The impact can be divided into social responsibility and government regulations. Social responsibilities include environmental control (pollution, noise, trash removal, and animal welfare); health, safety, and social benefits to employee; employee education, training, and retraining; marketing fairness and truth; privacy and ethics; and equal opportunity (Turban, et al., 1999). Information systems can assist technology companies to deal with those social responsibilities. For example, Boeing, the industry's leader in

the manufacturing of airplanes, applies electronic training programs to implement employee education, training, and retraining. By moving the training programs online, employees in Boeing can get the updated training from any location at any time. Boeing estimates that by using its computer-based training program online, it saves approximately 25 percent of the training costs. (Mermon, 1996). Several social responsibility issues are related to government regulations regarding health, safety, environmental control, and equal opportunity. Some regulations not only cost money but also make it more difficult to compete with counties that lack such regulations (Turban, et al., 1999). To cut the costs of environmental, health, and safety (EHS) and comply with local, state, or federal regulations, some companies developed information systems for environmental management. Those information systems provide adequate, timely information with which to make decisions, leading to the elimination of unnecessary environmental expenses through the adoption of pollution prevention initiatives and best manufacturing practices. For example, EarthSoft Inc. developed Environmental Quality Information System (EQuIS) to provide environmental data management solutions for chemical and petroleum industry.

The global markets are changing. A global economy and strong competition, a unique work force, and powerful consumers can characterize today's market. The stabilized world political environments have created the foundation necessary for a global economy. Telecommunications and the Internet accelerate this globalization and open the door to a large number of buyers, sellers, and competitors worldwide. Rapid and inexpensive communication and transportation modes increase the magnitude of international trade (Turban, et al., 1999). Previously confined within an industry or a

region, competition is now becoming global. A large number of companies face competition from products created in countries where labor and other costs are low or where there is an abundance of natural resources. However, some large companies have taken advantage of low-cost production in developing counties and high product price in developed country to earn the highest profits. On the other hand, the Internet and electronic commerce bring customers information about products, price, and quality comparisons, which increase the competition (Turban, et al., 1999). Consumers are demanding more detailed information about products and services. They want to know, for instance what features are available, what warranties they will receive, and what financing is available. Information expectations increase as consumer become more knowledgeable, and companies need to be able to deliver information quickly to satisfy these customers. Customers want customized products, at high quality, and low prices. For example, Dell computers will take the order of the computer of your choice over the Internet and deliver it to your home within 72 hours. The increased competition forces companies to look for better ways to do business, and IT is frequently evaluated as a potential solution. The success of companies doing business in a competitive global environment depends on the alignment of the information system and the global business strategy. (Ive & Learmouth, 1993)

The environments that surround technology companies are increasingly becoming more complex and turbulent. The pressures on technology companies are increasing and technology companies must take responsive actions. In addition, technology companies may see opportunities in these pressures. Information systems can assist technology companies to accomplish and meet those challenges.

Classification of information systems

In order to understand how information systems can assist technology companies to meet today's challenges, it is necessary to review the classification of information systems. Information systems can be classified in several ways: organizational levels, major functional areas, support provided, and the Information System (IS) architecture (Turban, et al., 1999). Regardless of how they are classified, the structure of these systems is the same because each contains hardware, software, data, procedures, and people (Stair, 1992). The researcher will describe three ways to classify information systems in this section.

One way to classify information systems is according to organization structure. Organizations are made up of components such as departments, teams, and work units. For example, a technology company may have a human resources department, accounting department, engineering department, and information technology department. These components form an organization that may report to a higher organizational level, such as a division or a headquarters, in traditional hierarchical structures. Although some organizations are reengineering themselves into innovative structures, such as those based on cross-functional teams, today the vast majority of organizations still have a traditional hierarchical structure (Turban, et al., 1999).

Typical information systems that follow the organizational structure are departmental, enterprise-wide, and inter-organizational. In the departmental information system, a technology company uses several application programs in one functional area or department. For instance, in managing human resources, it is possible to use one program for screening applicants and another for monitoring employee turnover. Some of the

applications might be completely independent of each other; whereas, others are interrelated. The collection of application programs in the human recourses area is called a human resources information system. This refers to as a single departmental information system even despite containing several application subsystems. While departmental information systems are usually only related to one functional area, enterprise information systems are the collection of all departmental information systems. The SAP (a leading ERP software vender) enterprise information system is an example of an enterprise-wide information system. It integrates several departmental information systems such as accounting, marketing, human resources, and engineering into a single information system. Inter-organizational systems connect several organizations, are common among business partners, and are extensively used for electronic commerce. For example, the worldwide airline reservation system is composed of several systems belonging to different airlines (Turban, et al., 1999).

Information systems can also be classified by the function they perform. The major functional information systems are: accounting, finance, manufacturing (operations/production), marketing, and human resources management (Turban, et al., 1999). The accounting information system supports accounting information flow; collects sales data and other relevant data such as advertising and promotions, merchandise and cash flow. It improves the accounting procedures, and helps functional managers make quicker and better decisions. The finance information system supports finance management, like fund investment and stock exchanges. The manufacturing information system supports manufacturing management and manufacturing, such as Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) and Total Quality

Management (TQM). The marketing information system supports marketing and sales. Amazon.com is a good example of an information system being used for marketing and sales. The human resources management information system supports the human resources management, such as recruiting, training, and payroll management. In each functional area, some routine and repetitive tasks exist that are essential to the operation of the organization (Turban, et al., 1999).

A third way to classify information systems is according to the type of support they provide, regardless of the functional area. For example, an information system can support office workers in almost any functional area and managers, regardless of where they work, can be supported by a computerized decision-making system (Stair, 1992). The major types of systems under this classification are: transaction processing system (TPC) supports repetitive, mission-critical activities and clerical staff. Management information system (MIS) supports functional activities and managers. Office automation system (OAS) supports office workers. Decision support system (DSS) supports decision making by mangers and analysts. Executive information system (EIS) supports executives. Group support system (GSS) was initially developed to support key people meeting together to make decisions in a common location. It was expanded to allow those people to communicate from different remote locations (through a variety of media) to make their decisions. Intelligent support system (ISS) mainly supports knowledge workers, but can support other groups of employee (Turban, et al., 1999).

ISO 9000 quality standards

The researcher will review ISO 9000 quality standards in the last section of this chapter. ISO short for International Organization for Standardization and founded in

1947, is a worldwide federation of national standards bodies from some 130 countries (one from each country) that promotes the development of international standards which facilitate the international exchange of goods and services, and develop cooperation in the spheres of intellectual, scientific, technological, and economic activity. The standards include interface standards, protocol standards, and quality standards (http://www.iso.ch). The ISO 9000 series of quality standards are an international consensus on good management practices with the aim of ensuring that the organization can consistently deliver the product or services that meet the client's quality requirements. These good practices have been distilled into a set of standardized requirements for a quality management system, regardless of what the organization does, its size, or whether it's a private, or public organization. Directives of the ISO require that all standards be reviewed every five years, but the majority of the changes were for the purposes of clarification (Paradis & Small, 1996). The researcher will focus on the 1994 revision of ISO 9000 in this paper.

There are five Standards in the basic ISO 9000: 1994 series. These five Standards are either conformance models or guides. A conformance model is a Standard to which your organization must conform in order to be certified. A guide is a set of recommendations concerning the establishment of an effective quality system in order to be certified in one of the conformance models. Each standard is listed and described in Figure 2.1 ISO 9000 Standards List and Table 2.1 ISO 9000 Standards Description.

Figure 2.1

ISO 9000 Standards

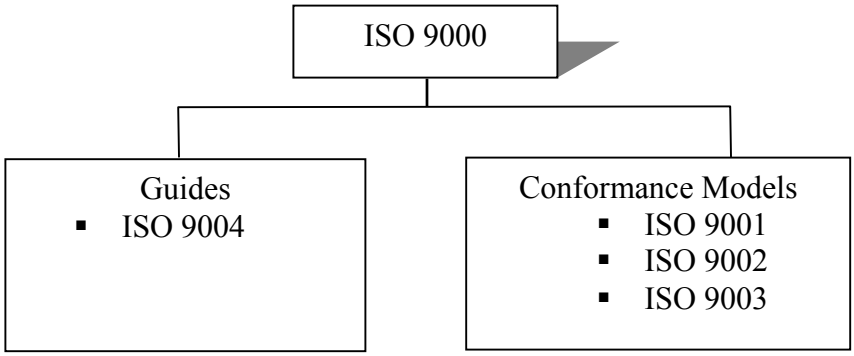


Table 2.1

ISO 9000 Standards Description

Type of Standard	Name of Standard	Description of Standard
Conformance Model	ISO 9001	Quality assurance in design/development, production, installation, and servicing.
	ISO 9002	Quality assurance in production, installation, and servicing.
	ISO 9003	Quality assurance in final inspection and test.
Guide	ISO 9000	Guidelines for selection and use of the standards on quality management, quality system elements, and quality assurance.
	ISO 9004	Guidelines for quality management and quality system elements.

(Paradis & Small, 1996)

ISO 9001 is for organizations that design, produce, install, and service products; it contains twenty elements. ISO 9002, for organizations that produce, install, and service products, contains nineteen elements of the twenty. ISO 9003 is for organizations that assure quality through final inspection and testing, and it contains sixteen elements of the twenty. Table 2.2 ISO 9000 Standards Elements lists the twenty sections of the Standard and identifies which ISO 9000 conformance model covers these elements.

Table 2.2
ISO 9000 Standards Elements

Sections	ISO 9001	ISO 9002	ISO 9003
4.1 Management Responsibility	●	●	●
4.2 Quality System	●	●	●
4.3 Contract Review	●	●	●
4.4 Design Control	●		
4.5 Document and Data Control	●	●	●
4.6 Purchasing	●	●	
4.7 Control of Customer Supplied Product	●	●	●
4.8 Product Identification and Traceability	●	●	●
4.9 Process Control	●	●	
4.10 Inspection and Testing	●	●	●
4.11 Control of Inspection, Measuring, and Test Equipment	●	●	●
4.12 Inspection and Test Status	●	●	●
4.13 Control of Nonconforming Product	●	●	●
4.14 Corrective and Preventive Action	●	●	●
4.15 Handling, Storage, Packaging, Preservation, and Delivery	●	●	●
4.16 Control of Quality Records	●	●	●
4.17 Internal Quality Audits	●	●	●
4.18 Training	●	●	●
4.19 Servicing	●	●	
4.20 Statistical Techniques	●	●	●

(Paradis & Small, 1996)

These twenty elements will be briefly overviewed as the following:

1. Management Responsibility

The Standard requires that management shall provide for a quality policy, assignment of responsibility and authority to personnel, resources of a management representative, and a management review for the suitability and effectiveness of the quality system (Paradis & Small, 1996). A job description, position description, or authority and responsibility statement for all people whose work affects product quality is required (Beaumont, 1996).

2. Quality System

The standard requires that the organization keep an updated set of documents to control and direct all work activities affecting product and service quality. Carry out day-to-day work in accordance with these documents. Prepare a Quality Manual, identify and acquire the resources and skills needed to achieve the required quality, update and improve procedures, and identify and prepare quality records (Beaumont, 1996).

3. Contract Review

The standard require that the organization shall review contract or accepted order with the customer to ensure that customer requirements are adequately defined, and the organization has the capability to meet these needs and keep records of these contract reviews (Paradis & Small, 1996).

4. Design Control

The organization shall provide a design procedures manual. The design procedures must be based on fulfillment of the design specification. Realistic and current plans for design and development projects must be created, documented, and maintained. Assign qualified

people to the design and verification work, based on their experience, education, or training. Provide adequate resources to the people doing the work. Design control includes design input, design out, design verification and design change. Maintain an orderly procedure for controlling design changes. This procedure must require the identification, documentation, review and approval of all design changes (Beaumont, 1996).

5. Document and Data Control

The organization shall control all the quality system documents and data to ensure availability of documented information to those requiring it (Paradis & Small, 1996). Provide workers up-to-date, authoritative documents and control document changes (Beaumont, 1996).

6. Purchasing

The organization shall ensure that the purchased product conforms to specified requirements. Establish and use approved suppliers lists based on product quality requirements, as well as a history of the supplier to consistently fulfill these needs. This performance history will give an indication as to whether or not quality management regarding the suppliers is effective. Maintain a written record of the approved suppliers. With the prior permission, the customer may verify, either at the supplier's location or at the receiving area, if the material or services that have purchased conform to specification or not (Beaumont, 1996).

7. Control of Customer-Supplied Product

The organization shall provide for verification, storage, and maintenance of customer-supplied products provided for incorporation into the product. If the customer-supplied

product damaged or is unsuitable for use, the organization must report it to the customer and a record must be kept (Beaumont, 1996).

8. Product Identification and Traceability

The organization shall provide any necessary identification and traceability of incoming materials, in-process product, and finished products. This identification must be recorded as a Quality Record (Beaumont, 1996).

9. Process Control

The production, installation, and servicing processes are operated under controlled conditions. When the quality of work can only be verified by destructive testing or prolonged use of the product, then special attention must be paid to how the work is carried out. Keep records of how the work is carried out, what equipment was used, and who did the work (Beaumont, 1996).

10. Inspection and Testing

The organization shall ensure that an incoming product is verified for conformance to specified requirements, an in-process product is inspected and tested as necessary, and finished product is verified as conforming to specified requirements prior to release. Records of test results and acceptance criteria used in the final testing must be kept (Beaumont, 1996).

11. Control of Inspection, Measuring, and Test Equipment

The organization shall control, calibrate, and maintain inspection, measuring, and test equipment and software used in the quality system to demonstrate the conformance of product to specified requirements; and ensure that measurement uncertainty is known and consistent with the required measurement capability (Beaumont, 1996).

12. Inspection and Test Status

The organization shall ensure the identification of inspection and the test status of product throughout production, installation, and servicing. A record should be kept of the person or persons who approved the tested product (Beaumont, 1996).

13. Control of Nonconforming Product

The organization shall ensure that a nonconforming product is prevented from unintended use or installation. Define who is responsible for deciding what to do with nonconforming products (Beaumont, 1996).

14. Corrective and Preventive Action

The organization shall investigate the cause of nonconforming product and consider corrective action needed to prevent recurrence, and analyze the quality system to detect and eliminate potential causes of nonconforming product. Make sure corrective actions work and record changes to procedures that result from corrective actions (Beaumont, 1996).

15. Handling, Storage, Packaging, Preservation, and Delivery

The organization shall provide adequate handling, storage, preservation, packaging, and delivery of the product to ensure that it meets the specified requirements (Beaumont, 1996).

16. Control of Quality Records

The organization's control of quality records process shall ensure that the quality records demonstrate that the quality system operates effectively, and required product quality is achieved. Records must be stored with retrieval and preservation needs in mind. Establish

a policy for the length of time various types of records will be retained. If previously promised, the customer will have access to the records (Beaumont, 1996).

17. Internal Quality Audits

The organization's internal quality audit plan shall verify that your quality activities and related results meet requirements, and determine the effectiveness of the quality system. A written report is to be made of audit findings; with the manager of the area being audited quickly, correct any problems found (Beaumont, 1996).

18. Training

The organization shall identify training needs and train personnel to meet these needs and keep training records for all employees (Beaumont, 1996).

19. Servicing

When servicing is a specified requirement in the contract, the organization shall control that servicing and verify that it meets specified requirements (Paradis & Small, 1996).

20. Statistical Techniques

The organization shall identify and use appropriate statistical techniques as necessary to verify the acceptability of process capability, product characteristics, and service (Paradis & Small, 1996).

CHAPTER III

RESEARCH DESIGN

Introduction

This chapter describes the research method and process used to review and analyze the existing body of knowledge in information systems that are to be used to assist technology companies in compliance with ISO 9000 quality standards.

Research design

In research design, quantitative and qualitative methodologies are two major methods. Quantitative methods use standardized measures that fit diverse various opinions and experiences into predetermined response categories. The advantage of the quantitative approach is to facilitate comparison and statistical aggregation of the data. This gives a broad, generalizable set of findings (Patton, 1987). Quantitative method uses statistical procedures to interpret numeric data and records the results of findings in the numbers. It is used in discovering, verifying, or identifying causal relationships among concepts that derive from a theoretical scheme. By quantitative methods, researchers have come to mean the techniques of randomized experiments, quasi-experiments, multivariate analyses, and sample surveys. This study did not use quantitative methods because quantitative research methods compare research results with an existing body of knowledge. Such knowledge was not available to the researcher due to the nature of the topic.

A qualitative methodology is naturalistic in which the researcher records the results of the findings in a language without predetermined research categories. A qualitative

methodology provides depth and careful scrutiny of the program situations, events, people interactions and observed behavior (Patton, 1987). Qualitative methods can be used to uncover and understand what lies behind phenomenon. It can give the intricate details of phenomena that are difficult to convey with quantitative methods (Strauss & Corbin, 1990). Qualitative research is exploratory and open minded, which is applicable to the study of a new field like designing an information system for technology companies to comply with ISO 9000 quality standards.

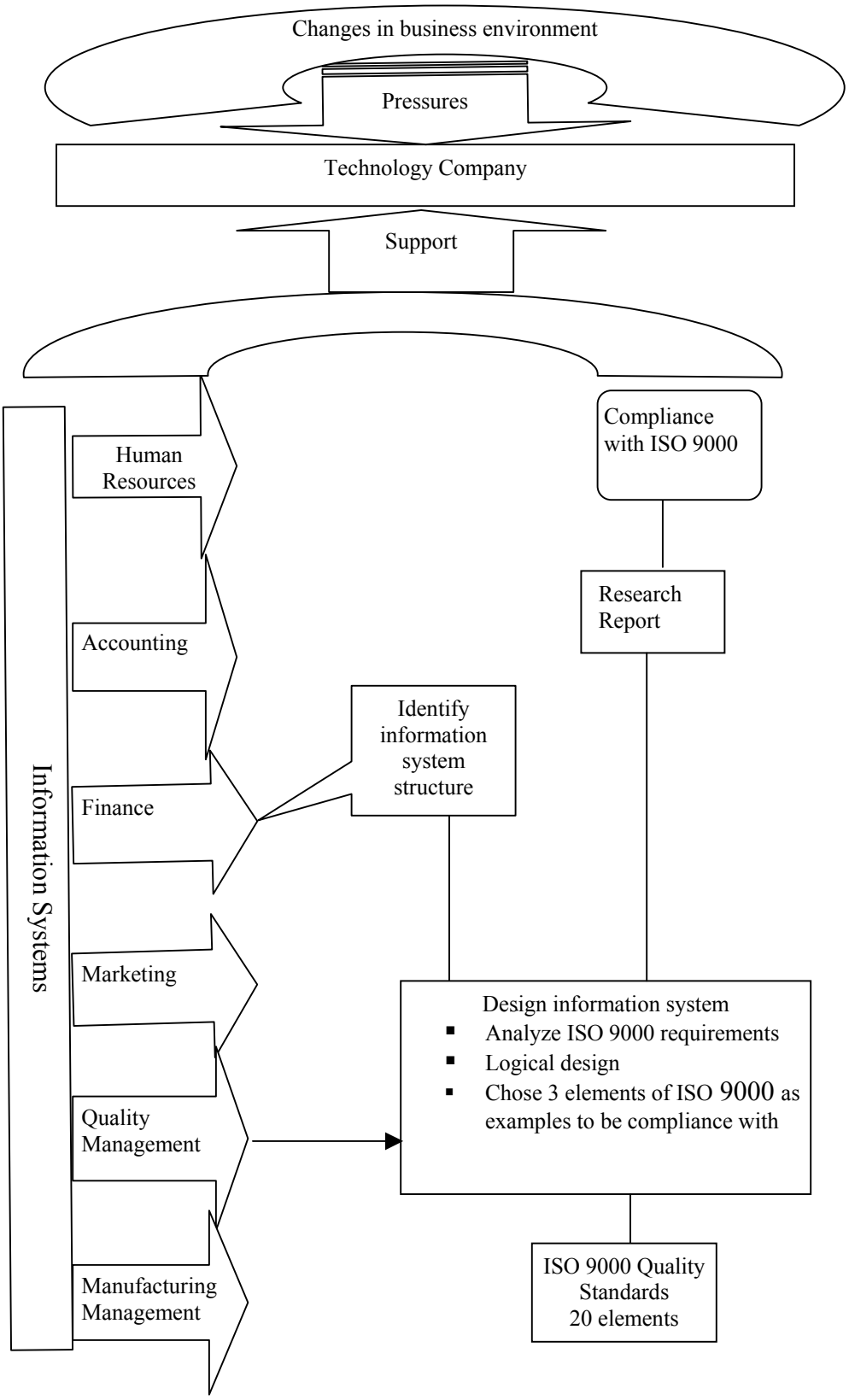
For the purposes of this study, the qualitative methodology was selected. The reasons are as follows:

1. This topic presents a new application in the information technology area.
2. Sufficient information is not available to use quantitative measures and an experimental design.
3. Information systems that assist quality management and standards compliance are still at an early stage of development.
4. The nature of information technology is dynamic.
5. There is a lack of comparative quantitative information for this research

Research Approach

The researcher has approached this research as depicted in the following flowchart (Figure 3.1 Research Approach).

Figure 3.1 Research Approach



CHAPTER IV

REPORT OF FINDINGS

Introduction

This chapter describes the findings of this study. It has two sections.

- The first section describes a development model for a technology company information system according to the relationship between the information system categories, the technology company's information needs, ISO 9000 quality standards, and logical information system design.
- The second section describes the application of the development model.

The Model

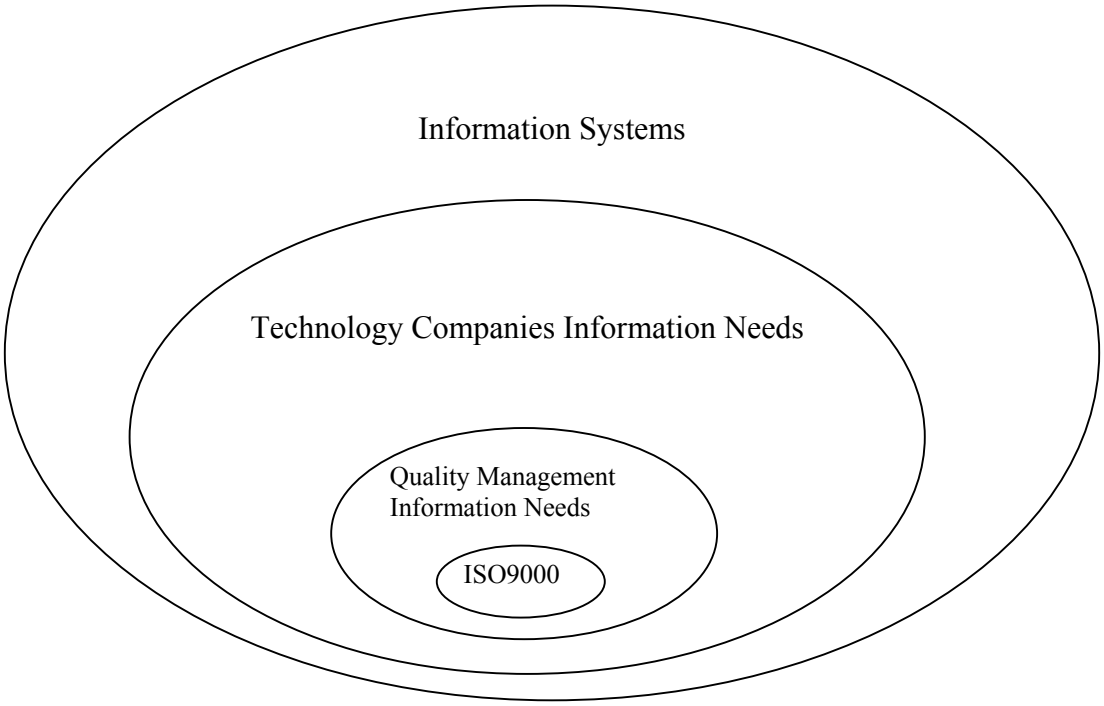
This section has three subsections. The first subsection addresses the relationship between the information system categories, the technology company's information needs and ISO 9000 quality standards. The second subsection describes the model for designing an information system based on ISO 9000 quality standards. The third subsection introduces Logical Data Structure, which is a tool for logical design information system.

1. Information System Category Relationship

In Chapter II, the researcher reviewed today's challenges to technology companies, especially quality management and ISO 9000 quality standards requirements, and the researcher described information systems that are used to assist technology companies in meeting some of the challenges. The relationship between the information system category, technology companies, and ISO 9000 quality standards is represented in the Figure 4.1: Information System Categories.

Figure 4.1

Information System Categories



2. Designing an Information System based on ISO 9000

According to the relationship between the information system category, technology companies, and ISO 9000 quality standards, the researcher has developed a model for designing a technology company's information system based on the requirements of ISO 9000.

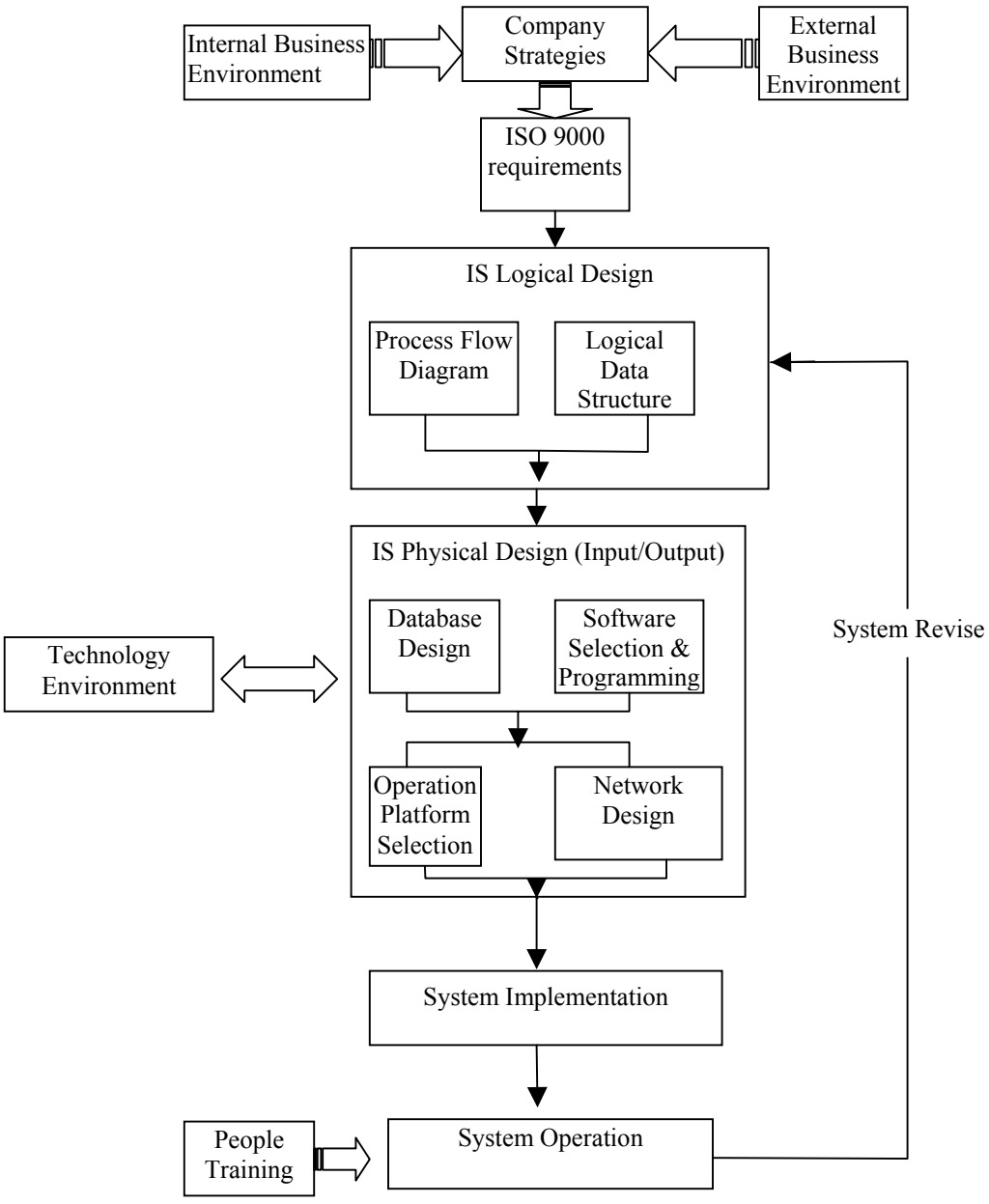
An information system's design is a complex process, which includes several phases such as scope definition, system requirements analysis, current system analysis, system logical analysis and design, system physical analysis and design, system implementation and operation (Brookes, Grouse, Jeffery, Ross, & Lawrence, 1982).

For the purpose of this study, the researcher divided the design into four phases. The first phase is the requirements analysis based on the company's strategies and ISO 9000 quality standards. The second phase is logical design. There are a number of tools for logical design, such as process flow diagram, logical data structures (LDSs) or entity-relationship model (E-R model), which depict the relationship of data and are tools for data modeling (Kroenke, 1999). The third is the physical design. This phase includes the selection of software, database design and programming, the selection of operation platform, and network design according to the technical environment. The last phase is system implementation and operation, which involves employee people training (Brookes, et al., 1982).

This model is represented in the Figure 4.2: Quality Information System Driver.

Figure 4.2

Quality Information System Driver



3. Logical Data Structure (LDS) Overview

The second phase of designing an information system is logical design. It is necessary to review the information about the tool-Logical Data Structure which is a tool for database logical design.

The study of the database has always been an important study in information systems design. The purpose of a database is to store and retrieve data (data about many interrelated things) effectively so as to keep track of things. For example, a sales person in a technology company wants to get customer credit information before making sale. He can review all the information by retrieving the data from the relational databases such as the customers database, the contracts database, the billing database, and the payment database. All those relational databases keep track of the business's clients.

One critical task for database design is the logical design. The logical design transforms the business object conceptual model into a structure defined in terms of database objects (Langford, 1998). Data modeling is the process of creating a logical representation of the structure of a database. Data modeling is the most important task in the development of effective database applications. If a data model is incorrect or inefficient, no amount of programming can compensate for the negative impact on applications (Kroenke, 1999).

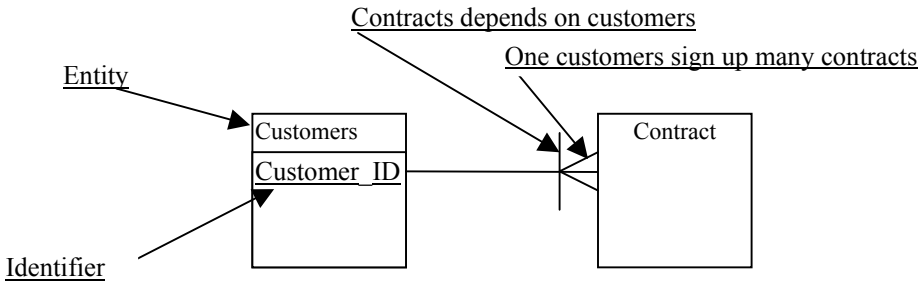
Logical Data Structure (LDS) is one of tools for data modeling which focus on the user's needs. It helps technical analysts (software application developers and database designers) communicate with users or with each other. Technical analysts use LDS for understandidng existing systems and for designing new information systems. Software application developers use LDS to help them develop programs in the Database

Management System (DBMS). LDS lets users disregard unimportant or tangential details about the physical expression of data (Carlis & Maguire, 2000).

The LDS model organizes data into entities-any person, place, thing, concept or event of lasting interest to the organization, and about which the organization finds value in keeping information (Carlis & Maguire, 2000). Each entity is represented on an LDS by a box. Entities have attributes, defined as "data elements", which indicates something worth remembering for that entity. Each attribute is represented on an LDS by a line of inside-the-box text. An identifier is a minimal set of an entity's descriptors whose values distinguish entity instances from each other. It is represented as an attribute that is underlined. The relationships among the entities are represented by a box-to-box line. A chicken foot on the line indicates one-to-many relationship. The bar on the line indicates that one entity depends on the other entity. Figure 4.3, Basic LDS below illustrates these concepts.

Figure 4.3

Basic LDS



The application of the model

In this section, the researcher describes the application of development model using three of the twenty elements of ISO 9000:1994. For the purpose of this study, the researcher will address requirement analysis of ISO 9000 elements and logical design information system. This section has three subsections which will address the three elements: 4.3 Contract Review, 4.6 Purchasing, and 4.18 Training individually. The researcher analyze the requirements of each element, and then design the process flow diagram and Logical Data Structure. Finally gave an example from an actual company for each element

1. Contract Review – Element 4.3

The requirements are the following:

The purpose of Contract Review is to ensure that the company understands customers' needs and has the capacity and capability to meet those needs. The company shall establish and maintain documented procedures for contract review and for the coordination of these activities. Before the submission of the acceptance of a contract or order, the contract or order shall be reviewed by the company to ensure that: a) the requirements are adequately defined and documented; where no written statement of requirement is available for an order received by verbal means, the company shall ensure that the order requirements are agreed before their acceptance; b) any differences between the contract or order requirements and those in the tender are resolved; c) your company has the capability to meet contract or order requirements; d) all customer requirements can be met. You company shall identify how an amendment to a contract is made and correctly transferred to the functions concerned within the company's

organization. Records of contract reviews shall be maintained (QS 9000 Quality System Requirement, 1994).

Requirements analysis:

To achieve Contract Review, the information system should provide the following information: 1) All contracts should be stored and tracked by the system. 2) The information about the capacity and capability of the company should be stored and tracked by the system, such as facilities, personnel and production schedules of the company. 3) The information about the suppliers should be stored and tracked, such as the quality records of suppliers, the capacity and capability of suppliers. 4) The information about customers should be stored and tracked. 4) Any amendment to the contract should be tracked. 5) The quality requirements for each contract should be stored and tracked. 6) The procedures and job instructions developed from contracts should be stored and tracked.

To meet to requirements of this element, the researcher has developed the process flow diagram (see Figure 4.4, Contract Review Flow Chart p. 34).

Logical Data Structure (LDS)

To achieve the requirements of Contract Review, the information system should provide the information such as contract, customers, suppliers, quality requirements, production schedules, facilities, employees, etc. The researcher has developed the Logical Data Structure diagram (see Figure 4.5, Contract Review LDS, p. 35) to reflect the relations between those factors. The information system developed from this logical model will provide the information to support technology companies to achieve the requirements of Contract Review.

Figure 4.4

Contract Review Flow Chart

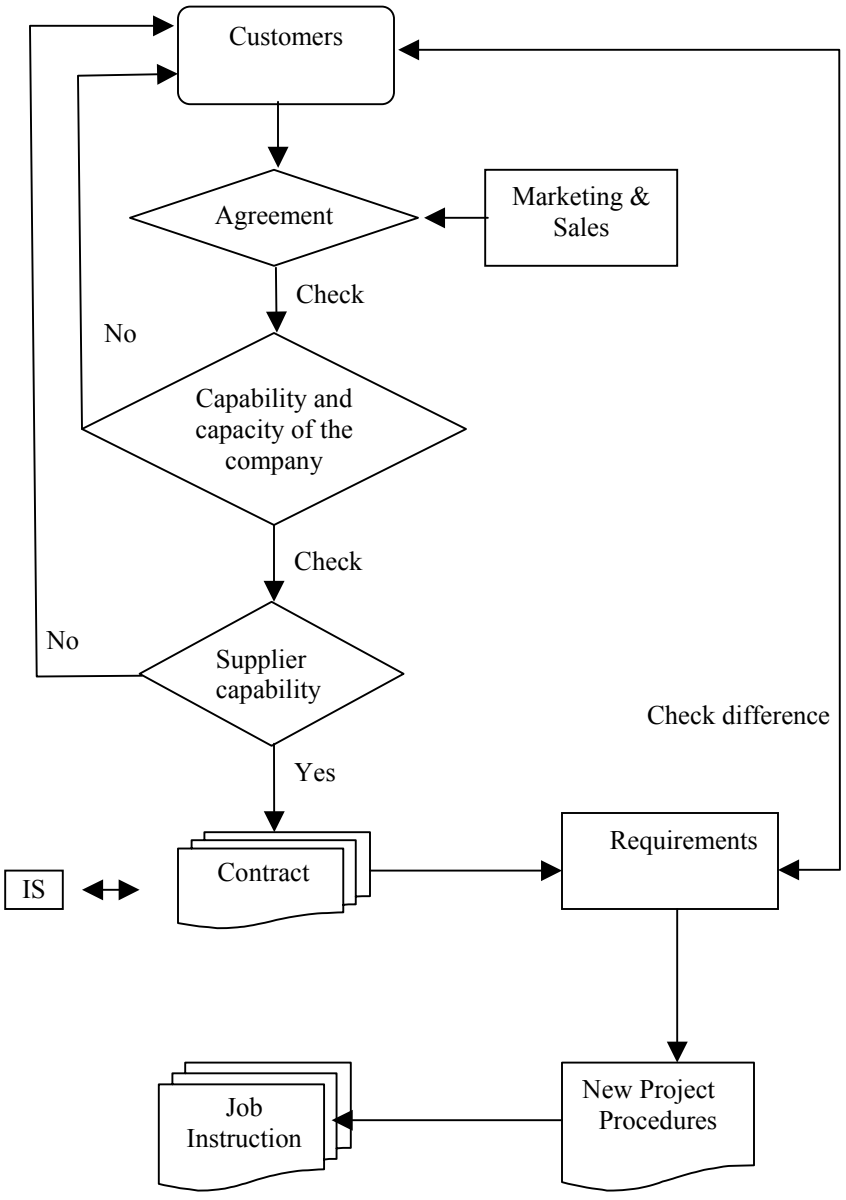
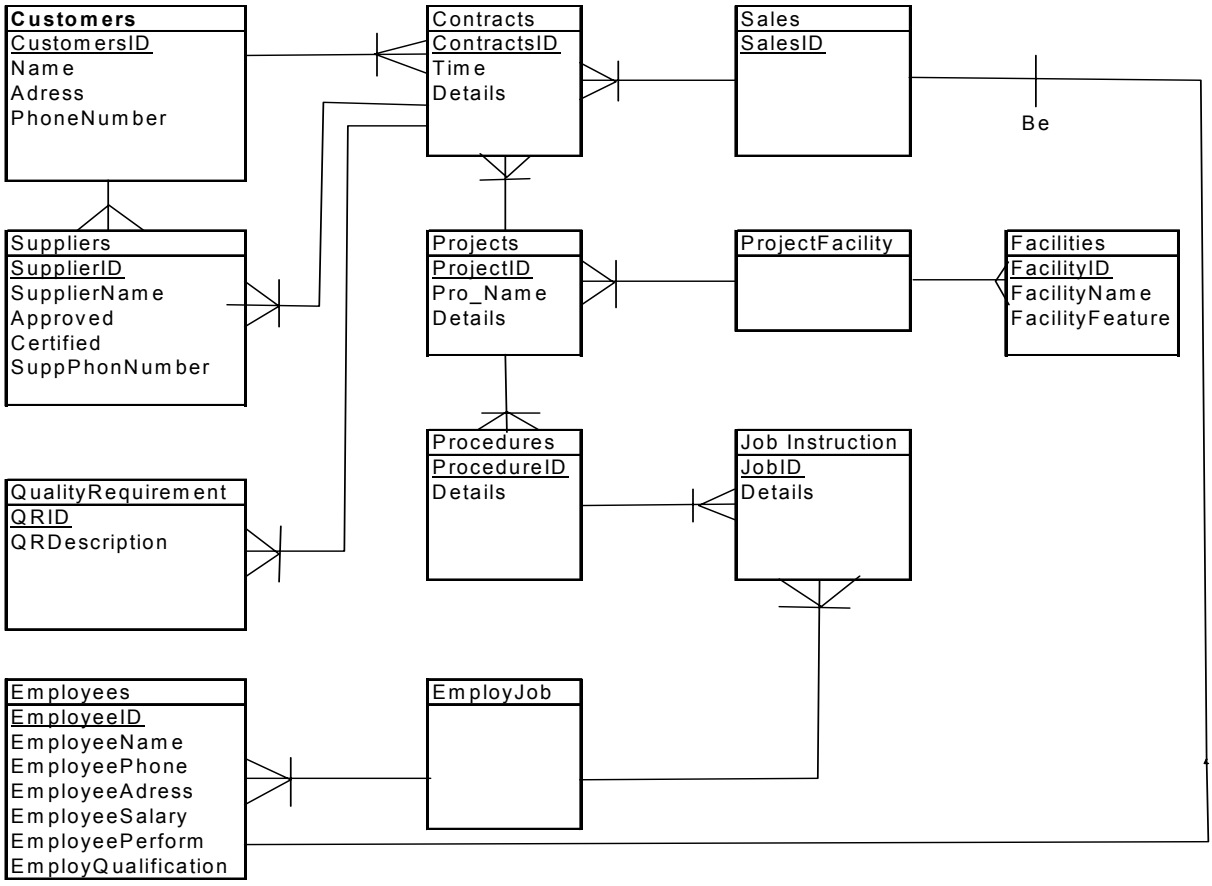


Figure 4.5

Contract Review LDS



Example

The researcher has cited an example of software contract review from the Boeing Company which is the largest aerospace company in the world in order to verify the requirements of Contract Review. The following details the requirements of software contract review for Boeing.

The Boeing Quality Management System Requirements for Suppliers document (D6-82479 July 17 2000):

In regard to software, before submission of a tender, or the acceptance of a contract or order (statement of requirement), the tender, contract, or order shall be reviewed by the supplier to ensure that the concerns listed below, at a minimum, have been addressed

- The technical feasibility of meeting the requirements.
- The software development standards and procedures to be used.
- Facilities, tools, software items, and data, to be provided by the customer, are identified and methods defined and documented to assess their suitability for use.
- The operation system or hardware platform.
- Agreement on the control of interfaces with the software product.
- Replication and distribution requirement.
- Assessment of possible contingencies or risks identified and the impact of these on subsequent activities.
- Life cycle processes imposed by the customer (if applicable).
- Information handled under the contract, which may be subject to concerns regarding intellectual property rights, license agreements, confidentiality, and the protection of such information (if applicable).
- Liabilities/penalties associated with the contract (if applicable).

(Retrieved April 10 2001 from the World Wide Web: http://www.boeing.com/companyoffices/doingbiz/supplier/)

The Boeing Company has translated the Contract Review requirements of ISO 9000 quality standards into these specific requirements for software contract review. For

example, the company expects the supplier to review the technical feasibility of meeting the requirements. This corresponds to the process flow diagram (see Figure 4.4, Contract Review Process Flow Chart p. 34) showing that the supplier should review its own capability and capacity to make sure it can meet the contract or order requirements. The supplier reviews the agreement on the control of interfaces with the software product to be provided, in accordance with the model so that any differences between the contract or order requirements and those in the tender are resolved. The supplier reviews software replication and distribution requirements, and requires that facilities, tools, software items, and data, to be provided by the customer, are identified and methods defined and documented to assess their suitability for use. This complies with the diagram to ensure that the requirements developed from the contract are adequately defined and documented.

2. Purchasing - Element 4.6

The requirements are the following:

The purpose of Purchasing is to ensure that purchased product conforms to specified requirements. This element requires three aspects about purchasing.

Purchasing Process: where the customer has an approved subcontractor list, the company shall purchase the relevant materials from subcontractors on the list. Any additional subcontractors may only be used after they have been added to the list by the customer's Materials Engineering activity. The company shall: a) evaluate and select subcontractors on the basis of their ability to meet subcontract requirements including the quality system and any specific quality assurance requirements; b) define the type and extent of control exercised by the company over subcontractors; c) establish and maintain

quality records of acceptable subcontractors. The company shall perform subcontractor quality system development using ISO 9000 as the fundamental quality system requirement. The company shall require 100% on time delivery performance from subcontractors. The company shall provide appropriate planning information and purchase commitments to enable subcontractors to meet this expectation. The company shall implement a system to monitor the delivery performance of subcontractors, including tracking of premium or excessive freight (QS 9000 Quality System Requirement, 1994).

Purchasing Data: Purchasing documents shall contain data clearly describing the product ordered, including where applicable: a) the type, class, grade or other precise identification; b) the title or other positive identification, and applicable issues of specifications, drawings, process requirements, inspection instructions and other relevant technical data, including requirements for approval or qualification of product, procedures, process equipment and personnel; c) the title, number and issue of the quality system standard to be applied. The company shall review and approve purchasing documents for adequacy of specified requirements before release (QS 9000 Quality System Requirement, 1994).

Verification of purchased product: The company shall establish and implement the inspection or other activities necessary for ensuring that purchased product meets specified requirements. The verification includes the company verification at subcontractor's premises and the customer verification of subcontracted product. Where the company or its customer intends to perform verification at the supplier's premises, the

company shall state the intended verification arrangements and method of product release in the purchasing information (QS 9000 Quality System Requirement, 1994).

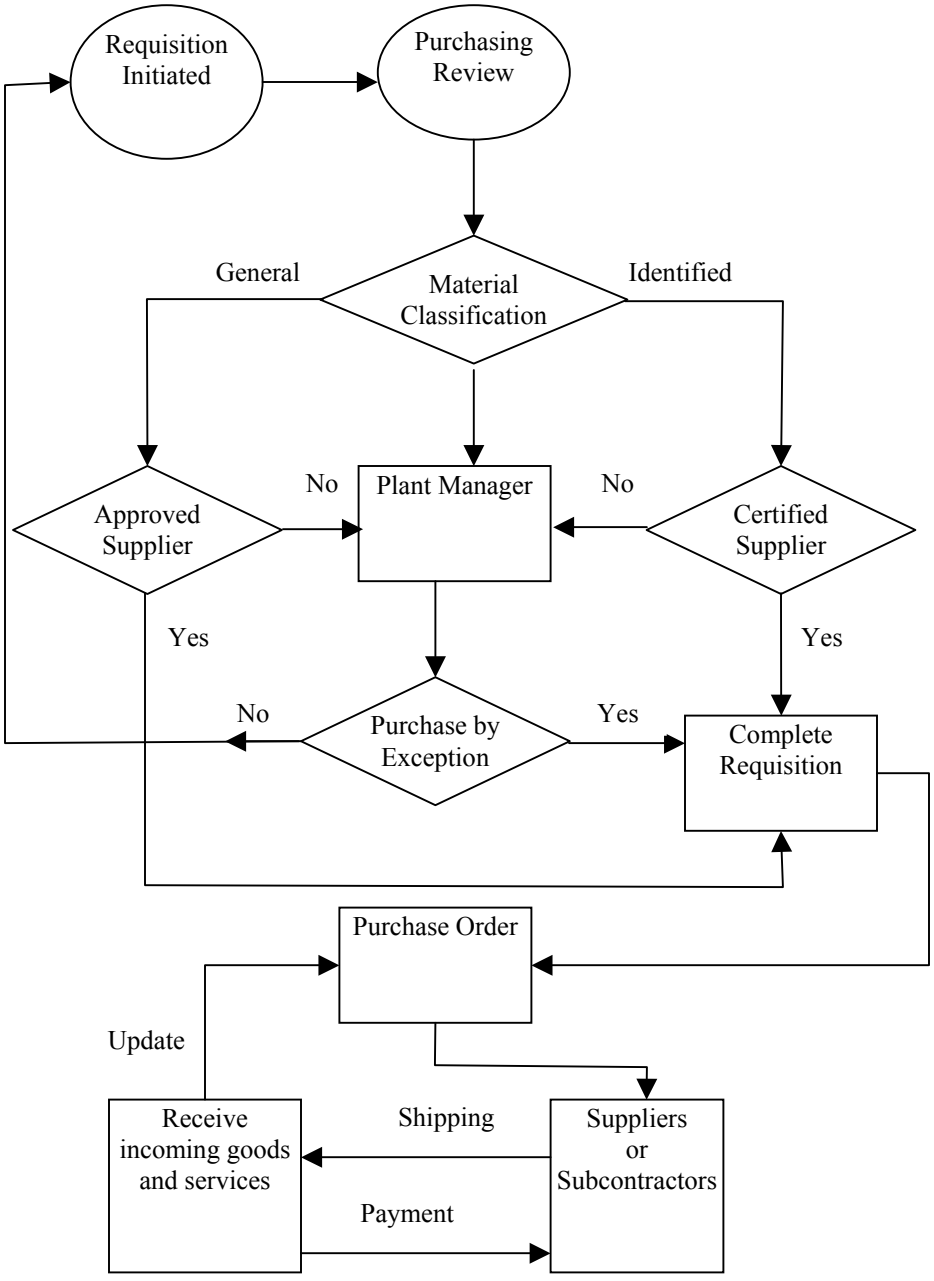
Requirements analysis:

To achieve the requirements of this element, the information system should store and track the following information: 1) the suppliers. 2) the customer's approved subcontractor list. 3) the quality records of subcontractors. 4) the purchase orders. 5) the shipping and receiving. 6) the purchased products detail, such as product number, type, class, grade or other precise identification. 7) the purchased data from suppliers. 8) the customer's verification where applicable.

To meet to requirements of this element, the researcher has developed the process flow diagram (Figure 4.6, Purchasing Flow Chart) as following:

Figure 4.6

Purchasing Flow Chart

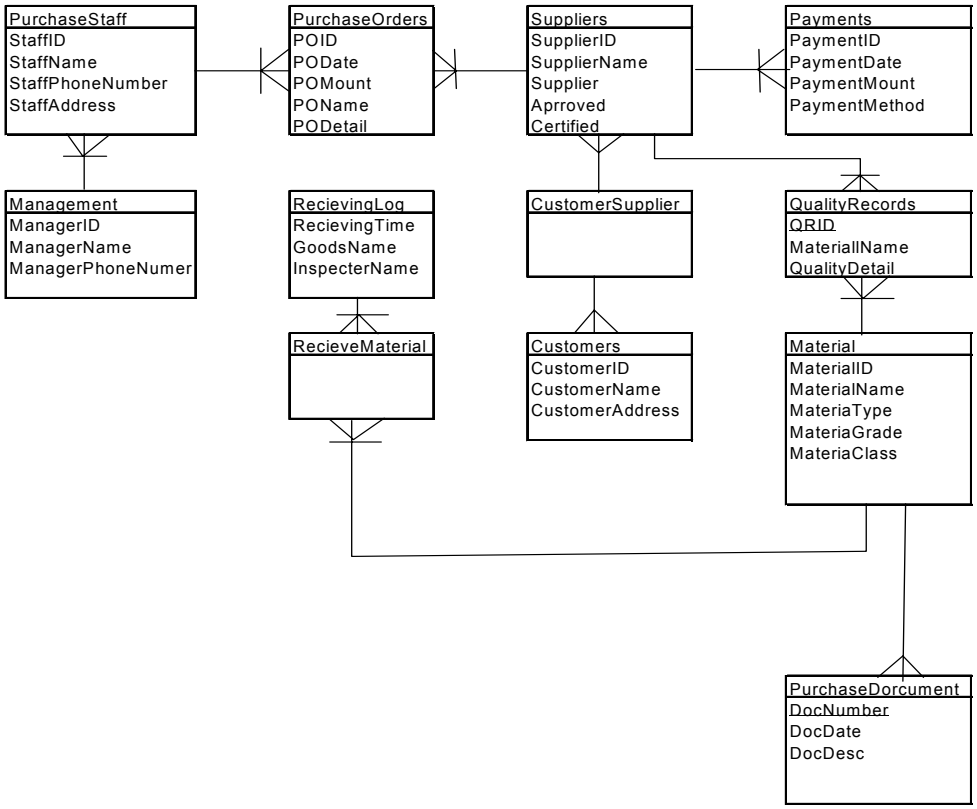


Logical Data Structure (LDS)

The researcher has developed the Logical Data Structure diagram (Figure 4.7, Purchasing LDS) to reflect the relationship between the factors to achieve the requirements of Purchasing. The information system developed from this logical model will provide the information to support technology companies to achieve the requirements of Purchasing.

Figure 4.7

Purchasing LDS



Example

The researcher has provided an example of software purchasing requirements from Boeing Company to verify the requirements of Purchasing. The following are the requirements of software purchasing for Boeing.

The Boeing Quality Management System Requirements for Suppliers document (D6-82479 July 17 2000):

Evaluation of Subcontractors

The supplier shall

- Evaluate and select subcontractors on the basis of their ability to meet subcontract requirements, including the quality system and any specific quality assurance requirements.
- Define the type and extent of control exercised by the supplier over subcontractors. This shall be dependent upon the type of product, the impact of subcontracted product on the quality audit records of the previously demonstrated capability and performance of subcontractors.
- Establish and maintain quality records of acceptable software subcontractors.
- Ensure that the organization having responsibility for approving subcontractors quality system has the authority to disapprove the use of sources.
- Periodically review subcontractor performance. Records of these reviews shall be maintained and used as a basis for establishing the level of supplier controls to be implemented.
- Maintain procedures that define the necessary actions to take when dealing with subcontractors who do not meet requirements

A list of approved software subcontractors shall be maintained and shall specify the scope of approval.

Purchasing data

Purchasing documents for software shall contain data clearly describing the product ordered, including, where applicable:

- Precise identification of the product ordered, such as product name and/or product number.
- Requirements specification, or the identity of it (or the procedure to identify requirements specifications where not fixed at the time ordered).
- Standards to be applied (e.g., communications protocol, architectural specification, engineering standards, or regulatory guidance).
- Procedures and/or work instructions.
- Requirements on personnel.

The procedures in section contract review also apply to subcontracts.

Verification of Purchased Product is same as ISO 9000 verification of purchased product.

Supplier Verification at Subcontractor Premises is same as ISO 9000 requirements.

Customer verification of subcontracted product: When specified in the contract, the supplier's customer or representative shall be afforded the right to verify at the source, or upon receipt, that the purchased software product conforms to specified requirements (Retrieved April 10 2001 from the World Wide Web: http://www.boeing.com/companyoffices/doingbiz/supplier/).

The Boeing Company established the specific requirements for software purchasing based on the requirements of ISO 9000 Purchasing element. For example, the company evaluates and selects subcontractors on the basis of their ability to meet subcontract requirements, including the quality system and any specific quality assurance requirements. The company establishes and maintains quality records of acceptable software subcontractors. The company periodically reviews subcontractor performance and maintains the records of these reviews to use as a basis for establishing the level of supplier controls. Those procedures are described in the Purchasing Process in the Purchasing element of ISO 9000 quality standards and are indicated in the Figure 4.6 Purchasing Process Flow Chart. In cases where the supplier abstained documents of software from subcontractors, the Boring makes sure that the supplier has conformed to all applicable standards (e.g., communications protocol, architectural specification, engineering standards, or regulatory guidance). The Logical Data Structure (Figure 4.7 Purchasing LDS) indicates that those requirements can be met by the information provided by the information system.

3. Training - Element 4.18

The requirements are the following:

The purpose of Training is to identify training needs and train personnel to meet these needs.

The company shall establish and maintain documented procedures for identifying training needs and provide for the training of all personnel performing activities affecting quality. Personnel performing specific assigned tasks shall be qualified on the basis of appropriate education, training and/or experience, as required. Appropriate records of

training shall be maintained. Training should be viewed as a strategic issue affecting all of the supplier's personnel. Training effectiveness shall be periodically evaluated (QS 9000 Quality System Requirement, 1994).

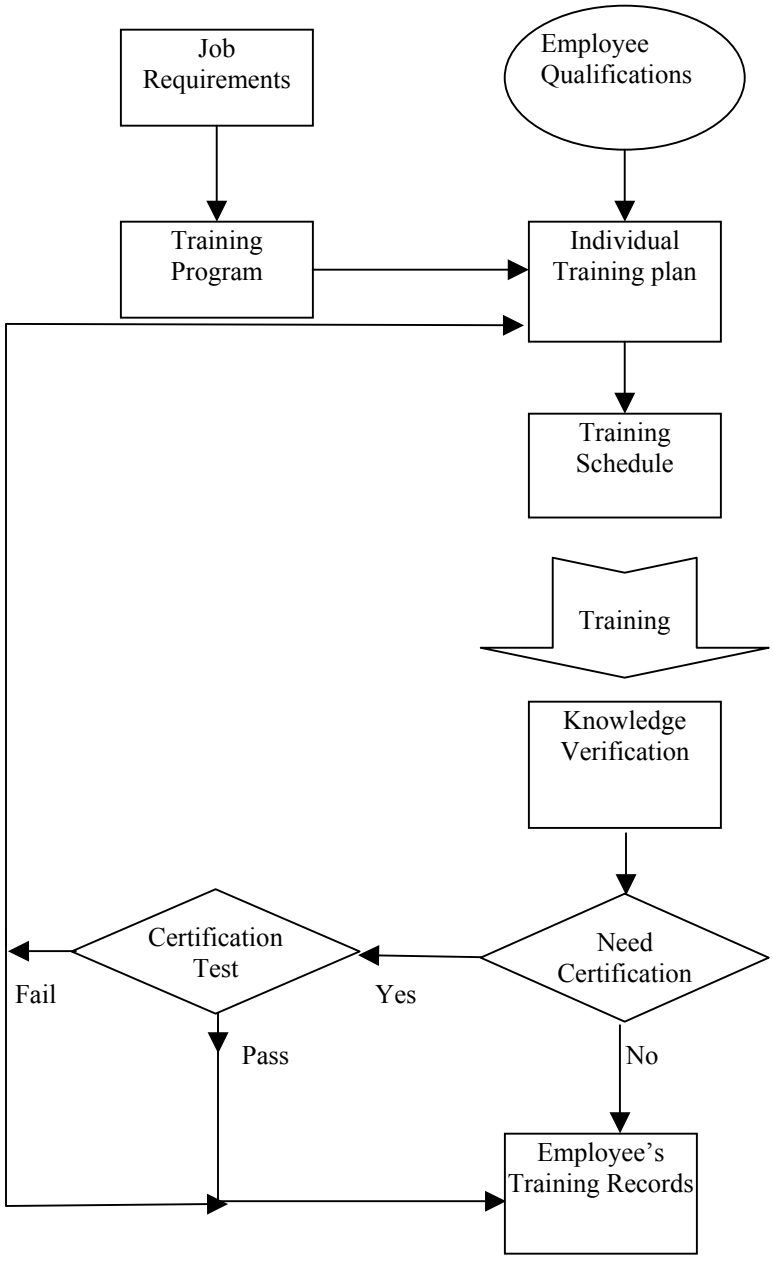
Requirements analysis:

To achieve the requirements of this element, the information system should store and track the following information: 1) training program developed from job requirements; 2) information about employees; 2) job requirements and descriptions; 3) job candidates' information such as qualifications, interview documents and follow up activities; 4) employee training schedules and training records; 5) personnel performance.

To meet to requirements of this element, the researcher has developed the process flow diagram (see Figure 4.8, Training Flow Chart p. 46) as following:

Figure 4.8

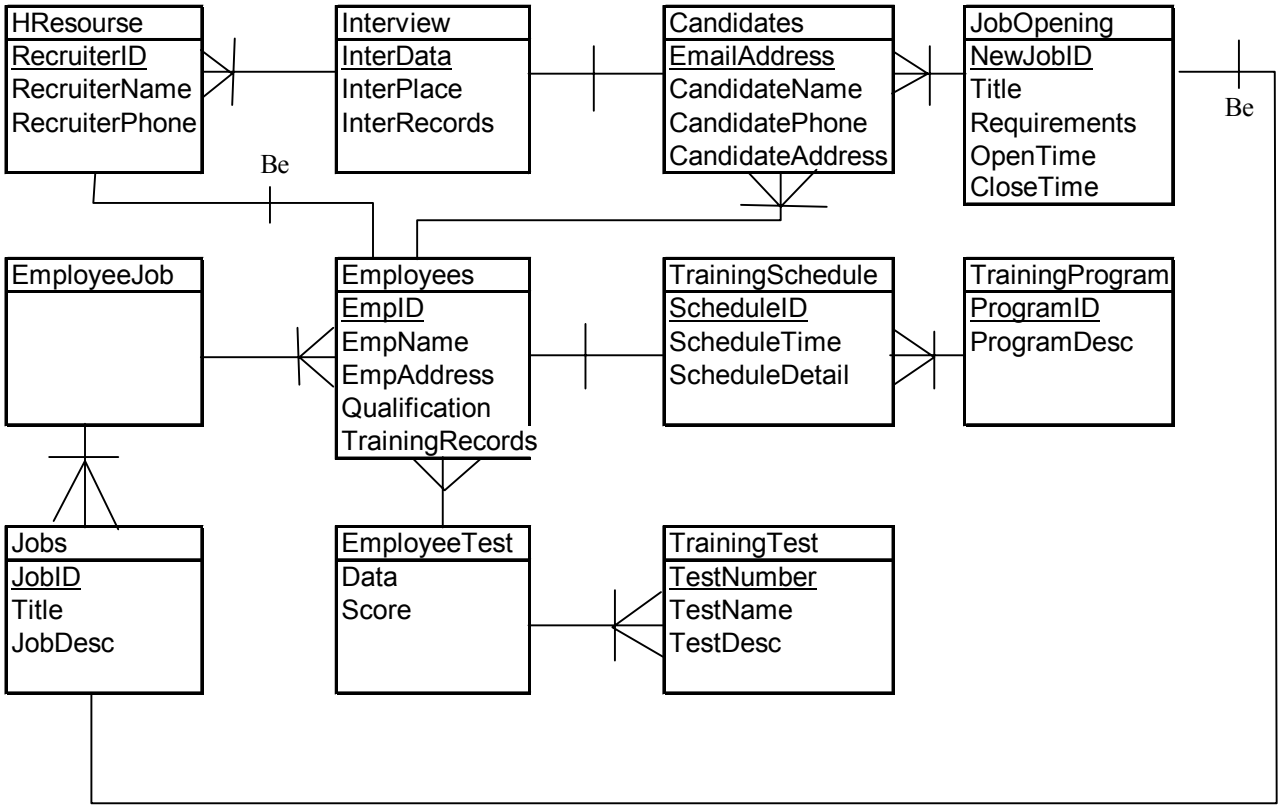
Training Flow Chart



Logical Data Structure (LDS)

The researcher has developed the Logical Data Structure diagram (Figure 4.9, Training LDS) to reflect the relationship between the factors to achieve the requirements of Training. The information system developed from this logical model will provide the information to support technology companies to achieve the requirements of Training.

Figure 4.9 Training LDS



Example:

The researcher has cited an example about training from NASA HQ ISO 9001 Training to verify the requirements of training. The following is NASA Headquarters about ISO 9001 training program.

The ISO 9001 standard requires that all personnel performing activities affecting quality be qualified on the basis of appropriate education, training, and/or experience. The Headquarters Common Process (HCP3410-4) titled Quality System Training defines the requirements and process for ensuring this requirement is met. The HCP states that all new hires and all individuals who will be assigned to HQ for longer than 90 days and who will be involved in the key products and processes of NASA HQ are required to complete the necessary Quality System On-the-Job Training within 90 days of their assignment (NASA HQ ISO 9001 Training, World Wide Web: http://www.hq.nasa.gov/hqiso9000/training.htm).

There are several ways this training can take place: reading the appropriate Quality System documentation; taking the HQS ISO 9001 Web Based Solar Training, and reading other documents and training materials developed by the HQ ISO 9001 Program Office. The following list of tools and resources were developed as HQS worked toward attaining their initial certification. As new resource tools become available they will be placed here (NASA HQ ISO 9001 Training, World Wide Web: http://www.hq.nasa.gov/hqiso9000/training.htm).

Headquarters ISO 9001 Solar Training Web-based Training Module that provides a basic understanding of the ISO 9001 standard and the HQS Quality

System. Target Audience: All employees (NASA HQ ISO 9001 Training, World Wide Web: http://www.hq.nasa.gov/hqiso9000/training.htm).

Standard ISO 9001 Training: Web-based Training Module that provides an overview of ISO 9000 background, content, and implementation process. Intended for anyone who needs to understand the concepts, philosophy, and requirements of ISO 9000. Target Audience: Implementors of ISO 9000 (NASA HQ ISO 9001 Training, World Wide Web: http://www.hq.nasa.gov/hqiso9000/training.htm).

Root Cause Analysis: PowerPoint presentation from seminar given by the HQ ISO Program Office on root cause analysis techniques. Target Audience: CPAS Reps and Process Owners (NASA HQ ISO 9001 Training, World Wide Web: http://www.hq.nasa.gov/hqiso9000/training.htm).

Lessons Learned and Corrective Actions on Quality Records: Guide for helping to ensure that quality records are identified and managed properly. Target Audience: Process Owners (NASA HQ ISO 9001 Training, World Wide Web: http:// www.hq.nasa.gov/hqiso9000/training.htm).

Guidelines for Use in Preparing and Reviewing HOWI's: Guide for helping process owners prepare Office Work Instructions. Target Audience: Process Owners (NASA HQ ISO 9001 Training, World Wide Web: http://www.hq.nasa.gov /hqiso9000/training.htm).

On-the-job Training (OJT): NASA Headquarters Quality System Training. PowerPoint presentation from training given by the HQ ISO Program Office. Meets the first level HQ Quality System training requirement of HCP3410-4 for OJT. Target

Audience: All employees (NASA HQ ISO 9001 Training, World Wide Web: http://www.hq.nasa.gov /hqiso9000/training.htm).

HQ Corrective & Preventive Action System (C/PAS) Training: PowerPoint Presentation from training given by the HQ ISO Program Office. Further expands on the first level of HQ Quality System training. Target Audience: CPAS Reps and all employees (NASA HQ ISO 9001 Training, World Wide Web: http://www.hq.nasa.gov /hqiso9000/training.htm).

Corrective Actions: Article from NASA HQ Bulletin that provides an overview of the HQS Corrective & Preventive Action System. Target Audience: All employees (NASA HQ ISO 9001 Training, World Wide Web: http://www.hq.nasa.gov /hqiso9000/training.htm).

The NASA Headquarters has developed a complete training program to meet ISO 9001 Training requirements. The Headquarters Common Process defines the requirements and process for ensuring the ISO 9001 training requirements are met. A World Wide Web based training information system provides all employees with needed training as required and when required by NASA. Employees can take training classes at any time, anywhere by log in their user account through the Internet. Web based test programs are also available for employees. Training test results are stored and tracked by the information system in the employees' database.

CHAPTER V

RECOMMENDATIONS

The researcher has the following recommendations:

1. The management of organization should incorporate information system education into their strategy planning.
2. Information system education should be integrated into formal higher education.
3. Functional managers should identify information system inventory.

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