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DEVELOPMENT OF COMPUTER SOFTWARE TO AID ENVIRONMENTAL DECISION MAKERS IN THE EDUCATION AND TRAINING OF AIR FORCE REMEDIAL PROJECT MANAGERS

THESIS

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AFIT/GIR/LSY/93D-8

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# DEVELOPMENT OF COMPUTER SOFTWARE TO AID ENVIRONMENTAL DECISION MAKERS IN THE EDUCATION AND TRAINING OF AIR FORCE REMEDIAL PROJECT MANAGERS

THESIS

Presented to the Faculty of the School of Logistics and Acquisition

Management of the Air Force Institute of Technology

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In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Information Resource Management

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# Preface

The purpose of this study was to define the Air Force Institute of Technology Civil Engineering and Services Environmental Education Centers' (AFIT/CEV-EEC) education process for environmental personnel and develop a prototype software package to streamline their functions. An additional objective of this research was to develop prototype knowledge-based systems to determine the feasibility of creating an environmental education course blueprint and certification process.

Even though this study was directed towards the AFIT/CEV-EEC office and environmental professionals, the methodology used could easily be adapted to other areas of education and certification. The knowledge-based systems created support the development of operational computer decision tools to assist environmental managers.

This research effort would not have been possible without the support of Colonel James Owendoff. We would like to thank the members of our database course team: Major Walt Van Daele, Captain David Morgan, and Lieutenant Jerry Cole. Their assistance during the process definition and prototype database design stages was invaluable. Also, Lynn Kelsie and Rich Evans' time and devotion towards the database design was critical to our success. We appreciate the patience and guidance of Lieutenant Colonel Mark Goltz, Doctor Craig Brandt, and Lieutenant Colonel William Schneider, our thesis advisors. A special thank you is extended to Lieutenant Colonel Schneider whose direction and enthusiasm helped keep us on track.

On the personal side, we would like to thank Cynthia Latke for her support and critical eye in the review process and for accepting the countless hours spent away from her husband. Also, we extend our gratitude to the Lyman family for their unconditional moral support.

Roger R. Ouellette
Bruce K. Lyman

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## Abstract

By the end of Fiscal Year 1991, the Air Force had identified 4,354 contaminated sites. Much like the 177 toxic sites at McClellan AFB, bases across the country and throughout the world are filled with chrome, lead, paint solvents and many other toxins that are rendering water supplies unusable and endangering the health of millions of people living in and around these bases. Air Force officials continue to identify contaminated sites with no end in sight. Since the cleanup of these toxic materials involves diverse, complex activities, the Air Force created the duty position of Remedial Project Manager to manage site cleanup efforts. In order for these site coordinators to effectively act as team leaders for project groups charged with site cleanup, they must be provided with relevant education and training.

This study defined the process by which Air Force environmental course managers provide education to environmental professionals, including RPMs. Once defined, the process was used to create a prototype relational database to enhance the course managers' ability to operate efficiently. This research also created two prototype

computer knowledge-based systems (KBS) to prove that KBS technology could be used to provide RPMs with a career education program and certification process.

# DEVELOPMENT OF COMPUTER SOFTWARE TO AID ENVIRONMENTAL DECISION MAKERS IN THE EDUCATION AND TRAINING OF AIR FORCE REMEDIAL PROJECT MANAGERS

## I. Introduction

At McClellan Air Force Base, Sacramento, California, the ground is filled with chrome, lead, and many other metals used in a major electroplating operation. Seemingly endless barrels of powerful solvents used to strip paint from aircraft and clean greased engines stand awaiting cleanup. Throughout McClellan's 3,500 acre base, the Air Force has spent $72 million just to locate 177 toxic sites. This contamination has caused local water wells to be shut down as a severe health risk to the surrounding communities (21:68).

Unfortunately, these toxic sites are not unique to McClellan Air Force Base. This scenario of contamination is repeated with varying levels of severity at over 4,300 Air Force sites, causing considerable health risks to millions of Americans (6:19). These figures continue to increase as more and more contaminated Air Force sites are continually identified with no end in sight (5).

Background

In 1980, the United States Congress created and passed the Comprehensive Environmental Response Compensation and Liability Act. Because of the large amount of money authorized by the act, it is better known as Superfund (8:40). The goal of Superfund was to give the Environmental Protection Agency (EPA) the authority to identify and clean contaminated hazardous waste sites created by private sector polluters and bill them for the cost. The time estimated by the EPA to identify and clean these sites in the United States was initially five years. As the EPA began identifying the contaminated sites, the estimated time to completion was extended indefinitely with a congressional review of the process every five years (8:41).

Since the Superfund law was focused at private polluters, the Department of Defense was left to be self regulated. In fact, the military was not forced by federal law to comply with the same environmental enforcement regimen as the civilian sector until September, 1992. Yet, in light of early Congressional attention to the environment and directives issued by President Carter in 1979, the Department of Defense created the Installation Restoration Program to begin identifying cleanup needs (21:69). As a result of the these directives, the Air Force began identifying and cleaning contaminated sites on many of its intallations. To strengthen these efforts, the Defense

Environmental Restoration Program was established in 1984, providing increased funding and authority to the Secretary of Defense (15:1-1).

By the end of Fiscal Year 1991, the Air Force had identified 4,354 contaminated sites. In April 1992, Gary Vest, Deputy Assistant Secretary of the Air Force, Environment, Safety, and Occupational Health, reported the Air Force had completed clean-up at 835 of '. : 4,354 sites identified, a process requiring approximately $1.. billion (6:19). The Air Force goal is to clean all identified sites by the year 2000 at an estimated total cost of $6.2 billion (6:19).

To attack the task of cleaning the multitude of sites threatening the American public, the Air Force and other services created a cleanup workforce. The latest direction given to the Air Force concerning environmental issues came in the form of a memorandum from the Secretary of Defense and the Air for Chief of Staff (18). This memorandum, dated 7 Jan 93, presents five objectives with many sub-objectives designed to instruct the workforce as to how to reduce the use and release of hazardous materials. Placing emphasis on preparing the workforce, the memorandum clearly states the need to "identify the education and training requirements to ensure each Air Force member understands the environmental standards of their job and how to comply" . . . "and provide the required education and training" (18).

At the conception of the cleanup workforce, the Air Force developed a series of courses through the Air Force Institute of Technology (AFIT) to educate environmental professionals in the area of environmental management. Also, the Air Force created an office under the AFIT School of Civil Engineering and Services Department of Environmental Management named the Environmental Education Center (AFIT/CEV-EEC). This office provides education to environmental professionals and other affiliated specialties in all aspects of environmental engineering and management by sending them to Air Force approved civilian courses (10).

<u>The Remedial Project Manager</u>

Since the cleanup of these toxic materials like the chrome and lead at McClellan AFB involves diverse, complex activities, the Air Force created the duty position of Remedial Project Manager to coordinate site cleanup efforts. Officially, a Remedial Project Manager is defined by the National Oil and Hazardous Substances Pollution Plan as:

> ... the prime contact for remedial or other response actions being taken at sites on the proposed or promulgated [National Priorities List] NPL and for sites no on the NPL but under the jurisdiction custody, or control of a federal agency... The RPM coordinates, directs, and reviews the work of other agencies, responsible parties, and contractors to assure compliance with the NCP, [Record of Decision] ROD, consent degree, administrative orders, and lead agency approved plans applicable to the response. (12:5)

The RPM acts as the team leader for a project group of specialists and support personnel tasked with the planning, execution, and evaluation of sites identified for site remediation under the Installation Restoration Program (12:6). An RPM who is knowledgeable and experienced in site remediation can ensure environmental response efforts are handled properly while reducing wasted resources and duplication of effort (12:1).

On installations such as McClellan AFB with its 177 sites, a multitude of these managers serve as site coordinators and are responsible for the complete restoration of the sites assigned to them.

## Research Problems

The purpose of this research is to provide possible solutions to three current Air Force environmental management problems. The first problem lies in the aforementioned environmental education center (AFIT/CEV-EEC). Currently, the method of maintaining information on environmental personnel (including site coordinators) involved in the civilian education process is inadequate (Lynn Kelsie, Interview). The second problem is the fact that no standard approach currently exists to educating site coordinators. While there are many specific environmental courses available, no education blueprint is in use to build a fully qualified site coordinator. This concept of qualification is the basis of the third and final research problem. Today, environmental managers have no way of knowing how competent a site coordinator is to perform his or her job. This problems leads to the possible creation of professional certification levels.

Research Objectives

The overall objective of this research is to develop prototype computer software to enhance Air Force environmental managers' ability to efficiently educate and train Air Force site coordinators. More specifically, there are three objectives.

1. Define the process by which Air Force officials identify and educate environmental personnel (including RPMs) through the office of AFIT/CEV-EEC.
2. Develop a prototype computer software package designed to streamline AFIT/CEV-EEC functions.
3. Create computer knowledge-based system(s) to determine the feasibility of creating the following:
   a. A course blueprint to educate RPMs.
   b. A site coordinator certification process.

In approaching objective one, we will be evaluating the process from the point of view of the two key staff members working in that office, Lynn Kelsie and Rich Evans. Because existing education requirements for Air Force site coordinators do not currently exist, the knowledge-based system(s) will only be able to rely on available courses and research discussed in chapter two to build its logic. If the use of knowledge-based system(s) proves possible, they could incorporate official course criteria not only for the site coordinator but for many other education programs.

## Conclusion

This chapter outlined the history and background of Air Force environmental issues and how they have gained a high level of involvement from senior Air Force officials and government agencies. It then led into the actual problem of educating and training site coordinators. Following the problem came a list of objectives that need to be met in order to produce a management aid to assist environmental decision makers and academic planners in educating these site coordinators.

Chapter II provides research related to the development of education specific to the needs of Air Force environmental professionals. The chapter also discusses many processes and tools used in projects similar to the one approached by this thesis. Chapter III reviews the method, or manner, in which the problems will be approached. It will identify which tools are chosen to conduct the research. The fourth chapter focuses on research analysis. In this case, the chapter will analyze the AFIT/CEV-EEC process of identifying and educating environmental personnel, present a prototype software package designed to increase office efficiency, and discuss the computer knowledge-based systems designed to test the feasibility of creating both an RPM course blueprint and a certification process. The last chapter, chapter V, will end this thesis with overall conclusions concerning the effectiveness of the research and software development as well as recommendations for future research.

## II. Literature Review

### Introduction

With the increased national and governmental attention on the environment, advanced methods must be found to improve the country's ability to address its environmental protection and cleanup needs. There will be a higher probability of success if highly trained and educated professionals are employed to plan, manage, and execute the cleanup and environmental protection programs (16).

This literature review will first discuss research and programs currently ongoing that have relevance to the education and certification of Air Force site coordinators. Next, the chapter will detail some potential techniques useful in defining the process by which Air Force officials identify and educate environmental personnel through the AFIT School of Civil Engineering and Services Environmental Education Center. Along with this process definition, four tools will be presented as options to help define and communicate the requirements process for software development. Finally, the chapter will present the concept of knowledge acquisition. Much like above, this section will also present possible tools to be used to place the knowledge gained into logic sequences for possible software development.

Environmental Related Research

To address the complex problem of environmental education requirements, the Massachusetts Institute of Technology for Research and Engineering (MITRE) has been employed to study the job requirements, to recommend curricula, and to identify available educational resources for an Air Force site coordinator (16). The MITRE corporation's February 1993 draft report identifies twelve areas of site coordinator responsibility as outlined by the Air Force Installation Restoration Program Remedial Project Manager Handbook (3). Recommended curricula for the site coordinator is also highlighted with a listing of potential courses to meet the education requirements (12:20-24).

Also, in a letter dated 16 June 92, Mr. Vest asked the Air Force Institute of Technology and the School of Aerospace Medicine to convene a series of working groups to develop a comprehensive, integrated environmental education and training plan (23). Responding to this request, Colonel Kenneth Hart, Commander, USAF School of Aerospace Medicine, began the process of completing a series of workshops to meet two goals. The first, is to define the USAF environmental, safety and occupational health education and training program (8). The second, is to identify education sources (schools, company workshops, etc.) to provide the educational opportunities outlined in the newly developed education and training program (9). Once the report is finalized, the USAF will have a better understanding of the environmental education requirements and training challenges facing every career field in the Air Force Materiel Command (9). These workshops should provide a better understanding of site coordinator tasks and the courses available to educate these personnel to better perform those tasks.

In addition to these two research efforts, a look at accomplishments by a different organization with similar problems may prove helpful. For example, the Defense Acquisition Workforce Improvement Act of 1990 is bringing more centralized management and more professional development, education, training and career opportunities to the acquisition workforce (19:3). This act developed a career development program for acquisition personnel complete with mandatory course requirements and structured career progression (19:18). It is possible many of these programs or program structures could provide some insight into solving many of the environmental workforce education and training problems.

Process Definition

When conducting research and transforming the findings into a useful form, there are many techniques and tool available. Our first research objective:

> Define the process by which Air Force officials identify and educate environmental personnel through the office of the Air Force Institute of Technology,

School of Civil Engineering and Services -
Environmental Education Center

Interview. To accurately collect the information concerning the existing process, the interview is very useful. Not only do repeated interviews serve to communicate the process, but they also allow the users to take an active role in the process definition stage of software development. In a similar effort to define a process, Major Phil McDowell and Captain David Morgan used interviews to collect information to model the Air Force TDY order process. Once the initial interview is complete, many tools can be helpful in adding structure to the users' process.

Concept Maps. "Concept mapping is the process of knowledge acquisition that captures an expert's conceptual structure of a problem" (13:54). Concept mapping allows the decision process to be categorized in nodes with links describing the relationship between the nodes. In a 1991 research effort, Captain Mark Harris used concept maps to help demonstrate how the AFIT's existing or near future resources can be applied to effective real time distance delivery of an logistics resident course that requires interaction between instructor and students (7:7). In Figure 1 below, Captain Harris depicted the many factors influencing an educational institution's goals. Because of the techniques flexibility, rapid construction, ease of interpretation, and simplicity, it lends itself to the rapid development of requirements for computer software (13:91-92).

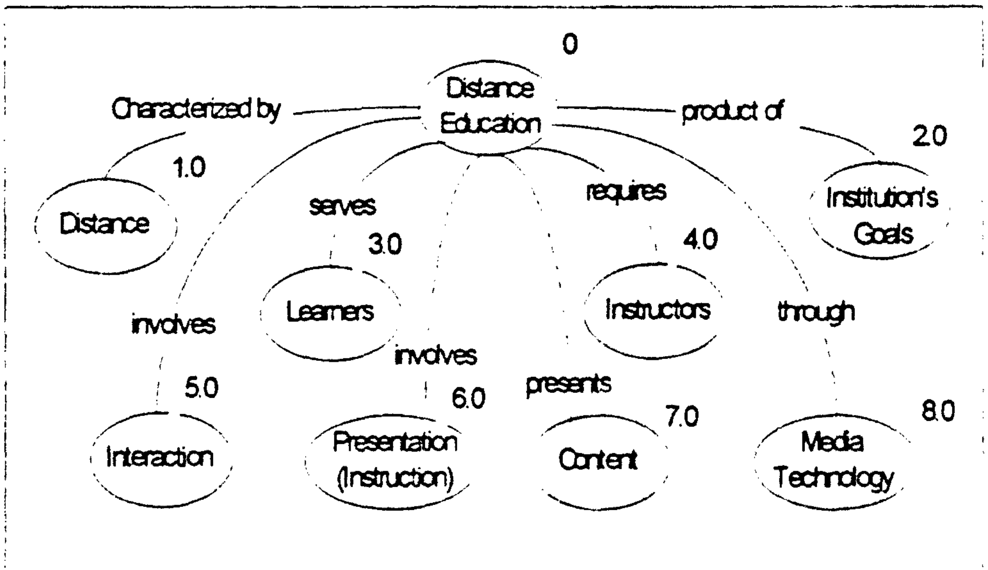


Figure 1: Concept Map of an Educational Institution's Goals (7:18)

Semantic Modeling. This concept of semantic modeling is a general term for the overall activity of attempting to represent meaning through models. These models can be very useful as an aid to systematic database design (2:581). One type of semantic modeling, entity/relationship diagrams, provides a very easy to understand pictorial representation of entities in a process (supplier, part, shipment, etc.) and the relationship that exists between them (2:584). The diagrams also include the entities' attributes (see fig 2). This particular definition and the example of an entity/

relationship diagram comes from the database systems course taught through the information resource management curriculum at the AFIT (1). Using student projects as examples, the instructor proved that if done properly, an entity/relationship diagram becomes an abstract database design.

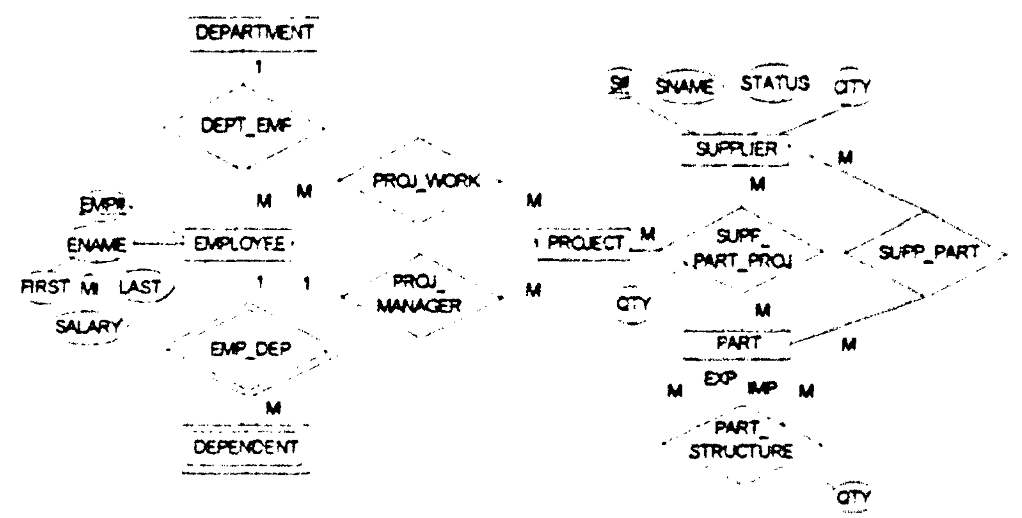


Figure 2: Entity/relationship Diagram Example (2:584)

Data Flow Diagrams. Data flow diagrams provide a useful model for communicating with users, other software designers, and managers about the present and proposed flow of data through an organization (2:59). Data flow diagrams are much like concept maps in that the nodes can be decomposed to show a more detailed look at the process. Unlike the entity/relationship diagrams which show static relationships, data flow diagrams show sequential data movement (see fig 3). Often times, these diagrams are used in conjunction with entity/relationship diagrams to provide a complete analysis of a process. When the database systems course described above is taught, these two techniques are combined.

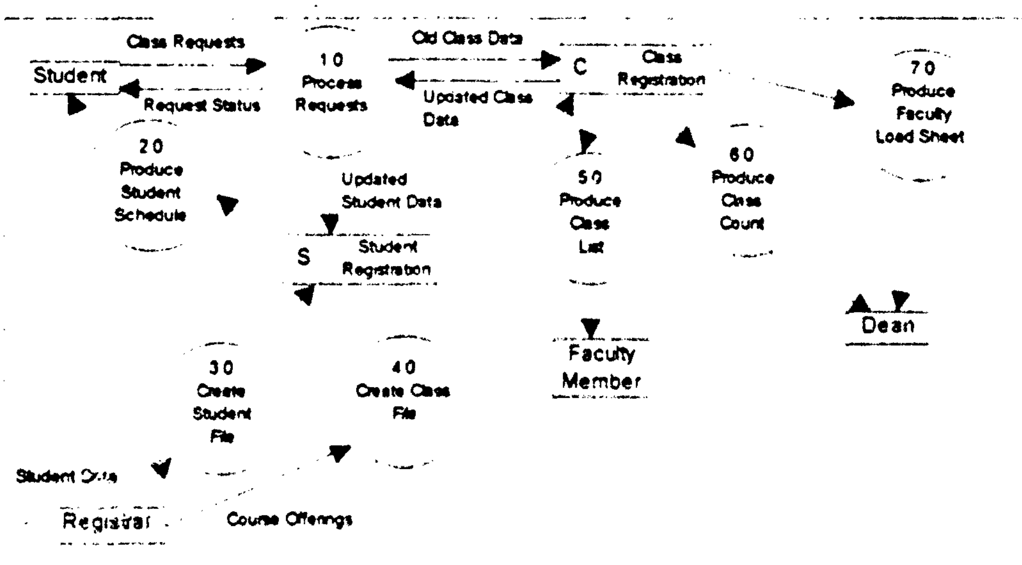


Figure 3: Data Flow Diagram Example (1)

<u>IDEF</u>. The term IDEF stands for <u>I</u>CAM <u>Def</u>inition and represents an activity modeling technique developed by the United States Air Force as a result of the Air Force's Integrated Computer Aided Manufacturing (ICAM) program (CIM-62). While the IDEF modeling technique has proved useful to accurately and effectively communicate Air Force business process improvements, it is much too complex a technique to be used in this research.

## Logic Development

Just as the success or failure of process definition lies heavily in the quality of the interviews, the success or failure of a knowledge-based system is dependent upon the quality of the logic acquired. A knowledge-based system is a computer system that attempts to replicate specific human expert intelligent activities (14:14).

Once the knowledge is gained, employing the use of certain logic tools will enable the proper development of a knowledge-based computer system. Since these tools are independent of any specific software, they can be used to communicate the logic used and for software development.

Flowcharts. One very basic method for logically representing knowledge is the flowchart. Flowcharts are diagrams that use special symbols and connecting arrows to display pictorially the flow of execution within a computer program egment (22:139) (see fig 4). This method is used extensively to instruct the AFIT Programming in True BASIC course at Wright Patterson Air Force Base. In initial program design, flowcharts are used to ensure the students understand the logic of computer programming. Once the knowledge of a process is known, the flowchart can be used to make up a decision structure to enable the computer to decide between a variety of choices (22:210).

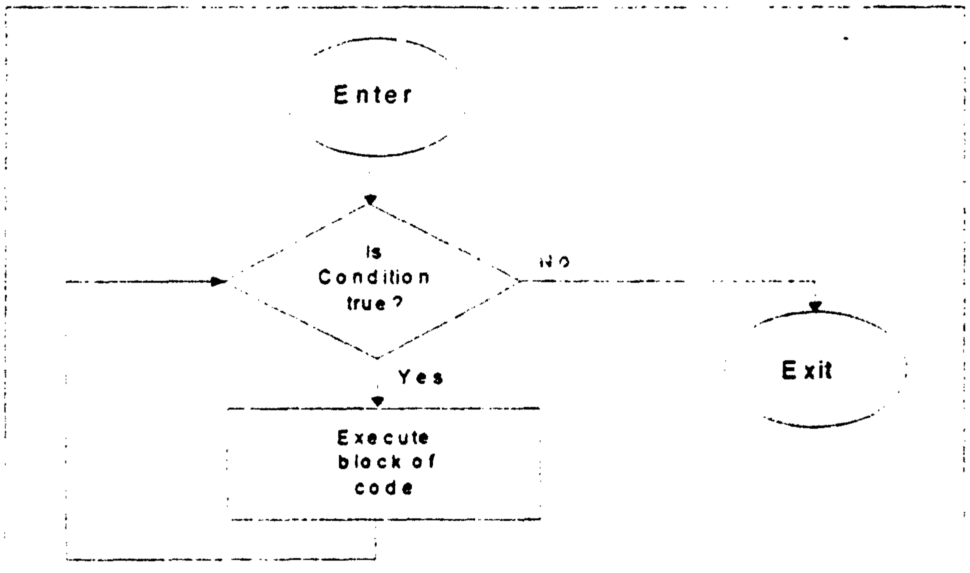


Figure 4: Flowchart Example (22:139)

Dependency Diagrams. A more complex approach to logic representation is the use of dependency diagrams. Such diagrams are outlines of the computerized version of the decision situation under study (see fig 5). Creating these dependency diagrams with related statements of rules and questions is referred to as the system design and documentation phase of knowledge-based system development (14:54). As taught in the AFIT Artificial Intelligent course, explicit dependency diagrams are essential to ensure sound logic before attempting to design any software (20).

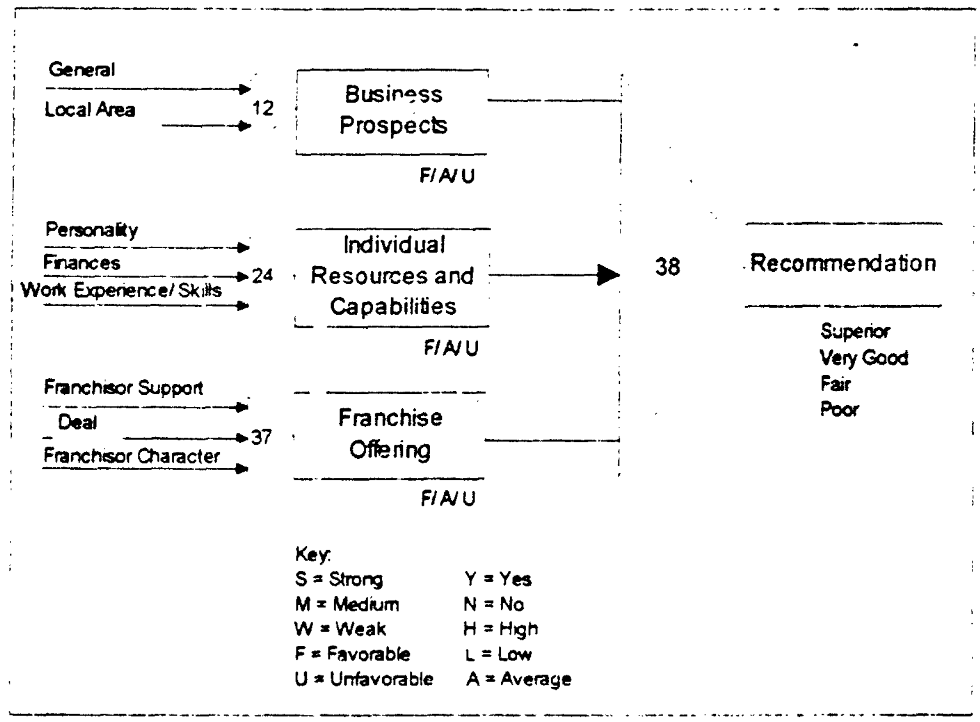


Figure 5: Dependency Diagram Example (14:70)

## Conclusion

The research being accomplished by both the Massachusetts Institute of Technology for Research and Engineering and the School of Aerospace Medicine will aid Air Force environmental managers in determining education and training programs for their personnel. A close examination of the programs instituted by the Defense Acquisition Workforce Improvement Act may also prove useful. While these research efforts are not fully complete, much of the information generated thus far can be used to produce the proposed knowledge-based system(s).

In approaching the objectives of process definition and software development (objectives 1 & 2), many tools are available. The interview is the only indispensable tool. Of the others presented, we have the luxury of choosing the tools most effective to isolate the process and prepare it in a way conducive to software development. This review provides a general overview of the available tools and their uses. Working examples of the tools selected for this research will be presented in chapter III, Methodology. The chapter will also detail the manner in which we plan to perform our research.

# III. Methodology

## Introduction

This chapter will outline the approaches used to provide computer software to assist in collecting and presenting data and information in the day-to-day decisions of managing Air Force Remedial Project Managers. To review, the research objective are:

1. Define the process by which Air Force officials identify and educate environmental personnel (including RPMs) through the office of AFIT/CEV-EEC.
2. Develop a prototype computer software package designed to streamline AFIT/CEV-EEC functions.
3. Create computer knowledge-based system(s) to determine the feasibility of creating the following:
   a. A course blueprint to educate RPMs.
   b. A site coordinator certification process.

The first section will discuss the use of interviews along with entity relationship and data flow diagrams as tools to define the AFIT/CEV-EEC process of providing education to environmental personnel. With the tools described, the section will provide the method to be used in designing the prototype computer software to streamline AFIT/CEV-EEC functions along with a method of implementing and testing that software. The next section will present the sources of knowledge and the methods to be used in developing a knowledge-based system. The stages of prototype development, along with the selected modeling tool will be included.

## The AFIT/CEV-EEC Process

The approach used in this research to develop a software tool to streamline the AFIT/CEV-EEC process will be based on the following stages in database design presented in the AFIT Database Management course (1).

1. Information collection
2. Process definition and model design
3. Requirements Collection and Software design
4. Implementation and testing

Information Collection. In order to properly design a software tool to improve any process, the information concerning the process and the basic user requirements for the software must first be known. To ensure the process information and tools are as complete and effective as possible, the users must be included from the onset of software design. To this end, the interview is very useful. Gaining an accurate picture of the entire education process of the office will require numerous personal interviews.

Process Definition and Model Design. Of the four process definition tools discussed in the literature review to help define the process, the data flow diagram will be used in conjunction with the entity/relationship diagram to pictorally represent the process. The primary reason for the choice is the ability of these two tools to combine to represent a complete process analysis. The information gained from the initial interviews will first be illustrated through the use of data flow diagrams. Information gained from the second set of interviews and the data flow diagrams will be transposed into an entity/relationship diagram used to visually represent the process in a manner easily integrated into a computer software tool (2:136).

Requirements Collection and Software Design. Once the education process is defined, more interviews will take place to begin the design of the actual software tool. Using the software requirements gained from personal interviews with the users, a commercial computer software shell will be chosen. These shells are general software architectures capable of being programmed to manage information (24:402). After the basic software is chosen, the software will be tailored to meet the specific needs of the AFIT/CEV-EEC office.

Implementation and Testing. Once the software system has been prepared it will be given to the users to input the required information to be managed. They will be trained on the use of the software and be encouraged to make suggestions for further tailoring. The deciding factor of the success or failure of the software will be to what degree it makes the office environment capable of more efficiently managing the education of environmental professionals. Throughout this final stage, follow up interviews are very important.

Knowledge-based Systems

Unlike the software tool designed for actual use, the purpose behind the creation of the knowledge-based system (KBS) prototype(s) is one of research only. These systems will be created to test the feasibility of using KBS technology in the development of site coordinator course progression and certification. Since neither a site coordinator course blueprint nor a certification process currently exist, the logic will be designed as an example of KBS usage based on the knowledge derived from the MITRE report, the work being done by the School of Aerospace Medicine, and class schedules from the AFIT/CEV-EEC office. The KBS prototype(s) are not intended to provide solutions to the Air Force challenges of designing RPM education guide or certification criteria.

The approach to be used in this research for knowledge-based system development is based on the methodology presented in the AFIT Artificial Intelligence course. From the text "An Introduction to Expert Systems", the KBS development life cycle is adopted (14:312) (see fig 6).

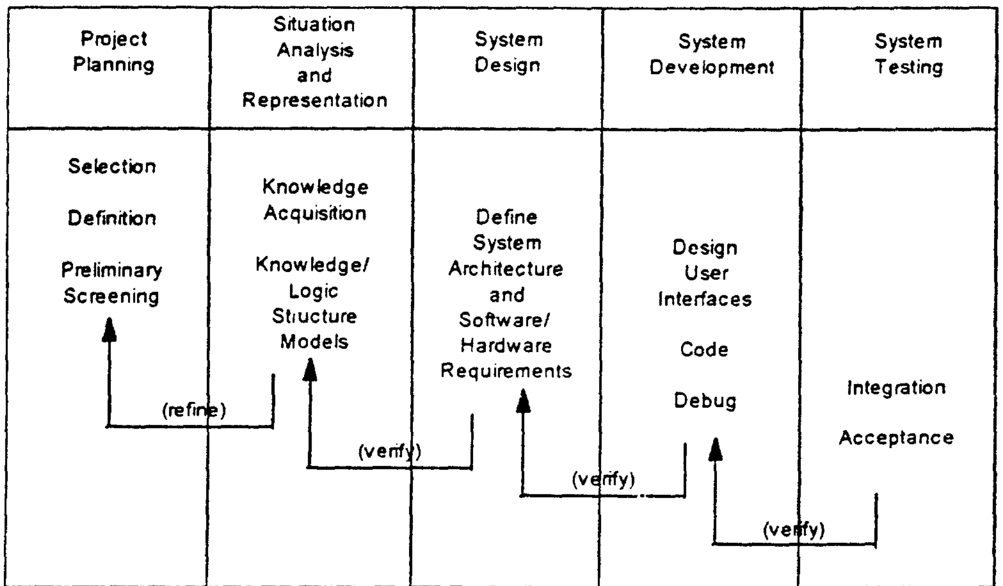


Figure 6: KBS Development Life Cycle (14:312)

Since the proposed prototype(s) will not be designed for implementation, this research will not emphasize the development of extensive user interface or user integration. In the second stage of the development life cycle (situation analysis and representation), dependency diagrams will be used for knowledge and logic structure models. Chosen for their ability to clearly represent complex logic (14:313), these diagrams will help analyze the site coordinator course blueprint and certification processes. Once the processes are represented, they will be transformed into computer ccmpatible logic to be coded into an existing software shell.

One key attribute of all the tools chosen for use in this research is their compatibility with software development. These tools have been proven useful to clearly represent processes and logic and are flexible enough to be used with many different software packages.

In the fifth stage of KBS development (fig 6), system development, a software shell will be chosen. Selecting a specific knowledge-based software package to run the logic is not nearly as crucial as the AFIT/CEV-EEC software. What is important is to evaluate the use of a KBS as a tool with respect to the research objectives. The question of whether or not a KBS can be used to help solve the two site coordinator specific problems can be answered by using many different KBS shells. An evaluation of the software used will be beneficial to the designers of any functional KBS designed in future efforts to solve the problems.

The selection will be based on simplicity and ease of prototyping. Since the focus of this portion of our research is not software dependent, choosing an easy-to-learn, basic logic software package will allow more time to be spent on the logic and less on the software.

The test for the knowledge-based system(s) will be how accurately these prototype(s) prove or disprove the feasibility of using KBS technology to create a site coordinator course blueprint and certification process.

Conclusion

The methodology presented provides a map for the research to follow. By taking the steps outlined, the research will follow a structured, logical process to develop the proposed prototypes. Not only will software prototypes be created by using this methodology, but the activities being modeled will also be represented in a manner conducive to further research and alternative software integration.

Chapter IV will present the success and failures experienced from following this methodology. The chapter will also contain a detailed analysis of the process definition, the logic, the software and all supporting data. Basically, the chapter will describe exactly what steps were taken to meet our research objectives and how successful those steps were.

## IV. Analysis

Using the information reviewed in chapter II along with the tools selected and methods developed in chapter III, the work to meet the research objectives was completed. This chapter will explain the specific steps taken, the analysis and outcomes.

The first section will be devoted to defining the AFIT/CEV-EEC process and developing a prototype software package designed to streamline office functions. The second section will be focused on the creation of a knowledge-based software prototype(s) to determine the feasibility of creating a site coordinator course blueprint and certification process. Each section will be divided into the stages of development outlined in chapter III and contain an analysis of the specific research objectives.

### AFIT/CEV-EEC Process

Research objectives one and two are both focused at solving an information management problem in the office of environmental education at the Air Force Institute of Technology. The first two objectives are:

1. Define the process by which Air Force officials identify and educate environmental personnel (including RPMs) through the office of AFIT/CEV-EEC.

2. Develop a prototype computer software package designed to streamline AFIT/CEV-EEC functions.

As outlined in Chapter III, the methodology chosen to approach the problem is divided into four stages. The first two stages were designed to meet research objective one (define the process) with the last two stages designed to meet research objective two (develop prototype software).

Information Collection. Before any modeling could take place, personal interviews were used successfully to collect the process information. The interview process began by interviewing Colonel James Owendoff (AF/CEVR) who provided the global view of the site coordinator education process. He also explained how the environmental education center fits into the overall Air Force environmental effort (see fig 7).

After two interviews and a written correspondence, Col Owendoff agreed to sponsor this research and directed further interviews concerning this portion of our research to the course managers, the individuals responsible for managing the AFIT/CEV-Environmental Education Office. After the initial interview with the two process owners, they were established as the immediate customers for the first two research objectives.

These initial interviews provided enough knowledge of the process for the research to move on to the second stage of methodology. Because of the importance of continually

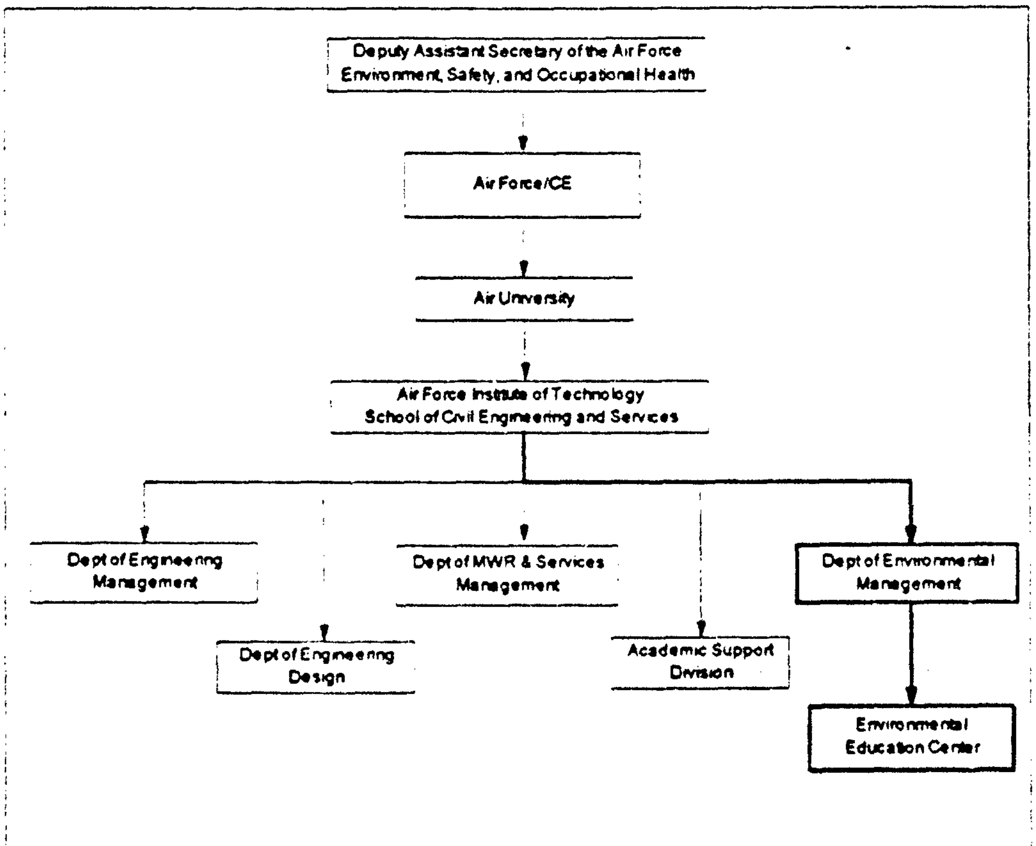

Figure 7: AFIT/CEV-EEC Hierarchy Chart

communicating with the customers, the interview was used extensively throughout all four stages.

<u>Process Definition and Model Design</u>. Before the interviews with Lynn Kelsie and Rich Evans, the course managers, were complete, we chose to begin modeling the process using concept maps (Appendix A). While this tool has many benefits and has been used successfully in the past, it was not able to meet all of our needs. Even though the tool proved unusable for system design, the hours of concept map modeling did have one benefit - it made us

take a very detailed look at the process and gave us the information needed to choose the most effective tool.

Through interviews, we learned the AFIT/CEV-EEC office is responsible for the education of military personnel in environmental compliance, pollution prevention, and remediation at vendor locations (civilian institutions) apart from AFIT. This education process begins when an applicant submits a course attendance request to either of the two course managers. Whoever receives the request, depending on the course type, approves or disapproves the request based on course validity and available funds. The course is valid only if the course is offered through the AFIT/CEV-EEC office or meets Air Force environmental education criteria. The information on approved requests is then placed in the office database. The letters of approval to the requesting personnel containing the dates and fund cites are then typed on a word processor. The applicant, upon course completion, returns a travel voucher and a course critique. With this information, the course managers periodically, weekly or bi-weekly, generate financial and statistical reports.

Using this process information, data flow diagrams were created, pictorially representing the process (see fig 8). This diagram represents an overview of the AFIT/CEV-EEC student request process. In this diagram, the student submits a request to attend a course. The request is processed using information from the student, course, and accounting files. From these updated files, student

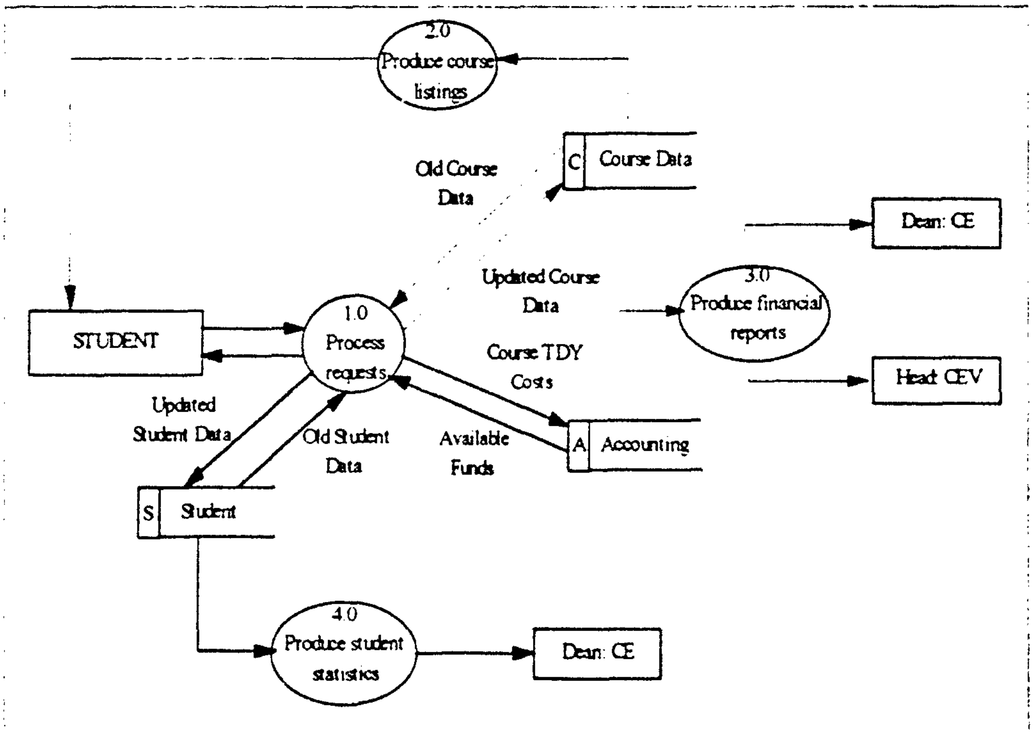


Figure 8: AFIT/CEV-EEC Data Flow Diagram

statistics, course listings, and financial reports are produced. Once this process overview data flow diagram was validated by the course managers, we further decomposed each activity (Appendix B). Each of these decomposed diagrams were then shown to the course managers and validated. Using this technique proved very effective in clearly showing process detail. With minimal explanation, the users were able to understand the diagrams and offer additional information to help clarify each activity.

With the process more clearly understood, we were able to look at the entities involved in the process and describe the relationship between them. For this we used the entity/relationship diagram (see fig 9). This modeling technique not only allowed us to look at how the entities in the process related to each other, but it also represented these relationships in a form easily converted to computer software.

In the diagram, the entities are represented by the rectangular boxes and their relationships are in the diamond boxes. The words in the circular shapes attatched to an entity are attributes of the entity. The number of arrows entering an entity depends on the relationship that an entity has with another. For example, one vendor offers many courses (two arrows into course), but each course is only offered by one vendor (one arrow into vendor). Once the software was chosen, the entity relationship diagram was used as a template to program the software shell.

Requirements Collection and Software Design. The primary complaint the course managers had about their current database software was the fact that it was very frustrating and time consuming to use. Not only was retrieving data difficult, but they also had no ability to alter the tables or software themselves. They were forced to depend on the system administrator to fix any problems they had. Unfortunately, months would lag between user

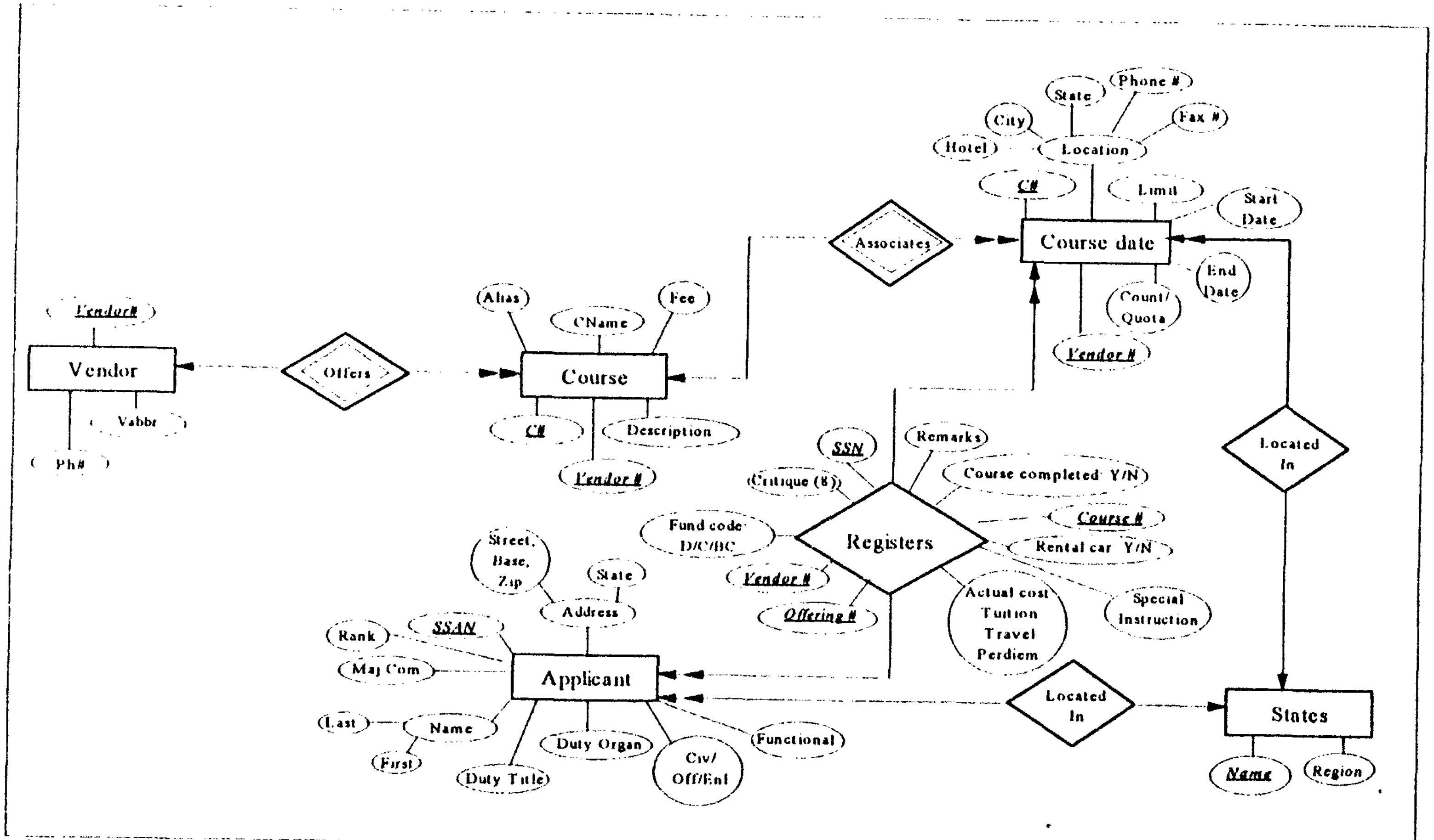


Figure 9: AFIT/CEV-EEC Entity Relationship Diagram

complaints and reprogramming. The six basic user complaints with the current software were:

1. The course availability listing must be reworked from scratch each quarter for release to the field.
2. Determining statistics by MAJCOM is not possible.
3. Identifying what functional organization (JAG, CE, PA, etc.) is using AFIT/CEV-EEC for education is not possible.
4. All reports and figures are manually retrieved, taking more than 60% of their computer time.
5. Large quantities of repetitive and overlapping processing are being performed between the two users.
6. Users complain the current system is unreliable and the user interface is difficult to work with.

A need not mentioned by the users was deduced from the growing national and military emphasis on the environment. With the education program becoming more organized and in demand, an information management system incapable of expansion would prove to only be a short term solution to a long term challenge. With this in mind, we added the need for expandability to the list of software requirements.

Understanding the needs of the users, the process, and the relationship between the process entities, a relational database software package was chosen that could most effectively solve the problems. To chose such a database, THIS

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from $795.00 to $139.95 for promotional reasons. This enabled us to acquire the package to perform the research.

Once the software package was chosen and agreed upon by the users, a list of nine basic criteria for software performance was created. This list was based on information gained through the interviews along with the data flow and entity/relationship diagrams. The software must be able to:

1. Identify both courses and applicant residing in a particular region and major command.
2. Simplify report retrieval by providing outputs from standard information queries.
3. Maintain a course and course availability file for all courses offered. This will allow for a more efficient means of producing a quarterly course listing.
4. Reduce the amount of repetitive report generation performed outside the database.
5. Reduce the amount of labor intensive record keeping.
6. Reduce the amount of repetitive data input.
7. Place database on PC platform (windows) to increase system reliability and user friendliness.
8. Allow users to perform information queries as needed.

9. Allow a user to become the database administrator to set database policy and modify structure or files in the database as needed.

To accomplish these tasks, six tables in Paradox for Windows were created. These tables are: states, course dates, course, vendor, people, and register. A reference to the entity/relationship diagram in Appendix B, figure B6, will show how the diagram was used in software design. Even the entity attributes were taken directly from the entity/relationship diagram. A complete description of the tables used to build the software, along with their relationships, table examples, a dictionary of terms, and trial information queries can be found in Appendix D.

Implementation and Testing. To implement the information management tool, the tables were filled with course data taken from the AFIT/CEV-EEC course guide, arbitrary vendor data, and imaginary personal information (Appendix D). Upon completion, the software was demonstrated and given to the course managers so they could become familiar with the system. After they had time to use the software, we returned to see if they had any questions or needed any further training.

As stated in Chapter III, the test of prototype success is its ability to make the office staff capable of more effeciently managing the education of environmental professionals. Paradox for Windows, combined with the software programming completed for this research, definitely passed this test. Both users, along with their immediate supervisor, were impressed with the software's ability to meet all the criteria developed in stages two and three. The users were especially pleased with the ability to easily operate and alter the software to keep pace with the changing needs of the office.

Analysis. The combination of tools used to define the process and create the relational database was very effective. The use of concepts maps in the initial interview phase proved very helpful in defining the AFIT/CEV-EEC process. Fully understanding the process and the relationships that exist between the process entities was key to the success of the first research objective. To this end, the ability to integrate the data flow diagrams and the entity/relationship diagrams were key to the success we achieved in software design. Throughout the process definition, the involvement of the users at every step added validity to the diagrams and created a sense of ownership among the course managers. Another influential factor of success was the time spent collecting user requirements for software performance. Once these requirements were known, selecting a software package was not difficult. Paradox for Windows, progammed for the specific needs of the AFIT/CEV-EEC office, is a product able to increase the levels of user efficiency and effectiveness. The software is versatile, easy to program, and capable of expansion. Also, the Paradox for Windows user interface is friendly and simple to operate. As indicated by the responses from the course managers, Lynn Kelsie and Rich Evans, throughout the process definition and system development, the end result represents a possible solution to the AFIT/CEV-EEC problem. The course managers now have a tool available they can easily control and adapt to the ever changing needs of a growing educational process.

## Knowledge-based System Development

As discussed in the third chapter, the primary goal of the third research objective is not to produce operational software but to prove or disprove the ability of knowledge-based system(s) (KBS) to create a site coordinator course blueprint and certification process. To restate, the third research objective is:

> Create computer knowledge-based system(s) to determine the feasibility of creating the following:
>
> a. A course blueprint to educate RPMs.
>
> b. A site coordinator certification process.

With this in mind, the approach is focused more at logic development than on software choice or prototype development. While the focus is not software development, two functional KBSs had to be produced to meet the objective. Using the following five stage methodology, presented in chapter III, the research was conducted.

<u>Project Planning</u>. Similar to the database design methodology, an interview with Colonel Owendoff began the project planning for KBS development. He is the source from which the knowledge of the problem was gained. He was interested in seeing if a computer software tool could be developed to standardize site coordinator education and certification. Based on this request for research, the third research objective was created.

The planning to meet this objective began by collecting as much information concerning site coordinator education as possible. As presented in the knowledge-based system section in chapter III, we referenced the MITRE Air Force site coordinator education report, the environmental education research being done by the School of Aerospace Medicine, and the class schedules from the AFIT/CEV-EEC office. As an example of a similar education format, we referenced the Defense Acquisition Workforce Improvement Program created in 1990 (19). Using these sources as a knowledge base, we planned the development of two prototype systems. It is important to emphasize that the design of both the logic and the actual software in both knowledge-based systems is based upon our research and logic formulations, not that of Air Force policy or environmental standards.

Situation Analysis and Representation. To pictorally represent the logic used to create each of the prototypes, we used the dependency diagram. The main strength of these diagrams is their ability to be used as outlines for software development. While the knowledge used in both prototype systems is based on the same information, each system has its own function. The first, a site coordinator educational assistant, was created to establish the ability of KBS technology as a tool to provide site coordinators an educational blueprint for career progression. The second was created to test the feasibility of utilizing KBS technology to certify site coordinators based on education, experience, and training. Since this is the only stage in which the development of these two KBSs differ, they will be discussed separately.

Blueprint KBS. The knowledge used to create this KBS was mostly derived from the AFIT/CEV-EEC class schedule and the MITRE report. Using this information, a set of objectives the knowledge-based system must meet to provide a site coordinator with an educational blueprint was created. This KBS must:

1. Determine if the environmental professional is a site coordinator.
2. If so, determine if the site coordinator is at an introductory or advanced proficiency level.
3. If introductory, identify the courses required for the site coordinator to achieve an advanced rating.

4. If advanced, determine the desired task area of concertration the site coordinator needs to become more proficient in.

5. Based on the response, determine what direction is the most appropriate for the site coordinator to take.

From these objectives, we derived the logic needed to run the knowledge-based system and represented it in a dependency diagram. By definition, the dependency diagram presents the logic in a form easily transposed into programming code (see fig 10). On the far left of the diagram are the questions and possible answers the KBS user would be asked and expected to answer. The triangular boxes immediately to the right hold the logic which takes the user's answers and decides the RPM level or type of advanced education (in rectangular boxes to right). Rule set 3 (large triangular box to right) holds the logic that decides the recommended course based on the RPM level and type of advanced education. With this dependency diagram, we were able to incorporate the overall logic of the system along with the questions and possible answers that were used in the actual program code.

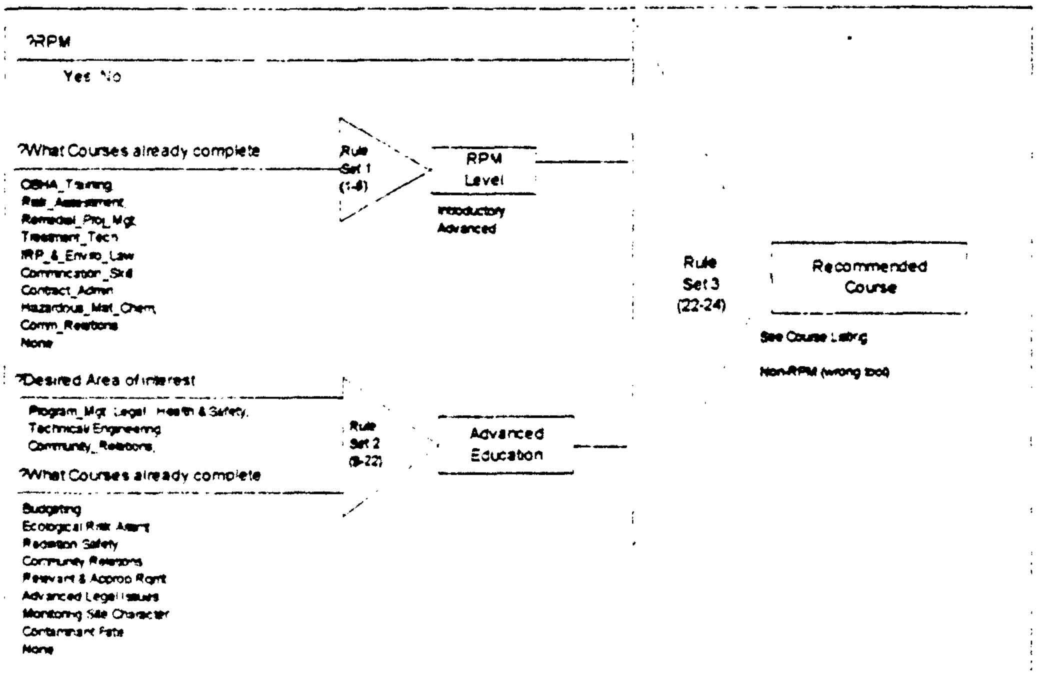

Figure 10: Blueprint Dependency Diagram

Certification KBS. The information used for this KBS was derived from the MITRE report. The approach for determining certification was modeled after the Defense Acquisition Workforce Improvement Program. To determine a site coordinator's level of certification, this KBS had to determine:

1. The preparation level of the site coordinator's completed academic degree.
2. What type of environmental experience the site coordinator has had in his or her career.
3. The site coordinator's level of formal introductory and advanced training.

To meet these objectives, logic was created from the information available and represented in four separate dependency diagrams. The first, (see fig 11) provides an overview of the logic progression.

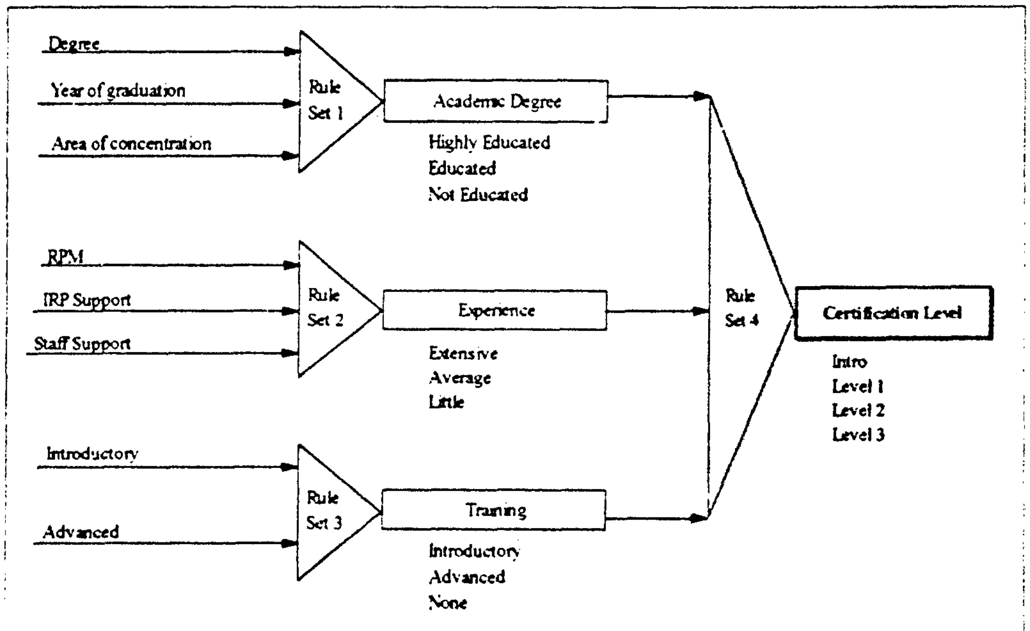


Figure 11: Certification Overview Dependency Diagram

Each of the following dependency diagrams contain the logic, questions, and possible answers to meet the three separate KBS objectives. There exists a separate dependency diagram to determine a site coordinator's academic degree, education, and training (Appendix E). All the dependency diagrams combine to determine the overall certification level of the site coordinator being examined.

System Design. Since the creation of the two KBS prototypes was for research purposes only, an analysis of the existing software shells to determine the one most capable of meeting the research needs was not conducted. Instead, a software shell presented through the Artificial Intelligence course at AFIT was used. The system shell used during the course was VP-Expert. Familiarity with the programming rules enabled the research to focus on meeting the objectives with minimal time spent learning to use the software shell. The Artificial Intelligence course also provided the knowledge to program windows into the software to make a clear demonstration of the knowledge-based system possible. The main criteria in the system design stage was to prove the logic created could operate in a knowledge-based software environment.

System Development. The actual programming of the logic into the software shell was a matter of converting the dependency diagram into VP-Expert rules capable of meeting the KBS objectives. The process of programming consisted of designing and coding a rule for every possible combination of answer to the questions in each KBS. Once this was complete, the path a user can take through the software to recommend courses or determine certification levels depends entirely on the responses. The actual VP-Expert code is contained in Appendix F.

System Testing. To test the systems, we used the software as an environmental manager would. We ran the program, answering the questions in many different ways to ensure the logic used was sound and the software provided the expected responses. To further test logic validity and ability, a demonstration of the prototypes was conducted for Capt Michael Shoukat, intructor of the Artificial Intelligence course at AFIT. After he checked the dependency diagrams, program code, and software operation, he validated the prototypes' ability to meet the objectives. A demonstration of the software was then conducted for Colonel Owendoff (AF/CE) and his staff. They responded positively and are interested in continued research in this area.

Analysis. Based on feedback from the AFIT instructor and Colonel Owendoff's staff, both KBS software prototypes were considered appropriate to solve the problems. They proved that a site coordinator educational blueprint and certification process could be managed through the use of knowledge-based software. The only real flaw in the prototypes is that they are very limited to change. If anyone wished to alter the course offerings or certification criteria, they would have to alter many lines of detailed code. Upon completion of the prototypes we realized the use of a database containing course offerings and certification criteria would have made the software tools much more flexible. If the software design included a database, the system could reference an easily changed file to gain the information needed to make the final decisions.

Conclusion

The three objectives the research and prototype development described in this chapter were meant to solve one problem and answer a two part question. The difficulty the AFIT/CEV-EEC office staff was having managing the large quantities of information was degrading their ability to be effective resource managers. By defining the process by which they provide education to environmental professionals, we were able to build a database prototype specifically tailored to their needs. Both members of the office staff were a part of the software design from the very beginning. This constant designer/customer communication led to a more complete software package and an office staff eager to adopt the software. Given a problem, we defined it and provided a solution, successfully fulfilling our first two research objectives.

The third research objective was born out of Colonel Owendoff's desire to know if KBS technology could be used to create a site coordinator educational course blueprint and certification process. After the information was gathered, we began planning to build two knowledge-based systems to answer the questions. Following the plan, we created the logic and built the prototypes. To ensure the validity of both the logic and coding, we demonstrated the software to both an AFIT instructor of artificial intelligence and Colonel Owendoff's staff. All agreed the KBS prototypes proved knowledge-based technology can be used to create and standardize both a site coordinator course blueprint and certification process.

One success of this research is the flexibility of the models to define the process and represent the logic. If, in the future, researchers or systems users choose to change the software shells, the information and the format represented in the models could be used as a framework for the new software. Viewing this research as only a means to software design lessens the importance of process definition and logic development.

The final chapter of this thesis, Chapter V, will draw conclusions from the entire research effort and make recommendations for future research.

## V. Conclusions and Recommendations

By the end of Fiscal Year 1991, the Air Force had identified 4,354 contaminated sites. Much like the 177 toxic sites at McClellan AFB, bases across the country and throughout the world are filled with chrome, lead, solvents, and many other toxics that are rendering water supplies unusable and endangering the health of millions of people living in and around these bases. Air Force officials continue to identify more contaminated sites with no end in sight. Since the cleanup of these toxic materials involves diverse, complex activities, the Air Force created the duty position of Remedial Project Manager (site coordinator) to manage site cleanup efforts. In order for these site coordinators to effectively act as team leaders for project groups of specialists and support personnel tasked with the planning, execution, and evaluation of site cleanup, they must be provided with relevant education and training.

This chapter reviews the current literature focused at meeting the education and training needs of Air Force site coordinators. The chapter then presents the methodology used and results of the research completed to meet the objectives of this thesis. Finally, the specific recommendations born out of the research are discussed.

Environmental Literature

Before the work to meet the research objectives could begin, environmental research efforts and similar Air Force programs had to be reviewed. This review discovered that the Massachusetts Institute of Technology for Research and Engineering (MITRE) had been tasked with developing the job requirements, curricula, and educational resources to provide Air Force site coordinators with the education and training needed to effectively manage contaminated Air Force sites. Also, the School of Aerospace Medicine has created working groups to develop a comprehensive, integrated environmental education and training plan. These working groups are attempting to define a USAF environmental, safety, and occupational health education program and identify environmental education sources. A review of Air Force programs addressing concerns similar to environmental needs discovered an education program created by the Defense Acquisition Workforce Improvement Act of 1990. This act developed a career development program for acquisition personnel complete with mandatory course requirements and structured career progression.

Once the relevant environmental research was examined, a review of the existing tools that could be helpful in meeting the research objectives was conducted. By reviewing tools to meet objectives one and two, we learned of the interview, concept maps, entity/relationship and data flow diagrams, and IDEF. Each of these techniques had been successful in the past at defining processes. With many diverse tools available, a choice had to be made as to which tools or combination of tools was best suited for our research needs. Due to IDEF's complex nature, eliminating that technique from the group was not difficult. Choosing an effective combination from among the remaining tools was not as easy. Our first efforts at defining the process began with the use of the interview and concept maps. The information gained from this combination led our research away from concept maps and to a combination of entity/relationship and data flow diagrams.

Research of tools to support knowledge-based system development did not provide as many choices. The only useful tools to support both logic and programming development were flowcharts and dependency diagrams. Since flowcharts are more commonly used in programming basic computer languages, dependency diagrams were selected. These dependency diagrams are used extensively in developing both the logic and actual knowledge-based computer software.

Methodology and Results

Throughout this research, the objectives have been discussed separately. The first two objectives have been referred to as process definition and the last, KBS development. For clarity of presentation, the research objectives are:

1. Define the process by which Air Force officials identify and educate environmental personnel (including RPMs) through the office of AFIT/CEV-EEC.
2. Develop a prototype computer software package designed to streamline AFIT/CEV-EEC functions.
3. Create computer knowledge-based system(s) to determine the feasibility of creating the following:
   a. A course blueprint to educate RPMs.
   b. A site coordinator certification process.

Process Definition. By personally interviewing the AFIT/CEV-EEC course managers and transposing the process information onto data flow diagrams, we were able to define the office process in a detailed manner. Using these data flow diagrams as a basis to create the entity/relationship diagrams moved the research one step closer to actual software development. The next step was to choose the software package. Speaking with database users and computer experts along with referring to relevant literature led to the selection of Paradox for Windows. This software is capable of meeting all the identified user needs and is able to expand to adapt to future office requirements.

Once the software package was chosen and the entity/relationship diagram was validated through the course managers, the database system was created. The system was then demonstrated to the course managers and handed over for their use. The system was also demonstrated to Col Owendoff and his staff. All who were exposed to the system were satisfied it was capable to performing well in the AFIT/CEV-EEC environment.

KBS Development. The basis for the logic used to create the prototype knowledge-based systems was the research being conducted by MITRE and the School of Aerospace Medicine. The structure of the Defense Acquisition Workforce Improvement Program was used as an example of a successful Air Force program. Using this material, we transposed the logic for two knowledge-based systems into dependency diagrams able to support KBS programming. Upon completion of these diagrams, the knowledge-based software package VP-Expert was selected and coded with rules designed to represent the logic contained in the dependency diagrams. Since a site coordinator course blueprint and certification process do not currently exist, the successful demonstration of these knowledge-based systems only proved that KBS technology could be used to support such programs. The programs and the logic behind them would have to be thoroughly researched before any computer system could aid in their operation.

## Recommendations

The techniques used in this research for both the process definition and logic development proved to be a sound methodology. These techniques could easily and effectively be adapted to a wide variety of problems. Also, these tools, especially those used in the process definition stage, can be used regardless of the type of software employed. In fact, each of the software packages chosen could be replaced without altering any of the diagrams. The main reason for this flexibility is the time and effort spent at thoroughly defining the process and developing the logic. The focus of any effort to produce software to solve a problem must be at solving the problem independent of the software. If more time is spent developing the software than solving the problem, the end product could be a highly technical, computerized problem instead of a solution.

The prototype relational database created from this research is capable of meeting the needs of the AFIT/CEV-EEC course managers and could easily be implemented to a working database. If the AFIT/CE Dean decides to implement Paradox for Windows throughout his staff, the work completed for this research could be used as a basis for a civilian contract. If, before implementation, the course managers decide Paradox for Windows is not the preferred software package, they could adapt another package for their use. The existing data flow and entity/relationship diagrams could be used to support such a project.

Because no standards exist, the logic developed to support the creation of the two knowledge-based systems was not based on any Air Force structured programs or directives. While the tools used to represent this logic are sound, the logic behind a site coordinator course blueprint and certification process must be standardized and implemented by Air Force officials before any software tool can be implemented. Looking to programs such as the Defense Acquisition Workforce Program could prove very effective in establishing course direction and certification criteria for Air Force site coordinators.

By proving that KBS technology could be used to support site coordinator issues, these results have sparked the need for more in-depth research in the area. If KBS technology is used in future research efforts, choosing a software shell other than VP-Expert would be advantageous. The system is not conducive to user interaction, programming development, or database integration. A review of available KBS software packages, much like our review of relational database packages, would provide the researchers with a more powerful, flexible, user-friendly software tool more capable of supporting operational KBS programming.

## Appendix A

### Concept Maps

The first concept map, the decision process model (see fig A1), was created from information provided by Colonel Owendoff in a January 1993 interview. In this map, the AFIT/CEV-EEC decision process is modeled. The entities presented accross the top of the map (historical data, education and training, etc.) are part of the course managers decision process. The attributes presented below each entity (accessions, base requirements, budget, etc.) are all subcategories of the entities.

The second concept map, the AFIT/CEV-EEC decision map (see fig A2), is an alternate, more flexible method of presenting the information presented in the first concept map. This map is an overview of the entities involved in the course managers' decision process and the relationships between. This map and the five decomposition maps were developed using information gained through interviews with Lt Col Maricle and Maj Duncan, staff members of AFIT School of Civil Engineering and Services. Technical advice and formulation assistance was given by Lt Col Schneider, one of the thesis advisors.

The third, fourth, and fifth decision maps are the first through third iterations of the "WHO" entity presented in fig A2 (see figs A3, A4, A5). Each iteration is a result of discussions with Lt Col Maricle and Maj Duncan and a review of the environmental education research completed by the School of Aerospace Medicine. The final iteration (see fig A5) most accurately represents the environmental personnel who apply for courses through the AFIT/CEV-EEC office.

The "AIR FORCE EDUCATION GOALS" entity is decomposed in figure A6 and the "BUDGET" entity is decomposed in figure A7. Both maps were developed at the same time, using the same process, as the "WHO" entity decompostion was developed. Since these decompostions were not as complex, only one iteration was needed.

As stated in Chapter V, these concept maps were not used for system design. However, they did provide the basis for the data flow and entity/relationship diagrams.

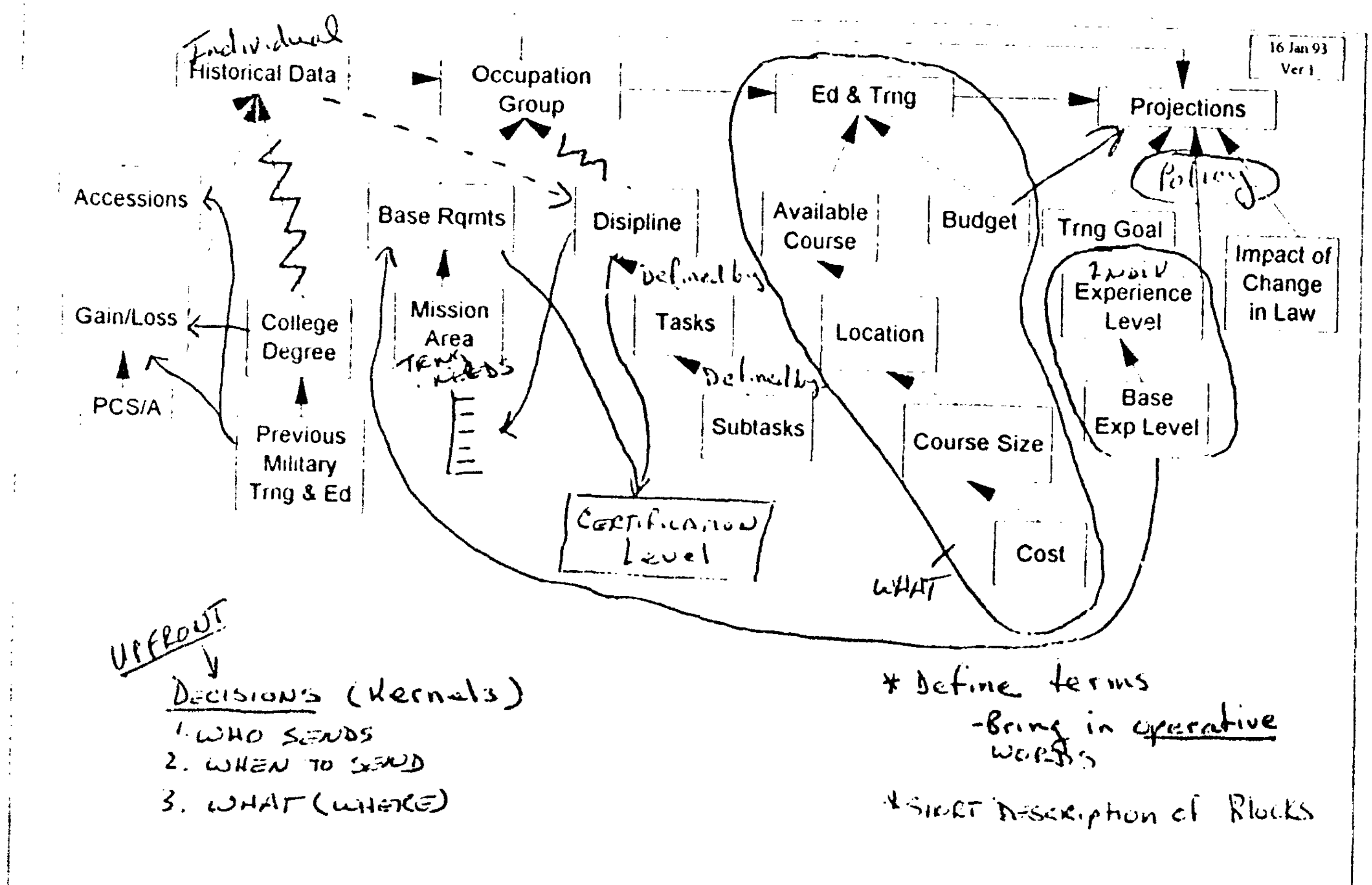


Figure A1: Broad Scope Concept Map

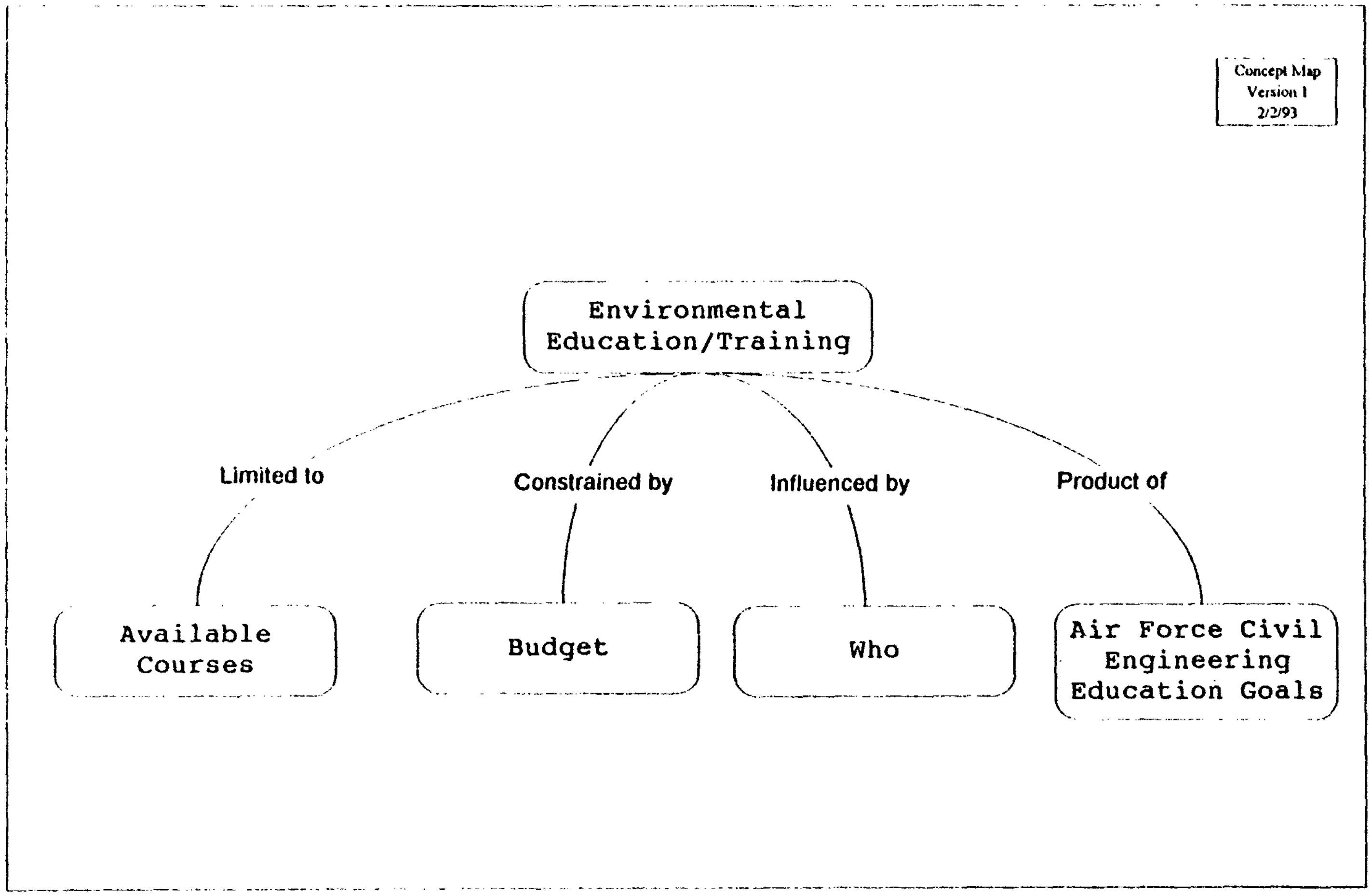


Figure A2: Decision Concept Map (1.0)

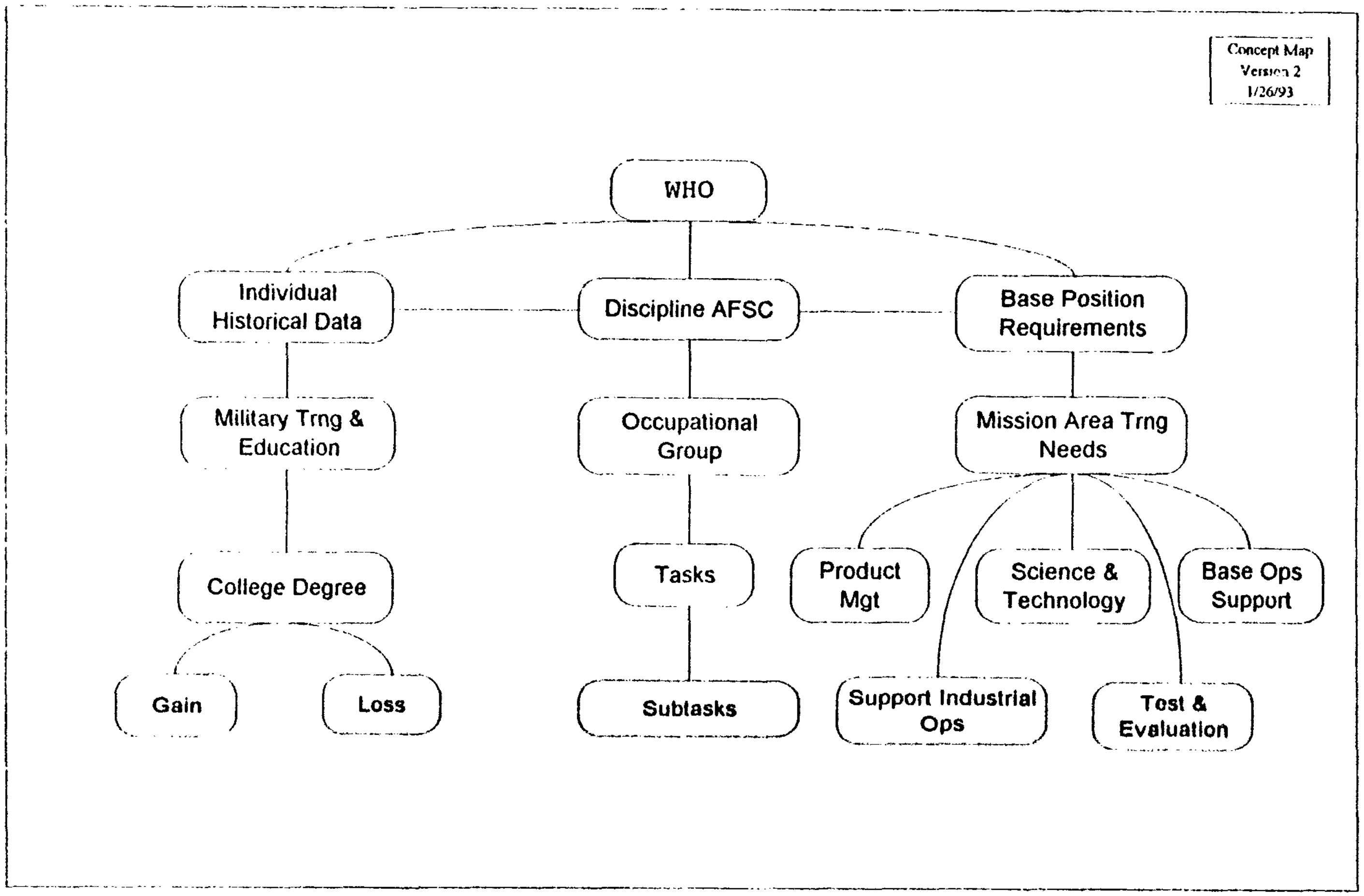


Figure A3: Who Kernel

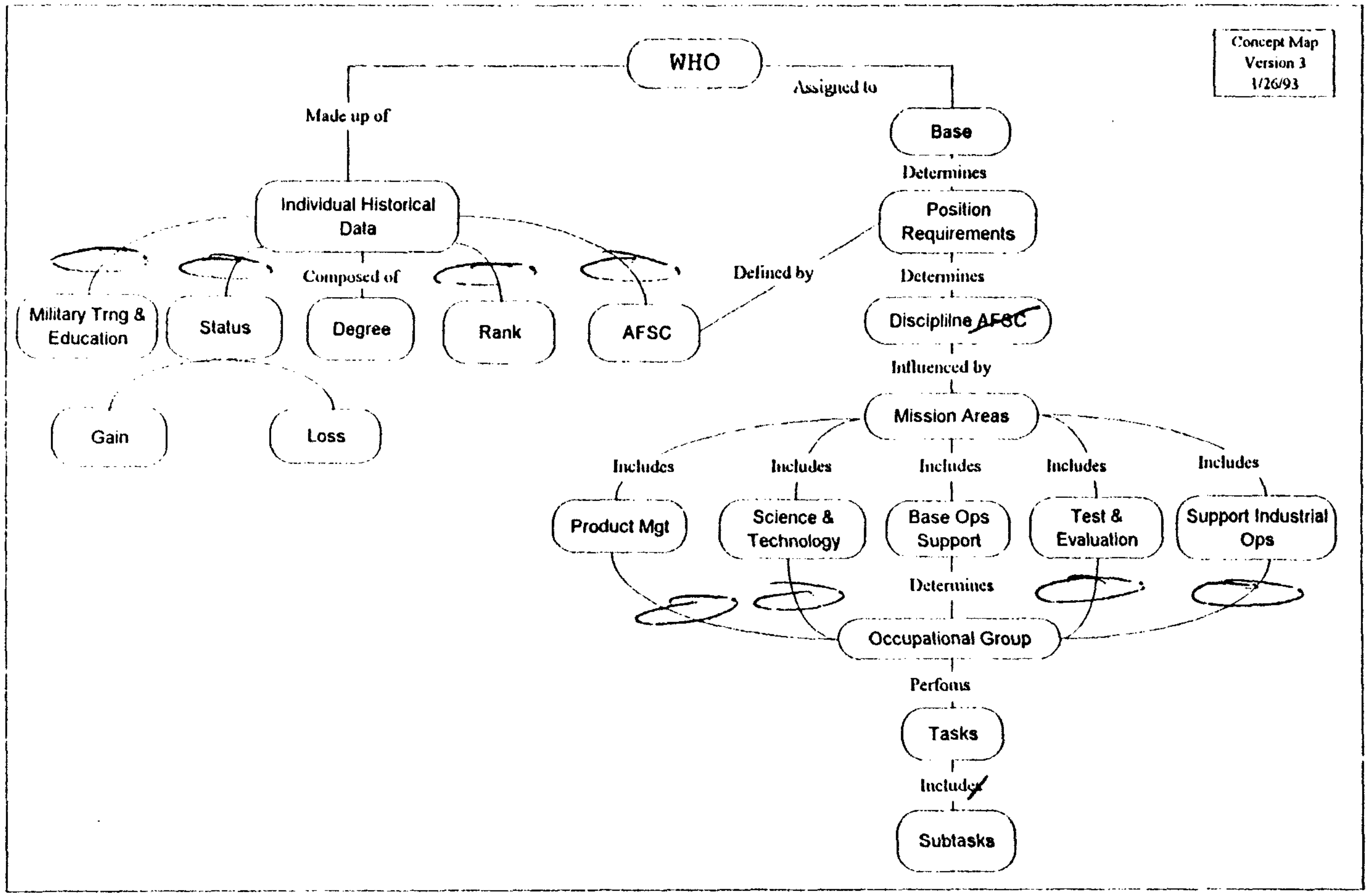


Figure A4: Revised Who Kernel

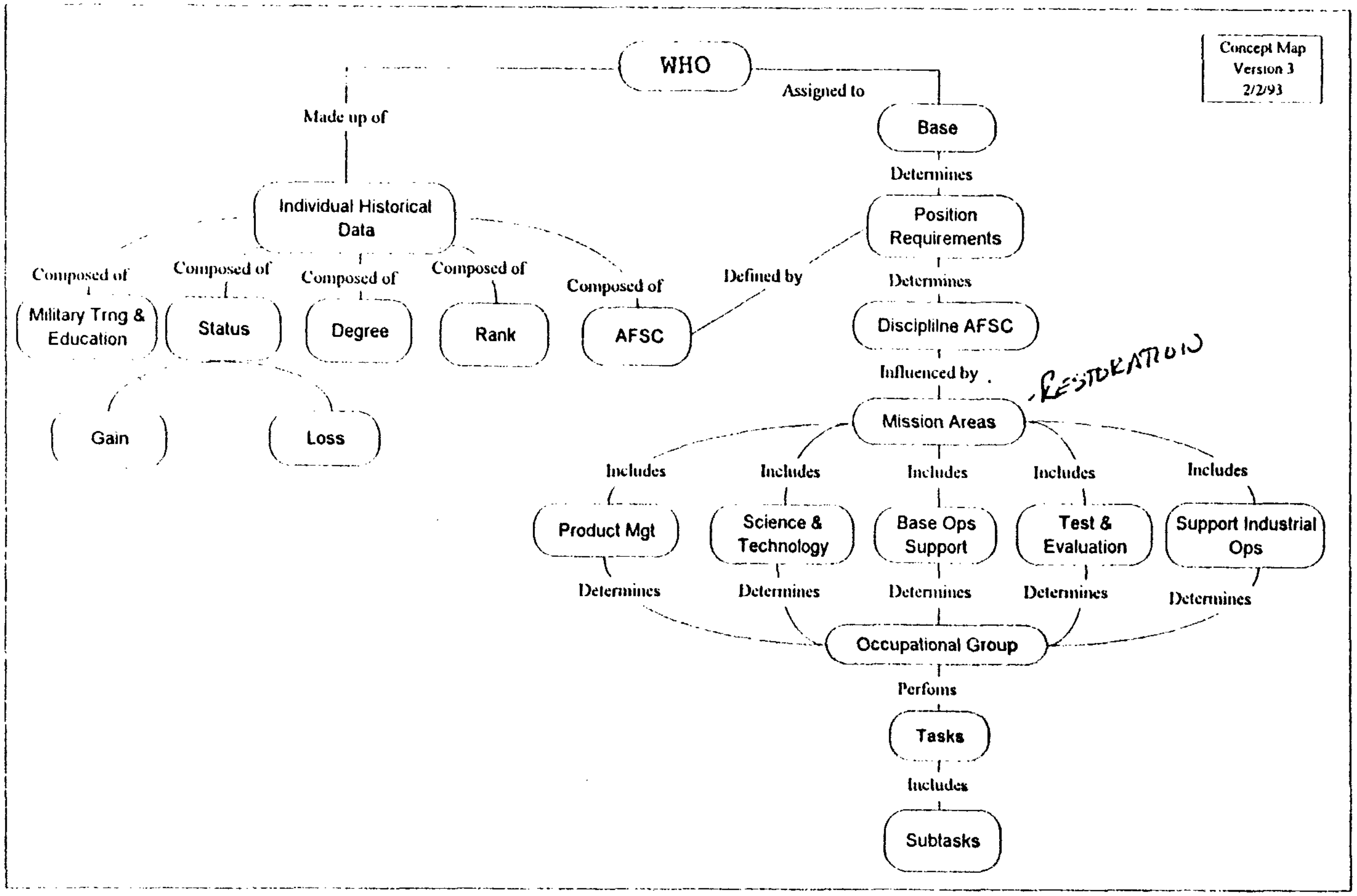


Figure A5: Completed Who Kernel

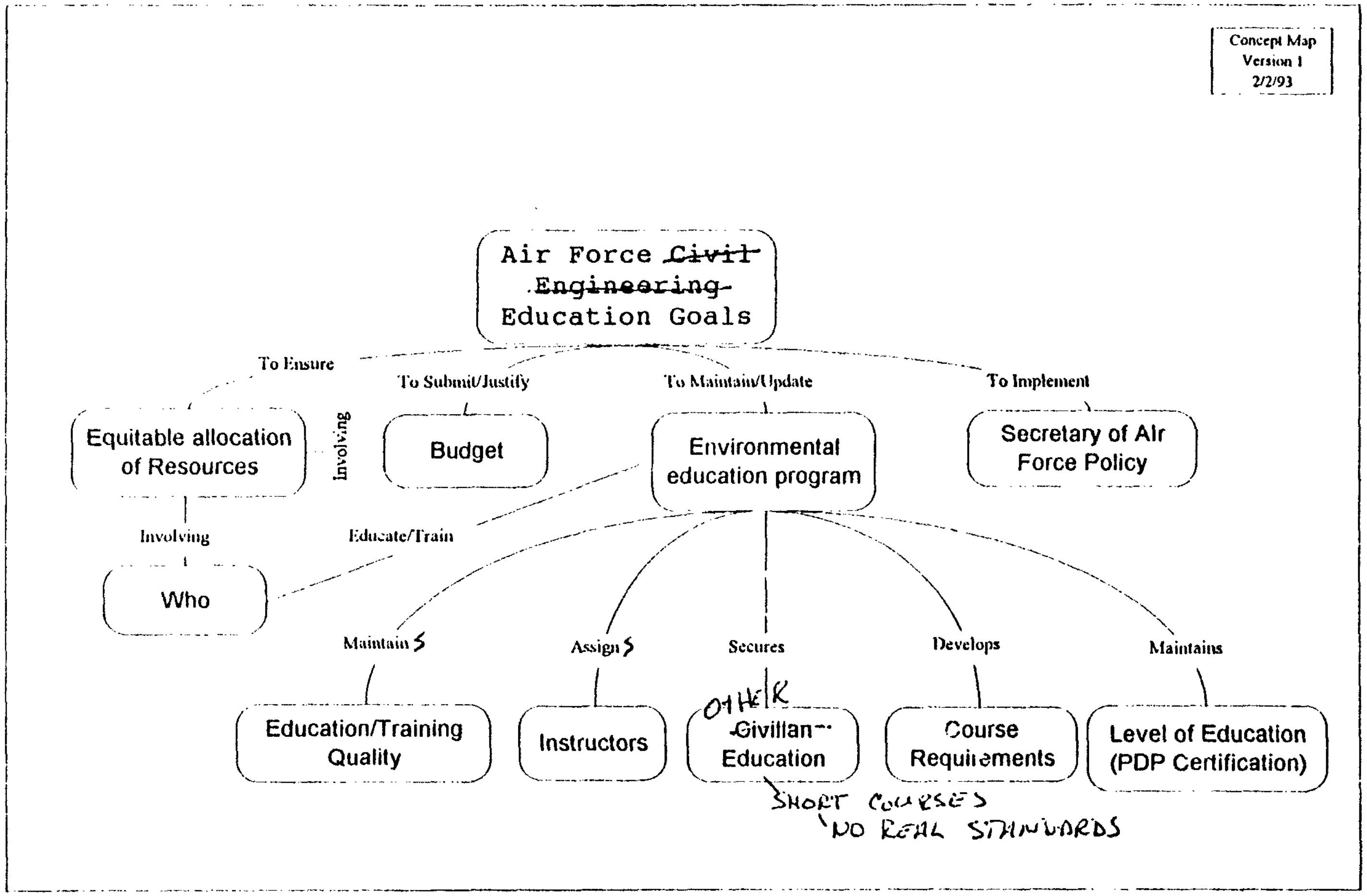


Figure A6: Goals Kernel

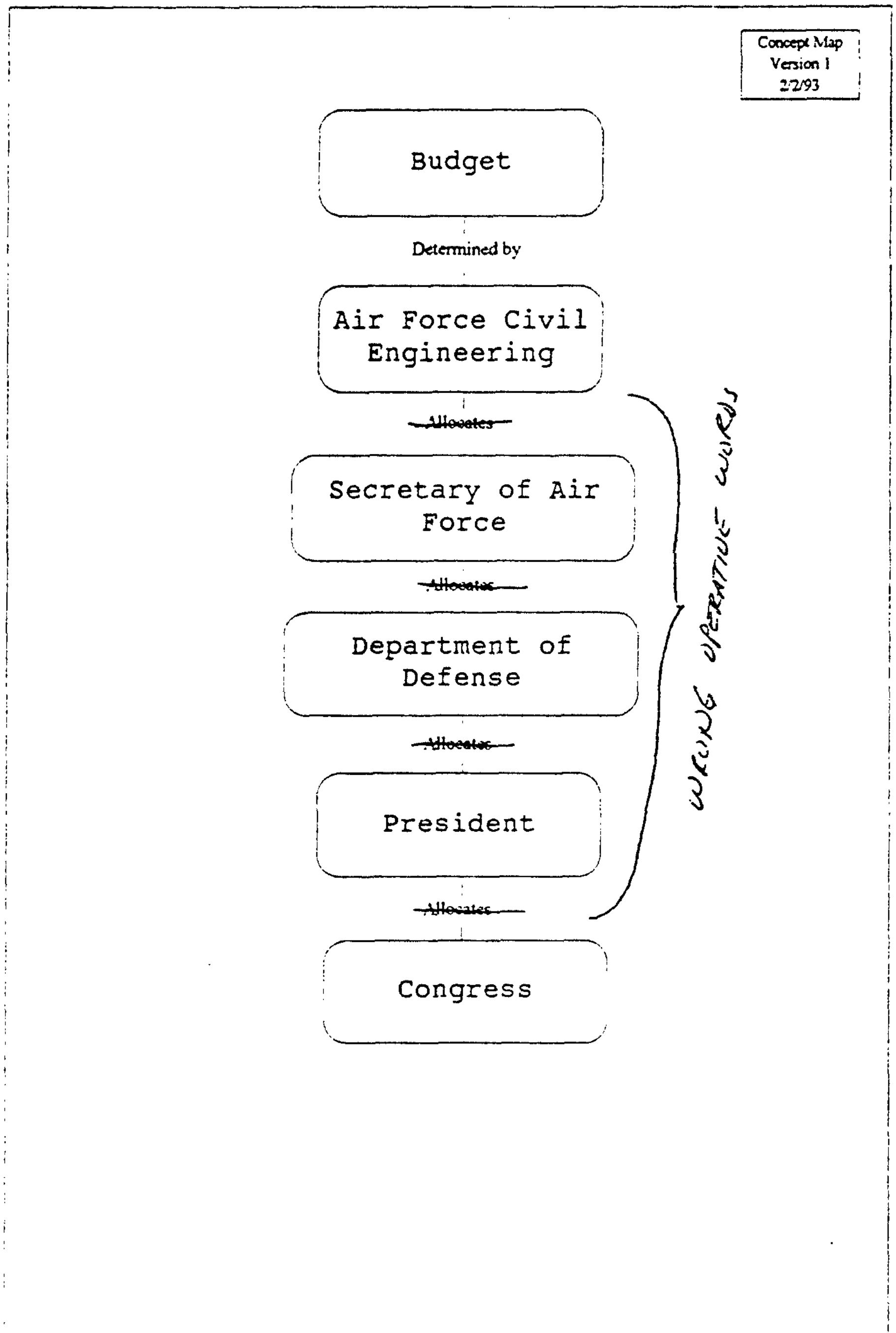


Figure A7: Budget Kernel

## Appendix B

### Data Flow Diagrams

The first diagram in this appendix (see fig B1) pictorially represents the overview of the AFIT/CEV-EEC course manager functions. Using the information gained from the initial interview stage and the use of concept maps, the overview data flow diagram was created. In this diagram, the course managers are performing activities to directly support three entities contained in rectangular boxes: student, Dean of the AFIT School of Civil Engineering and Services department, and Head of the Department of Environmental Management. These course managers perform four main activities contained in the sphere shapes: process student requests, produce course listings, produce financial reports, and produce student statistics. To efficiently perform these activities, the course managers access and update three data files: accounting, student data, and course data. For example, the student sends a request to attend a course to the course managers. The course managers update the student data file with the new student information. Periodically, weekly or bi-weekly, the course managers use the information stored in the student data file to produce student statistical reports for the Dean of the AFIT School of Civil Engineering and Services.

Once the process overview was complete and validated through discussions with the course managers, each of the activities was decomposed to show process detail. The steps of interviewing the course managers, developing draft data flow diagrams, and finalizing the diagrams through continued interviews was taken for each of the decomposed data flow diagrams (see figs B1-B4).

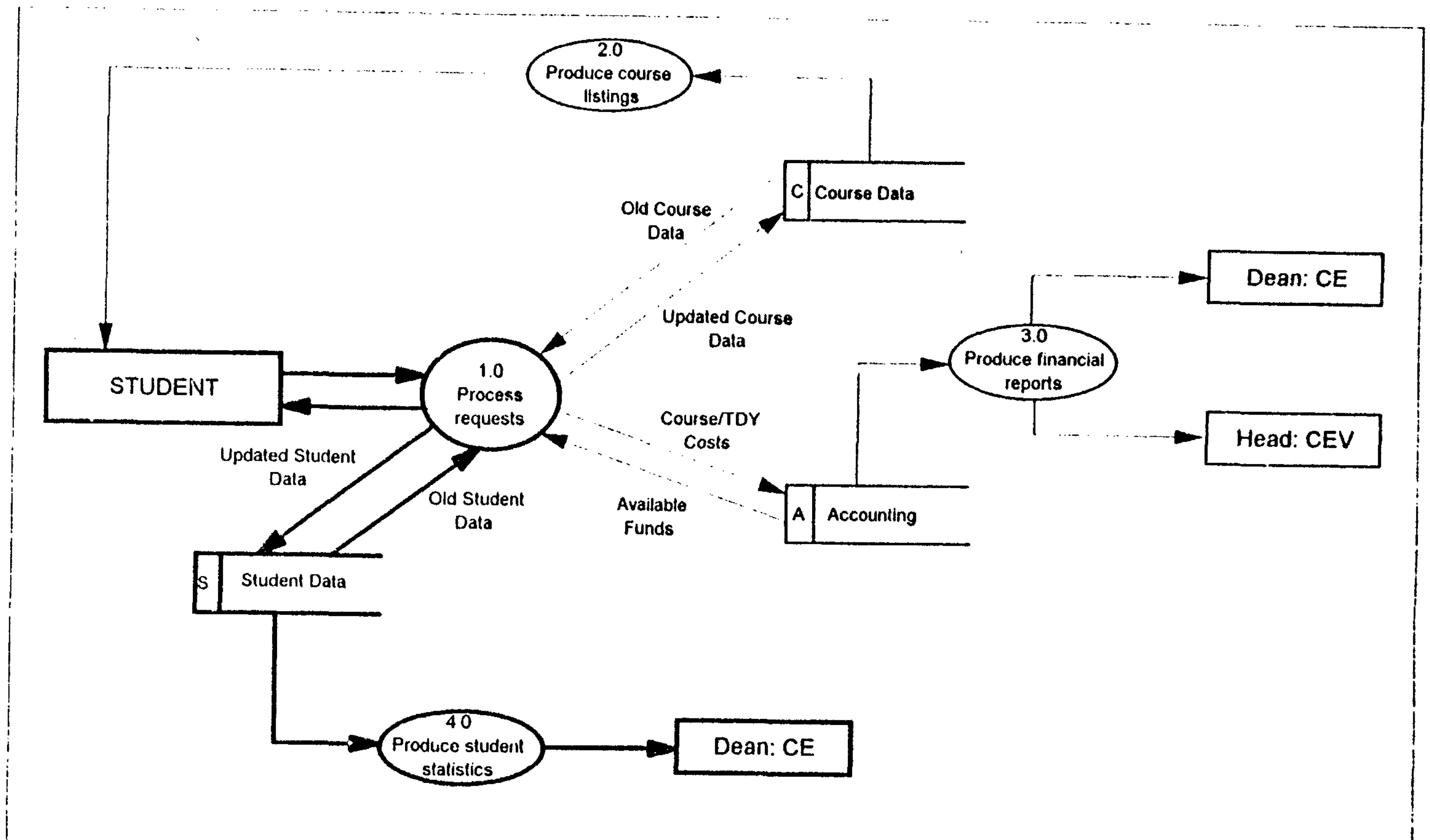


Figure B1: AFIT/CEV-EEC Data Flow Diagram

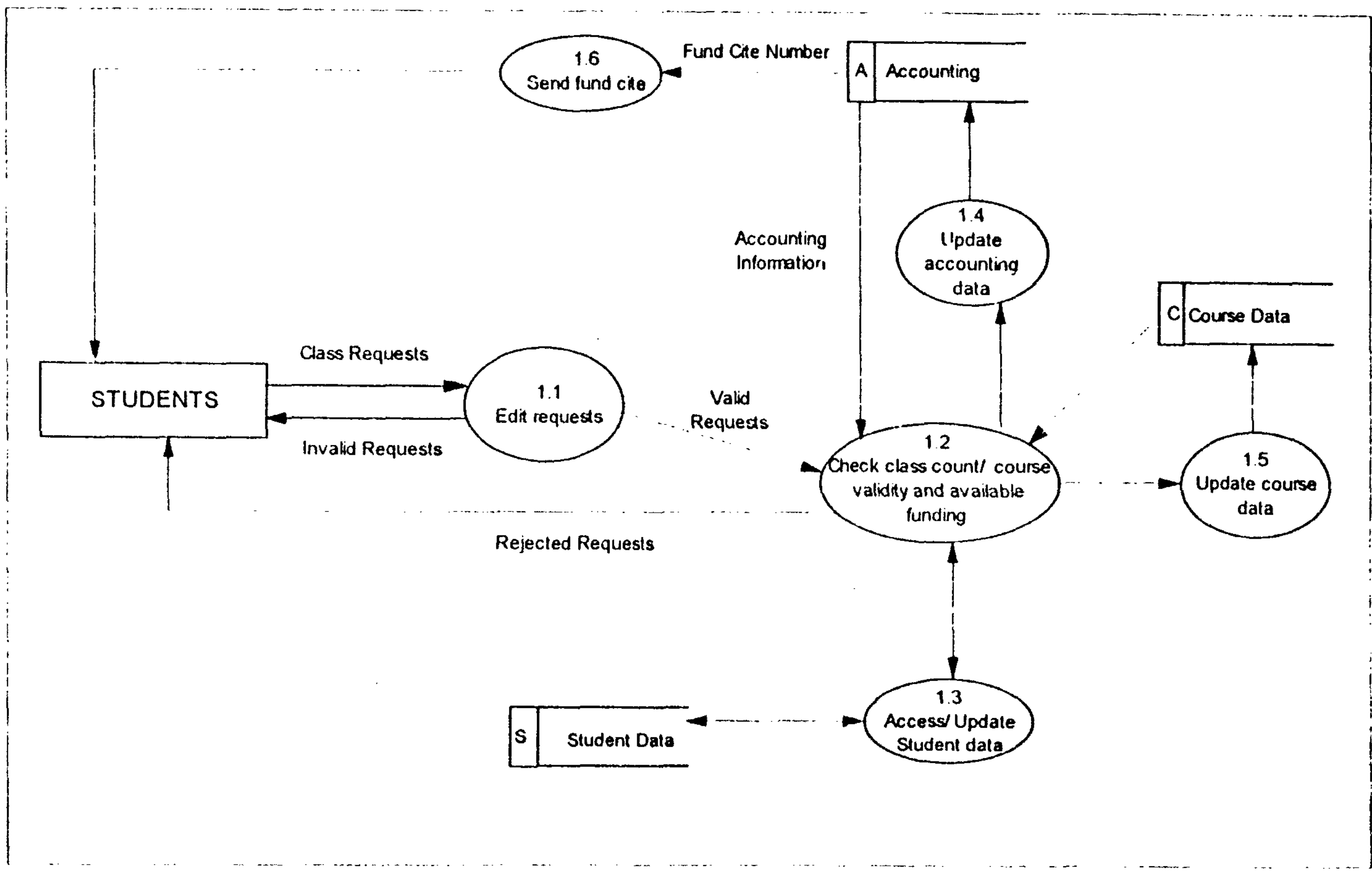


Figure B2: AFIT/CEV-EEC Student Request Process (1.0)

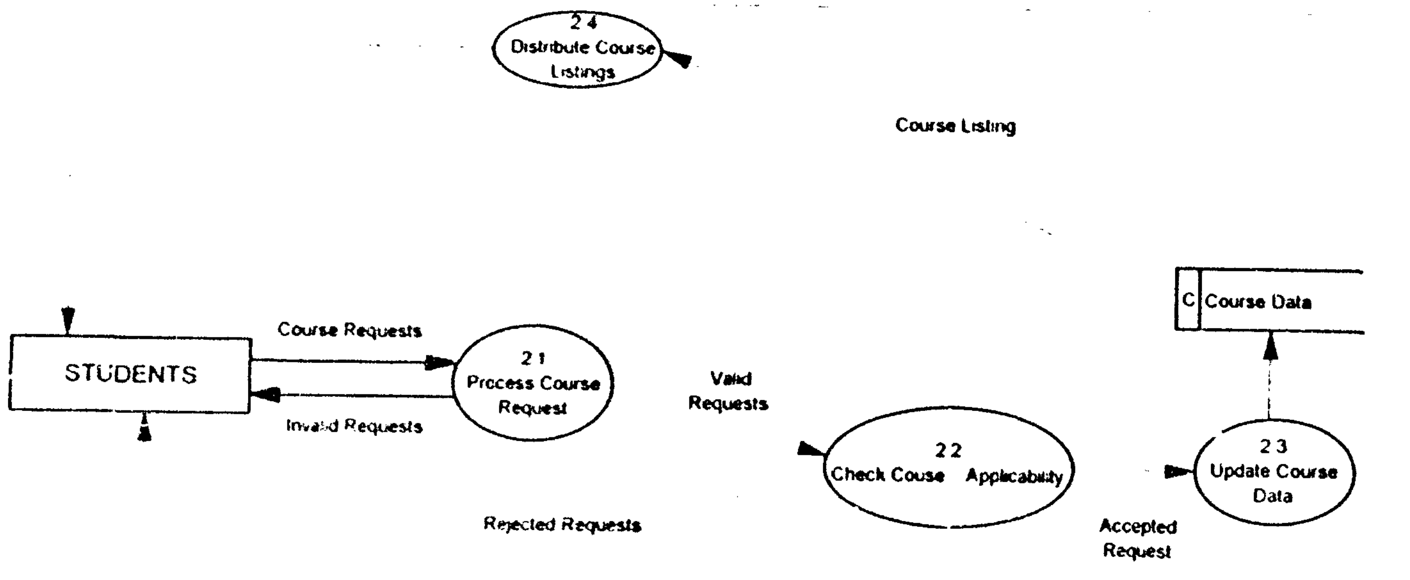


Figure B3 AFIT/CEV-EEC Course Listing Process (2 0)

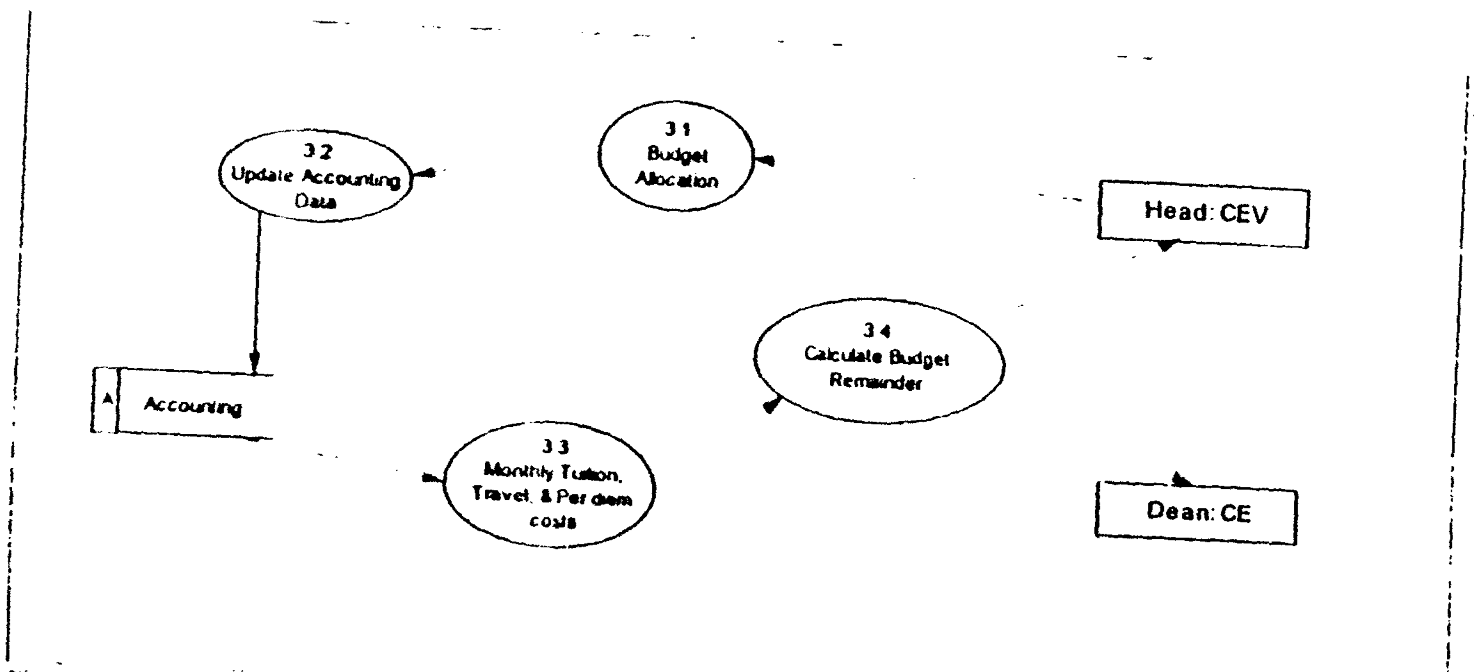


Figure B4 AFIT/CEV-EEC Accounting Process (3.0)

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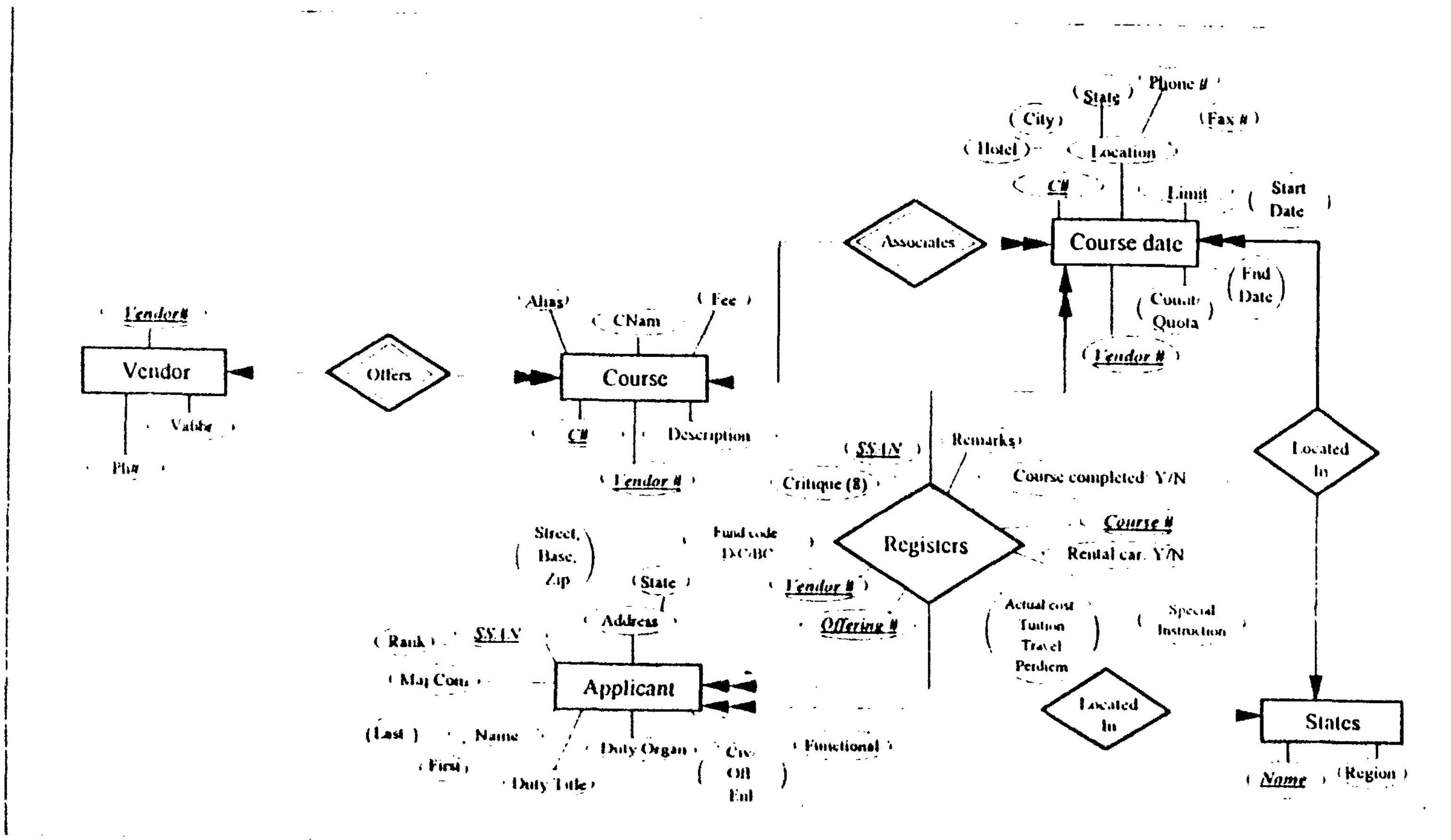


Figure B6: AFIT/CEV-EEC Entity Relationship Diagram

## Appendix C

| Products listed in Alphabetic order | Access 1.0 | Approach 2.0 | Forest & Trees 3.0 | ObjectView 2.0 | Paradox for Windows | PowerBuilder 2.0 | Q+E Database | Quest 2.0 | SQL Windows 4.0 |
|---|---|---|---|---|---|---|---|---|---|
| Cost | $495 | $399 | $790 | $1,799 | $795 | $1,495 | $299 | $595 | $1,995 |
| SYSTEM REQUIREMENTS: | | | | | | | | | |
| CPU | 386 | 286 | 386 | 386 | 386 | 386 | 286 | 386 | 386 |
| RAM recommended | 4MB | 4MB | 4MB | 4MB | 8MB | 4MB | 2MB | 4MB | 4MB |
| Hard disk space required | 14MB | 4MB | 4MB | 12MB | 12MB | 8.5MB | 4MB | 10MB | 10MB |
| File access | R/W | R/W | Read only | R/W | R/W | R/W | R/W | R/W | R/W |
| Local database engine | Yes | Yes | No | Yes | Yes | No | Yes | Yes | Yes |
| WINDOWS INTERFACE: | | | | | | | | | |
| MDI | Yes | Yes | No | Yes | Yes | Yes | No | Yes | Yes |
| Drag and drop | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes |
| Quick report generator | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes |
| Multitable forms with pop-up list box for data entry | Yes | Yes | N/A | Yes | Yes | Yes | No | Yes | Yes |
| QBE (query by example) | Yes | No | No | Yes | Yes | No | Yes | No | No |
| QBF (query by form) | Yes | Yes | No | Yes | No | No | Yes | Yes | Yes |
| Interactive SQL | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Built in charting and graphing | Yes | No | Yes | Yes | No | No | No | No | No |
| PROGRAMMING ENVIRONMENT: | | | | | | | | | |
| Language based on Basic or C | Basic | Neither | N/A | Both | ObjectPAL | Basic-like | Macro language | N/A | C-like |
| Embedded SQL | Yes | N/A | N/A | Yes | No | Yes | N/A | N/A | Yes |
| Extensible via DLL | Yes | No | No | Yes | Yes | Yes | Yes | No | Yes |
| Object-oriented | No | No | N/A | Yes | Yes | Yes | No | N/A | Yes |
| Debugger | Yes | N/A | N/A | Yes | Yes | Yes | N/A | N/A | Yes |
| Code check-in/check-out | No | N/A | N/A | Yes | No | Yes | N/A | Yes | Yes |
| Code/object reusability | Yes | N/A | N/A | No | Yes | Yes | N/A | N/A | Yes |
| Runtime fee | $495 | N/A | No | $199/user | No | $895 | N/A | N/A | $250 |
| Vendor training (cost/day) | None | Included | $595/2day | $1299/3day | None | $495/4day | $300/day | $595/2day | $1595/5day |

Figure C1: Windows Database Comparison (24: 426-427)

Appendix D

Database Table Structures

This database consists of six tables containing data on vendors, courses offered by vendors, dates and locations of course offerings, registration information, and information on course applicants. The sixth table, the State table, contains only two values; the state and corresponding EPA region. It is used as a lookup table for the other tables which need to access the region a particular state is in. A detailed structure for each table follows.

**Key to Field types used in these tables:

| | |
|---|---|
| Alphanumeric | A |
| Number | N |
| Currency | $ |
| Date | D |
| Formatted memo | F |

TABLE 1

VENDOR FILE STRUCTURE

| Field # | Field name | Type | Size | Key | Required Value | Min Value | Max Value | Default Value | Picture Value |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Vendor# | A | 2 | * | * | 1 | 99 | | |
| 2 | Vendor name | A | 40 | | * | | | | |
| 3 | Vendor abbreviation | A | 12 | | | | | | |

TABLE 2

COURSE FILE STRUCTURE

| Field # | Field name | Type | Size | Key | Required Value | Min Value | Max Value | Default Value | Picture Value |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Course # | A | 3 | * | * | 1 | 999 | | |
| 2 | Vendor # | A | 2 | * | * | 1 | 99 | | |
| 3 | Course name | A | 80 | | * | | | | |
| 4 | Description | F | 80 | | * | | | | |
| 5 | Fee | $ | | | | | | | |
| 6 | Alias | A | 80 | | | | | | |

TABLE 3

COURSE DATE (C-DATE) FILE STRUCTURE

| Field # | Field name | Type | Size | Key | Required Value | Min Value | Max Value | Default Value | Picture Value |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Vendor # | A | 2 | * | * | 1 | 99 | | |
| 2 | Course # | A | 3 | * | * | 1 | 999 | | |
| 3 | Offering # | A | 2 | * | * | 1 | 99 | | |
| 4 | Start date | D | | | * | | | | |
| 5 | End date | D | | | * | | | | |
| 6 | City | A | 12 | | * | | | | |
| 7 | State | A | 2 | | | | | | && |
| 8 | Limit | N | | | | 1 | 40 | | |
| 9 | Count | N | | | | 1 | 40 | | |
| 10 | Hotel | A | 15 | | | | | | |
| 11 | Phone | A | 14 | | | | | | (###)###-#### |
| 12 | Fax | A | 14 | | | | | | (###)###-#### |

TABLE 4

REGISTRATION INFORMATION (REGISTER) FILE STRUCTURE

| Field # | Field name | Type | Size | Key | Required Value | Min Value | Max Value | Default Value | Picture Value |
|---|---|---|---|---|---|---|---|---|---|
| 1 | SSAN | A | 11 | * | * | | | | ###-##-#### |
| 2 | Vendor # | A | 2 | * | * | 1 | 99 | | |
| 3 | Course # | A | 3 | * | * | 1 | 999 | | |
| 4 | Offering # | A | 2 | * | * | 1 | 99 | | |
| 5 | Fund code | A | 1 | | * | | | | |
| 6 | Rental car | A | 3 | | | | | No | {Yes.No} |
| 7 | Course complete | A | 3 | | * | | | No | {Yes.No} |
| 8 | Per diem | N | | | | | | | |
| 9 | Travel | N | | | | | | | |
| 10 | Tuition | N | | | | | | | |
| 11 | Car rental costs | N | | | | | | 0.00 | |
| 12 | Special instructions | A | 40 | | | | | | |
| 13 | Critique 1 | A | 1 | | | | | | |
| 14 | Critique 2 | A | 2 | | | | | | |
| 15 | Critique 3 | A | 1 | | | | | | |
| 16 | Critique 4 | A | 1 | | | | | | |
| 17 | Critique 5 | A | 1 | | | | | | |
| 18 | Critique 6 | A | 1 | | | | | | |
| 19 | Critique 7 | A | 1 | | | | | | |
| 20 | Critique 8 | A | 1 | | | | | | |
| 21 | Remarks | F | 40 | | | | | | |

## TABLE 5

## APPLICANT (PEOPLE) FILE STRUCTURE

| Field # | Field name | Type | Size | Key | Required Value | Min Value | Max Value | Default Value | Picture Value |
|---|---|---|---|---|---|---|---|---|---|
| 1 | SSAN | A | 11 | * | * | | | | ##-#-#### |
| 2 | Last name | A | 15 | | * | | | | |
| 3 | First name | A | 10 | | * | | | | |
| 4 | Rank | A | 5 | | | | | | |
| 5 | Civ enl off | A | 1 | | * | | | | |
| 6 | Functional area | A | 3 | | | | | | |
| 7 | Duty title | A | 20 | | * | | | | |
| 8 | Duty phone | A | 14 | | | | | | (###)###-#### |
| 9 | Organization | A | 12 | | * | | | | |
| 10 | Base | A | 15 | | | | | | |
| 11 | Street | A | 20 | | | | | | |
| 12 | State | A | 2 | | | | | | && |
| 13 | Zip | A | 10 | | | | | | *5{#}-*4{#} |
| 14 | MAJCOM | A | 10 | | | | | | |

## TABLE 6

## STATE FILE STRUCTURE

| Field # | Field name | Type | Size | Key | Required Value | Min Value | Max Value | Default Value | Picture Value |
|---|---|---|---|---|---|---|---|---|---|
| 1 | State | A | 2 | * | * | | | | |
| 2 | Region | A | 2 | | * | | | | |

## Referential Integrity

Referential integrity has been established between the tables in the manner shown in the diagram below. Any attempts to delete records in a parent table will cause a cascade deletion effect throughout the child tables, (i.e., as the tables are currently set, deletion of a vendor will cascade deletions of courses offered by that vendor which will casue deletions of course offerings for that course). As the tables are now constructed, strict referential integrity between the course dates table and the registration table has not been established. This is to insure that the deletion of a vendor will not cascade to the registration file (primary historical file) and cause the deletion of records for applicants who have already completed courses. When a course or a vendor needs to be deleted it will be necessary to use a query to find all applicants in the registration file who have applied for, but have not yet attended a deleted course or the course of a deleted vendor. Referential integrity between the applicant table and the registration table will be enforced as shown.

TABLE 7

REFERENTIAL INTEGRITY RELATIONSHIP

| Vendor | Courses | Course dates | Registration | Applicant |
|---|---|---|---|---|
| Vendor #-------> | Vendor# | Vendor # | Vendor # | |
| | Course #-------> | Course # | Course # | |
| | | Offering #<--no link---> | Offering # | |
| | | | SSAN <---------------> | SSAN |

Functional Dependencies

The data for the database has been arranged in such a manner that the primary keys are contingent on the functional dependencies. Listed below are the keys to each table and the attributes whose values are dependent on them.

Vendor # ----------> Vendor name, Vendor abbreviation

Vendor #, Course # ------------> Course name, Description, Fee, Alias

Vendor #, Course #, Offering # --------------> Start date, End date, City, State, Limit, Count, Hotel, Phone, Fax

State ----------> Region

SSAN ---------> Last name, First name, Rand, Civ enl off, Duty title, Duty phone, Organization, Base, Street, State, Zip, MAJCOM

Vendor #, Course #, Offering #, SSAN ---------> Vendor name, Vendor Addreviation, Course name, Description, Fee, Alias, Start date, End date, City, State, Course region, Limit, Count, Hotel, Phone, Fax, Fund code, Rental car, Course complete, Per diem, Travel, Tuition, Car rental costs, Special instructions, Critique 1,2,3,4,5,6,7,8, Last name, First name, Rank, Civ enl off, Duty title, Duty phone, Organization, Base, Street, State, Zip, MAJCOM, Users region

## Database Tables

| State | Region | State | Region | State | Region |
|---|---|---|---|---|---|
| AK | 10 | LA | 6 | OK | 6 |
| AL | 4 | MA | 1 | OR | 10 |
| AR | 6 | MD | 3 | PA | 3 |
| AZ | 9 | ME | 1 | PR | 2 |
| CA | 9 | MI | 5 | RI | 1 |
| CO | 8 | MN | 5 | SC | 4 |
| CT | 1 | MO | 7 | SD | 8 |
| DE | 3 | MS | 4 | TN | 4 |
| FL | 4 | MT | 8 | TX | 6 |
| GA | 4 | NC | 4 | UT | 8 |
| GU | 9 | ND | 8 | VA | 3 |
| HI | 9 | NE | 7 | VI | 2 |
| IA | 7 | NH | 1 | WT | 1 |
| ID | 10 | NJ | 2 | WA | 10 |
| IL | 5 | NM | 6 | WI | 5 |
| IN | 5 | NV | 9 | WV | 3 |
| KS | 7 | NY | 2 | WY | 8 |
| KY | 4 | OH | 5 | | |

Figure D1: State Database File

| Vendor# | Vendor name | Vendor abbreviation |
|---|---|---|
| 1 | ACME RETRO FIT | ARF |
| 2 | BETA CLEAN UPS | ACU |
| 3 | MAMA MIA WHAT A MESS SCHOOL | MAM WAMS |
| 4 | ECOLOGY INCORPORATED | ECO INC |
| 5 | ENVIRONMENTAL EDUCTION ENTERPRISES INC | EEE INC |
| 6 | NAVAL SCHOOL, CIVIL ENGINEER | NAVSCOCE |

Figure D2: Vendor Database File

| Course # | Vendor # | Course name | Description | Fee | Alias |
|---|---|---|---|---|---|
| 1 | 1 | AERATION TECHNOLOGIES FOR SOIL AND GROUND WATER CONTAMINATION | THIS COURSE OFFERS A COMPREHENSIVE IN DEPTH VIEW OF THEORY AND APPLICATION OF AERATION TECHNOLOGIES IN THE ENVIRONMENT | $750.00 | |
| 1 | 2 | ENVIRONMENTAL RISK ASSESSMENT | RISK ASSESSMENTS IN VARIOUS MEDIA TARGETED TO GROUND WATER SCIENTISTS AND ENGINEERS. | $695.00 | |
| 1 | 5 | AIR MONITORING INSTRUMENTATION | HANDS ON FIELD PRACTICE COURSE DESIGNED FOR THE PARTICIPANT TO UNDERSTAND AND USE AIR MONITORING INSTRUMENTS | $750.00 | AIR FIELD PRACTICES |
| 19 | 6 | SITE CHARACTERIZATION | UNDERSTANDING OF THE SITE CHARACTERIZATION PROCESS, TYPES OF DATA AND MEASUREMENTS NECESSARY, AND PROBLEMS ASSOCIATED WITHIN SITE CHARACTERIZATION. | $750.00 | SITE CHARACTERIZATION 101 |
| 2 | 1 | AERATION TECHNOLOGIES FOR MUCKY STUFF | TARGETED FOR THOSE HIGH RANKING INDIVIDUALS WISHING A BOONDOGGLE TRIP ANYWHERE | $750.00 | |

Figure D3: Course Database File

| Vendor # | Course # | Offering # | Start date | End date | City | State | Limit | Count | Hotel | Phone | Fax |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 10/10/10 | 10/10/90 | NEW YORK | NY | 8.00 | 1.00 | HILTON | | (215)998-7321 |
| 1 | 1 | 2 | 10/15/92 | 10/25/92 | DELRINO MAS | NJ | 9.00 | 9.00 | | | |
| 1 | 2 | 1 | 6/17/93 | 6/17/94 | SING SING | CA | 2.00 | 9,999.0 | BIG HOUSE | | |
| 2 | 1 | 1 | 10/5/90 | 10/30/90 | BOSTON | MA | | | | | |
| 3 | 2 | 1 | 6/6/89 | 6/7/99 | HONG KONG | CT | 45.00 | 3.00 | SAVOY | (000) 798-999 | |
| 3 | 3 | 1 | 7/12/89 | 7/19/90 | SAN PAULO | NM | 1.00 | | | | |
| 4 | 4 | 1 | 9/21/93 | 9/23/93 | PORTLAND | OR | 9.00 | 2.00 | MARRIOTT | (001) 987-987 | |
| 5 | 1 | 1 | 10/19/93 | 10/24/93 | DENVER | CO | 9.00 | 0.00 | MARRIOTT WEST | (111) 666-500 | |
| 5 | 9 | 1 | 10/5/93 | 10/7/93 | SEATTLE | WA | 9.00 | 0.00 | HOLIDAY CROWN | (000) 123-456 | |
| 5 | 9 | 2 | 10/19/93 | 10/21/93 | DENVER | CO | 9.00 | 1.00 | MARRIOTT WEST | (111) 666-500 | |
| 6 | 19 | 1 | 10/27/93 | 11/1/93 | WHITE PLAINS | NY | 8.00 | 2.00 | METRO AREA | (101) 876-543 | |
| 6 | 19 | 2 | 12/1/93 | 12/7/93 | FARMER CITY | IL | 9.00 | 8.00 | FARMER INN | (217) 555-121 | (217) 555-1234 |
| 6 | 4 | 1 | 8/7/93 | 8/19/93 | COLUMBUS | OH | 9.00 | 4.00 | RAMADA UNIV | (513) 989-898 | (513) 989-4110 |
| 6 | 4 | 2 | 11/4/93 | 11/7/93 | SAN DIEGO | CA | 9.00 | 2.00 | HOLIDAY TIN | (656) 987-148 | (656) 987-1243 |
| 6 | 4 | 3 | 11/11/93 | 11/14/93 | WASHINGTON | DC | 9.00 | 2.00 | GEORGETOWN INN | (203) 343-368 | |
| 6 | 77 | 1 | 10/19/93 | 10/23/93 | HOUSTON | TX | 3.00 | 0.00 | THUMP HOTEL | | |

Figure D4: Course Date Database File

| SSAN | Last name | First name | Rank | C/E/O | Duty title | Duty phone | Organization | Base | Street | State | Zip | MAJCOM | Functional |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 111-11-1111 | BLACKMAN | JOHN | LT | O | C/ ASH & TRASH | (000) 999-9999 | HELL RAISERS | BOLLING AFB | GUTTER ST | DC | 45434-9999 | IF/IFNOT | |
| 222-22-2222 | LUCKY | TERRY | DR | C | DIR ASH & TRASH | (213) 987-3333 | RAISED UP | BOLLING AFB | GUTTER ST | DC | 45434-9999 | PROB/N | |
| 333-33-3333 | SMITH | BJORN | GS13 | C | DEP STADTMEISTER | (000) 111-2223 | 615SMSQ | WRIGHT-PATT | Q ST | OH | 45433-5000 | AFMC | |
| 444-44-4444 | BILACOWSKY | CRUMJUM | COL | O | LORD ASH & TRASH | (000) 988-6565 | HELL | PENTAGON | BELOW GUTTER ST | DC | 12548-7412 | DEF/NOT | |
| 555-55-5555 | LANDRUSKY | BEJJIBOV | GEN | O | GOD ASH & TRASH | (000) 000-0001 | NASA/4077 | LOS ALAMOS | GROUND ZERO | NM | 00000-0000 | CAN/NO | |
| 666-66-6666 | SCHMIDT | GERHARD | GM15 | C | STADTMEISTER | (000) 111-2221 | 615SMSQ | WRIGHT-PATT | Q ST | OH | 45433-5000 | AFMC | |
| 777-77-7777 | RICKENBACHE | EDDIE | CAPT | O | ACE | (131) 876-5432 | 1TFS | LANGLEY | A ST | VA | 78217-5000 | ACC | |
| 888-88-8888 | BARNEY | FRED | MSGT | E | SUPERINTENDENT | (542) 987-6897 | 6785AMS | SCOTT | AFIT AVE | IL | 78234-3934 | AMC | |
| 999-99-9999 | BIRD | BIG | SES4 | C | OVERSEER | (111) 222-3334 | HQ AF | PENTAGON | MY WAY | VA | 78900-0001 | HQ AF | |

Figure D5: People Database File

| SSAN | V # | C # | Offer # | Fund | Rental car | Complete | Per diem | Travel | Tuition | Car costs | Instructions | Crit 1 | Crit 2 | Crit 3 | Crit 4 | Crit 5 | Crit 6 | Crit 7 | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 111-11-1111 | 1 | 1 | 1 | D | No | No | 789.00 | | | 0.00 | | | | | | | | | |
| 222-22-2222 | 3 | 2 | 1 | C | Yes | Yes | 567.00 | 345.0 | 765.00 | 100.00 | this is only 45 characters long so you b | 1 | 3 | 2 | 1 | 4 | 5 | 6 | this is the mon ster memo field, no limit as to it's size. |
| 333-33-3333 | 5 | 9 | 2 | D | No | No | 659.00 | 432.0 | 865.00 | 0.00 | | | | | | | | | |
| 444-44-4444 | 2 | 1 | 1 | C | No | No | | | | 0.00 | | | | | | | | | |

Figure D6: Register Database File

## Queries

1. Find the applicant with a SSAN of 222-22-222 to determine is he/she is in the database.

Query

ANSWER: : PRIV:ANSWER.DB

```
:PRIVE:PEOPLE.DB | SSAN          | Last name  | First name  | Rank  | Duty title |
                 | =222-22-2222  | Check      | Check       | Check | Check      |

:PRIV:PEOPLE.DB  |Organization   | Base    | MAJCOM  |
                 |Check          | Check   | Check   |
```

EndQuery

| Lastname | Firstname | Rank | Duty title | Organization | Base | MAJCOM |
|---|---|---|---|---|---|---|
| LUCKY | TERRY | DR | DIR ASH & TRASH | RAISED UP | BOLLING AFB | PROB/NOT |

Figure D7: First Query Answer

2. List the region, course #, and course name for all courses located in region 2.

Query

ANSWER: : PRIV:ANSWER.DB

```
:PRIV:C_DATES.DB  | Course # | State  |
                  | _EGO1    | _EGO2  |

:PRIV:STATES.DB   | State  | Region      |
                  | _EGO2  | Check = 2   |

:PRIV:COURSE.DB   | Course #      | Course name  |
                  | Check _EGO1   | Check        |
```

EndQuery

| Region | Course # | Course name |
|---|---|---|
| 2 | 1 | AERATION TECHNOLOGIES FOR SOIL AND GROUND WATER CONTAMINATION |
| 2 | 1 | AIR MONITORING INSTRUMENTATION |
| 2 | 1 | ENVIRONMENTAL RISK ASSESSMENT |
| 2 | 19 | SITE CHARACTERIZATION |

Figure D8: Second Query Answer

3. List the critique scores, course number, offering number, and vendor name for all course numbers equal to 2 and offering number equal to 1.

Query

```
:PRIV:REGISTER.DB | Vendor #      | Course #  | Offering #  | Critique 1 | Critique 2 |
                  | Check _EGO1   | Check = 2 | Check = 1   | Check      | Check      |

:PRIV:REGISTER.DB | Critique 3 | Critique 4 | Critique 5 | Critique 6 | Critique 7 | Critique 8 |
                  | Check      | Check      | Check      | Check      | Check      | Check      |

:PRIV:VENDOR.DB |Vendor # | Vendor name |
                | _EGO1   | Check       |
```

EndQuery

| Vendor # | Course # | Offering # | Critique 1 | Critique 2 | Critique 3 | Critique 4 | Critique 5 | Critique 6 | Critique 7 | Critique 8 | Vendor name |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 2 | 1 | 1 | 2 | 3 | 2 | 1 | 4 | 5 | 6 | MOMA MIA WHAT A MESS SCHOOL |

Figure D9: Third Query Answer

4. List the course number, course name, and vendor name for all courses offered by vendor 1 (ACME Retro Fit).

Query

ANSWER: :PRIV:ANSWER.DB

```
:PRIV:COURSE.DB  | Course # | Vendor # | Course name |
                 | Check    | _EGO1    | Check       |

:PRIV:VENDOR.DB  | Vendor #    | Vendor name |
                 | _EGO1, =1   | Check       |
```

EndQuery

| Course # | Course name | Vendor name |
|---|---|---|
| 1 | AERATION TECHNOLOGIES FOR SOIL AND GROUND WATER CONTAMINATION | ACME RETRO FIT |
| 2 | AERATION TECHNOLOGIES FOR MUCKY STUFF | ACME RETRO FIT |

Figure D10: Fourth Query Answer

Data Dictionary

| | |
|---|---|
| Alias | Previous name of a course if ever offered under different name |
| Base | Base applicant is assigned to |
| Car rental costs | Dollar value of car rental (if applicable) |
| City | City that a course is offered in |
| Civ enl off | Code to indicate if applicant is a civilian, officer, or enlisted member |
| Count | Number of students enrolled in a course |
| Course # | Unique number associated with a particular course |
| Course Complete | Code to indicate if a course has been completed and travel voucher has been submitted and approved |
| Course name | Name of a course offered by a vendor |
| Course region | Region that course is offered in |
| Course state | State that a course is offered in |
| Critique 1 | Value applicant assigned to section 1 of course critique |
| Critique 2 | Value applicant assigned to section 2 of course critique |
| Critique 3 | Value applicant assigned to section 3 of course critique |
| Critique 4 | Value applicant assigned to section 4 of course critique |
| Critique 5 | Value applicant assigned to section 5 of course critique |
| Critique 6 | Value applicant assigned to section 6 of course critique |
| Critique 7 | Value applicant assigned to section 7 of course critique |
| Critique 8 | Value applicant assigned to section 8 of course critique |

| | |
|---|---|
| Description | Description of the course offered by a vendor |
| Duty title | Applicants duty title at site of employment |
| Duty phone | Applicants office phone number at site of employment |
| End date | Date that a course ends |
| Fax | Fax number to hotel |
| Fee | Cost of the course as outlined in vendor's brochure |
| First name | Applicants first name |
| Functional Area | Applicants career field |
| Fund code | Air Force account which will pay for course |
| Hotel | Hotel name in which student will reside |
| Last name | Applicants last name |
| Limit | Total number of students allowed in a course |
| MAJCOM | Major Command that applicant is a member of |
| Offering # | Unique number depicting which offering of a particular course (needed if two offerings available on same date) |
| Organization | Organization applicant is assigned to |
| Per diem | Dollar value authorized for applicant's living expenses |
| Phone | Phone number of hotel |
| Rank | Applicants rank (civilian or military) |
| Remarks | Any pertinent comments |
| Rental Car | Yes/No variable indicating if rental car is authorized |
| Special instructions | Special instructions applicant needs to know about a course |
| SSAN | Unique social security number of the applicant |

| | |
|---|---|
| Start date | Date that a course starts |
| State | State in which applicants base is located |
| Street | Street address of applicants organization |
| Travel | Dollar value authorized for applicant's travel to and from course |
| Tuition | Actual dollar value of course tuition |
| Users region | Region that applicant's duty station is located in |
| Vendor # | Unique number associated with a particular vendor |
| Vendor name | Name of vendor that offers courses |
| Vendor abbreviation | Vendor's abbreviated name |
| Zip | Zip code in which applicant's base is located |

## Appendix E

### Dependency Diagrams

The dependency diagrams were used to logically represent the KBS knowledge in a manner conducive to software programming. The first diagram presented in this appendix is the Remedial Project Manager (RPM) Educational Assistant, or course blueprint (see fig E1). The diagram begins with four basic question sets (far left) grouped together with the choices possible to answer each individual question. Once these questions are answered by the software user, those answers are subjected to programmed rules (small triangle) which determine the outcome (small boxes). For example, the second question set asks questions to determine which of the listed courses a site coordinator has taken. Based on these answers, a set of logic rules (Rule Set 1) determines if the site coordinator is currently at an introductory or advanced RPM level. This determination and the advanced education determination below (Rule Set 2) are then subjected to Rule Set 3. Through the logic of this last rule set, the course direction is determined.

The second dependency diagram is an overview of the Remedial Project Manager Certification process. The basic logic is the same as the first dependency diagram. For example, for Rule Set 1 to determine the site coordinator's education level, the program will ask three sets of questions concerning degree, year of graduation, and area of concentration, respectively (see fig E2). Once all questions have been answered by the user and the rule sets have determined the site coordinators academic degree, experience. and training, Rule Set 4 combines this logic to determine the certification level. For clarity, each of these question sets is decomposed in separate dependency diagrams (see figs E3 - E5).

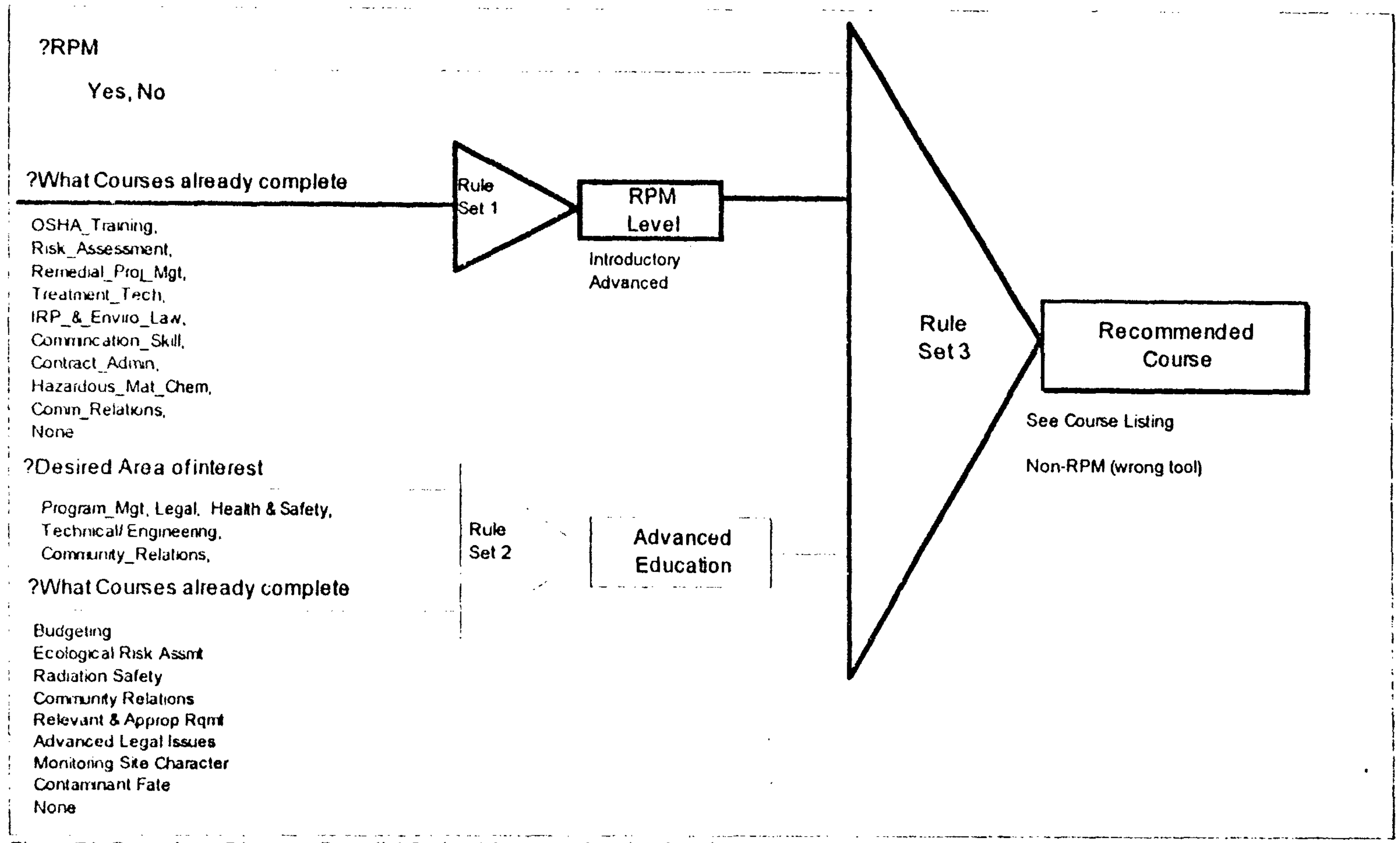

Figure E1: Dependency Diagram - Remedial Project Manager Educational Assistant

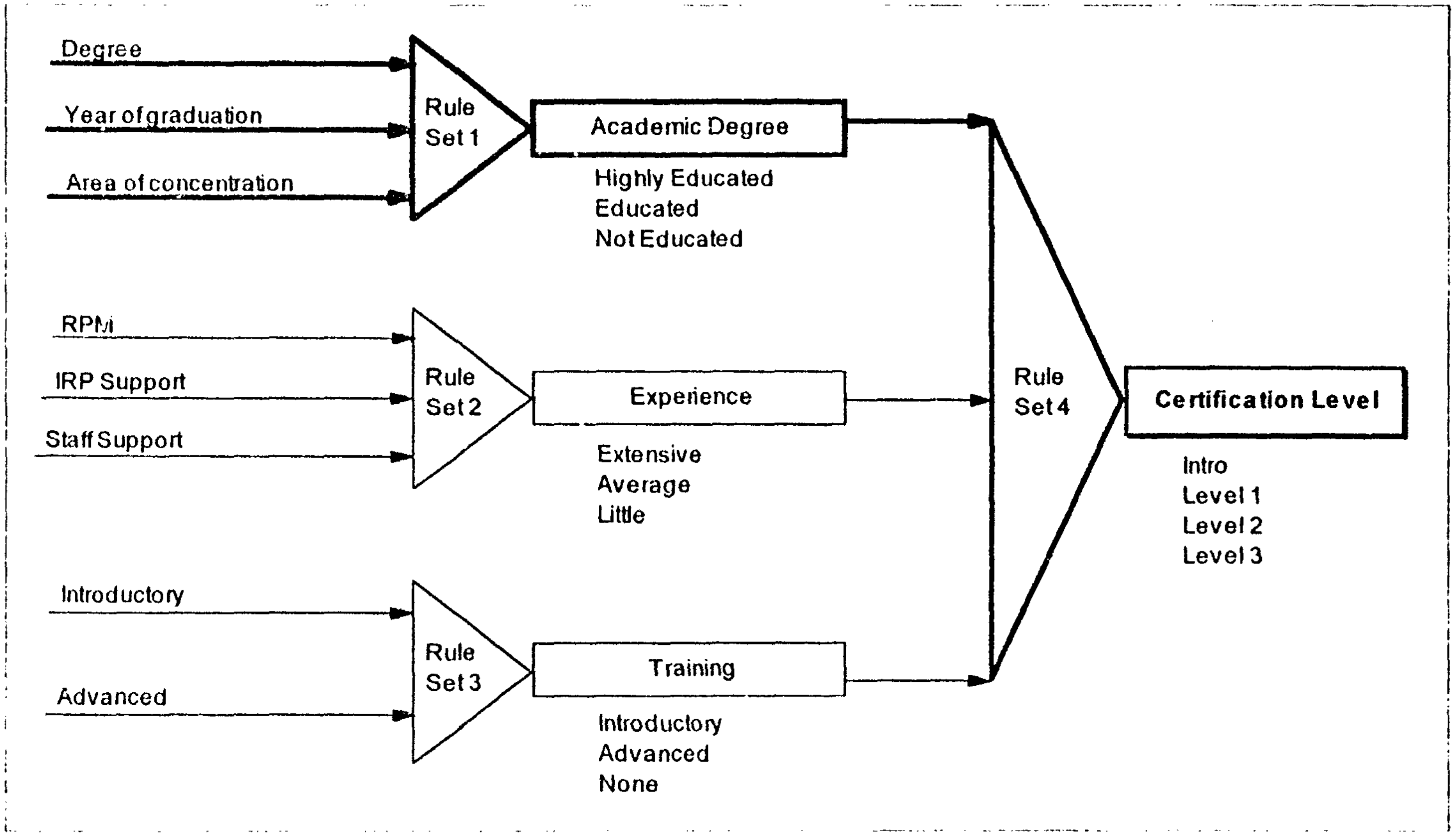


Figure E2: Overview Dependency Diagram - Remedial Project Manager Certification

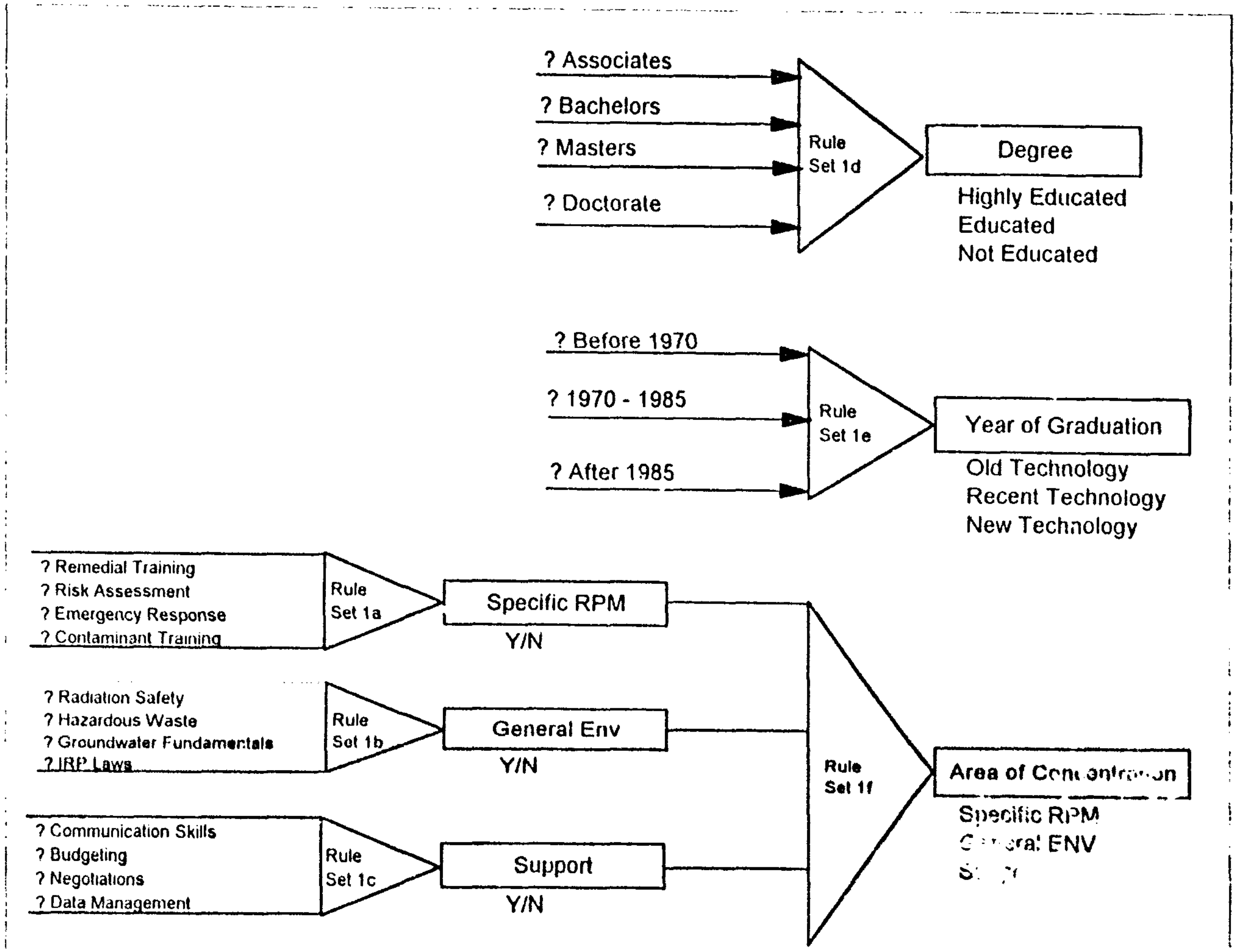


Figure E3: Rule Set 1 - Academic Degree

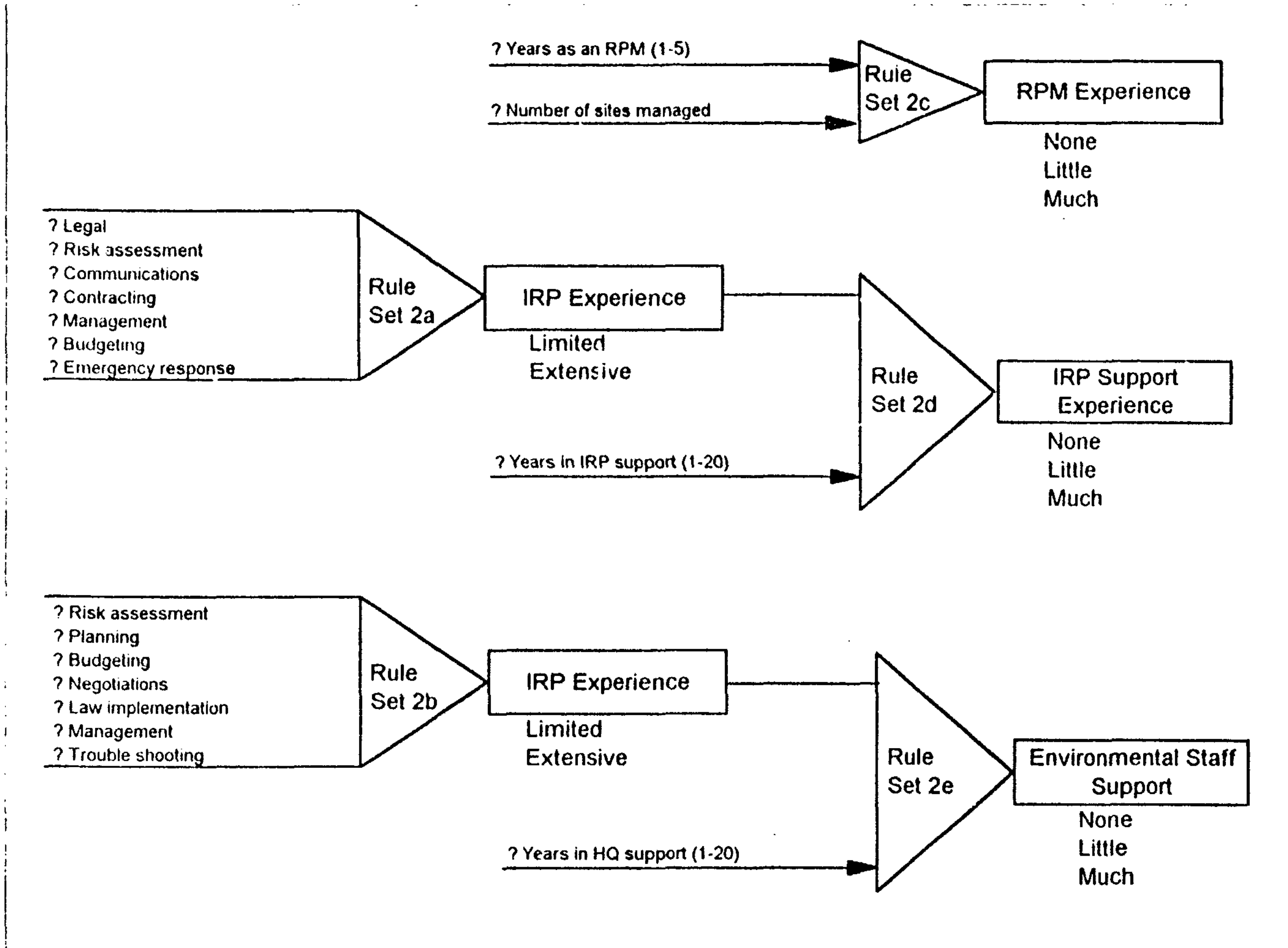


Figure E4: Rule Set 2 - Experience

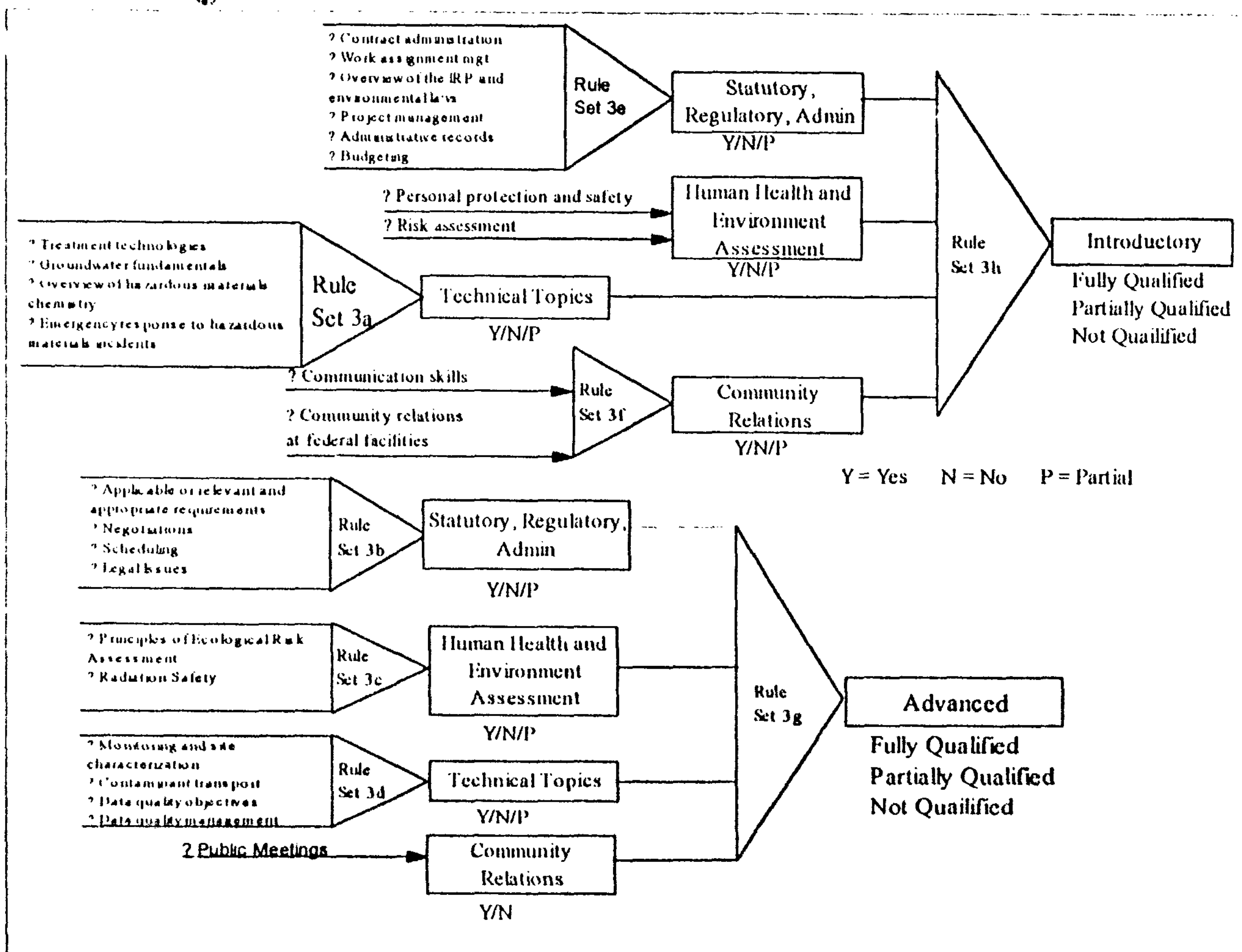


Figure E5: Rule Set 3 - Training

## Appendix F

Knowledge Base Code - Remedial Project Manager Educational Assistant

```
!**********************************************************************
!*
!*        REMEDIAL PROJECT MANAGER EDUCATIONAL ASSISTANT
!*
!**********************************************************************

BKCOLOR = 3;              !Set background color
RUNTIME;                  !Eliminate Rules & Facts window
ENDOFF;                   !Eliminate use of END key

!************************ OPENING WINDOW ******************

ACTIONS
  WOPEN 1,3,10,13,60,7                      !Open Welcome Screen
  ACTIVE 1
  DISPLAY "

              REMEDIAL PROJECT MANAGER
               EDUCATIONAL ASSISTANT


          This consultation assists you in determining the
           appropriate course for a RPM to register for based
           on the RPM's area of concentration.  It asks a
           series of questions to determine the best course
           for the RPM.

           Please press any key to begin consultation. ~
   "
```

```
!************************ INSTRUCTIONS WINDOW ********************

WCLOSE 1
WOPEN 1,1,1,5,77,2                                  !Opens Instruction screen
ACTIVE 1
DISPLAY "                    INSTRUCTIONS

        Use the arrow keys to move the lightbar to a desired answer choice,
        than press the ENTER key. (For multiple choice questions,
        press the ENTER key to select choices and the END key to continue.)"

!**************************** ACTION BLOCK ************************

WOPEN 2,7,1,14,77,3
ACTIVE 2                                            ! Activate Window 2

FIND Recommended_course                             ! Start Logic sequence
FIND RPM_level
WCLOSE 1
WCLOSE 2

WOPEN 1,5,13,14,48,7                                ! Open final display window
WOPEN 2,6,14,12,46,7
FIND message
ACTIVE 1
ACTIVE 2
;
! ***************************** RULES BLOCK **********************

RULE 1
 IF RPM_Status = No
 THEN Recommended_Course = Level_0;
! BECAUSE "Individual is not an RPM, thus this consultation is not the
!  appropriate education assistant tool for the individual." ;

! ********************** INTRODUCTORY RPM RULES ******************

RULE 1.1
  IF RPM_Status = Yes AND
    Intro_ed = None
  THEN RPM_level = Introductory
     Recommended_Course = HS10;
```

```
RULE 1.2
  IF RPM_Status = Yes AND
    Intro_ed <> None AND
    Intro_ed = OSHA_Training AND
    Intro_ed <> Risk_Assessment
  THEN RPM_level = Introductory
      Recommended_Course = HS11;

RULE 1.3
  IF RPM_Status = Yes AND
    Intro_ed <> None AND
    Intro_ed = OSHA_Training AND
    Intro_ed = Risk_Assessment AND
    Intro_ed <> Remedial_Proj_Mgt
  THEN RPM_level = Introductory
      Recommended_Course = PM20;

RULE 1.4
  IF RPM_Status = Yes AND
    Intro_ed <> None AND
    Intro_ed = OSHA_Training AND
    Intro_ed = Risk_Assessment AND
    Intro_ed = Remedial_Proj_Mgt AND
    Intro_ed <> Treatment_Tech
  THEN RPM_level = Introductory
      Recommended_Course = TE30;

RULE 1.5
  IF RPM_Status = Yes AND
    Intro_ed <> None AND
    Intro_ed = OSHA_Training AND
    Intro_ed = Risk_Assessment AND
    Intro_ed = Remedial_Proj_Mgt AND
    Intro_ed = Treatment_Tech AND
    Intro_ed <> IRP_&_Enviro_Law
  THEN RPM_level = Introductory
      Recommended_Course = LE40;
```

```
RULE 1.6
  IF RPM_Status = Yes AND
    Intro_ed <> None AND
    Intro_ed = OSHA_Training AND
    Intro_ed = Risk_Assessment AND
    Intro_ed = Remedial_Proj_Mgt AND
    Intro_ed = Treatment_Tech AND
    Intro_ed = IRP_&_Enviro_Law AND
    Intro_ed <> Communication_skill
  THEN RPM_level = Introductory
    Recommended_Course = CR50;

RULE 1.7
  IF RPM_Status = Yes AND
    Intro_ed <> None AND
    Intro_ed = OSHA_Training AND
    Intro_ed = Risk_Assessment AND
    Intro_ed = Remedial_Proj_Mgt AND
    Intro_ed = Treatment_Tech AND
    Intro_ed = IRP_&_Enviro_Law AND
    Intro_ed = Communication_skill AND
    Intro_ed <> Contract_Admin
  THEN RPM_level = Introductory
    Recommended_Course = PM21;

RULE 1.8
  IF RPM_Status = Yes AND
    Intro_ed <> None AND
    Intro_ed = OSHA_Training AND
    Intro_ed = Risk_Assessment AND
    Intro_ed = Remedial_Proj_Mgt AND
    Intro_ed = Treatment_Tech AND
    Intro_ed = IRP_&_Enviro_Law AND
    Intro_ed = Communication_skill AND
    Intro_ed = Contract_Admin AND
    Intro_ed <> Hazardous_Mat_Chem
  THEN RPM_level = Introductory
    Recommended_Course = TE31.
```

```
RULE 1.9
  IF RPM_Status = Yes AND
    Intro_ed <> None AND
    Intro_ed = OSHA_Training AND
    Intro_ed = Risk_Assessment AND
    Intro_ed = Remedial_Proj_Mgt AND
    Intro_ed = Treatment_Tech AND
    Intro_ed = IRP_&_Enviro_Law AND
    Intro_ed = Communication_skill AND
    Intro_ed = Contract_Admin AND
    Intro_ed = Hazardous_Mat_Chem AND
    Intro_ed <> Comm_Relations
  THEN RPM_level = Introductory
     Recommended_Course = CR51;

RULE 1.10
  IF RPM_Status = Yes AND
    Intro_ed <> None AND
    Intro_ed = OSHA_Training AND
    Intro_ed = Risk_Assessment AND
    Intro_ed = Remedial_Proj_Mgt AND
    Intro_ed = Treatment_Tech AND
    Intro_ed = IRP_&_Enviro_Law AND
    Intro_ed = Communication_skill AND
    Intro_ed = Contract_Admin AND
    Intro_ed = Hazardous_Mat_Chem AND
    Intro_ed = Comm_Relations
  THEN RPM_level = Advanced;

! ***************************** ADVANCED RPM RULES *****************

RULE 2.1
  IF RPM_level = Advanced AND
    Desire_area = Health_&_Safety AND
    Adv_ed <> Ecological_Risk_Asmt
  THEN Recommended_Course = HS15
     RPM_level = Advanced;
```

```
RULE 2.2
  IF RPM_level = Advanced AND
    Desire_area = Health_&_Safety AND
    Adv_ed = Ecological_Risk_Asmt AND
    Adv_ed <> Radiation_Safety
  THEN Recommended_Course = HS16
     RPM_level = Advanced;

RULE 2.3
  IF RPM_level = Advanced AND
    Desire_area = Health_&_Safety AND
    Adv_ed = Ecological_Risk_Asmt AND
    Adv_ed = Radiation_Safety
  THEN Recommended_Course = None
     RPM_level = Advanced;

RULE 2.4
  IF RPM_level = Advanced AND
    Desire_area = Regs_&_Community_Rel
  THEN Recommended_Course = None
     RPM_level = Advanced;

RULE 2.5
  IF RPM_level = Advanced AND
    Desire_area = Program_Management AND
    Adv_ed <> Budgeting
  THEN Recommended_Course = PM25
     RPM_level = Advanced;

RULE 2.6
  IF RPM_level = Advanced AND
    Desire_area = Program_Management AND
    Adv_ed = Budgeting AND
    Adv_ed <> Relevant&Approp_Rqmt
  THEN Recommended_Course = PM26
     RPM_level = Advanced;

RULE 2.7
  IF RPM_level = Advanced AND
    Desire_area = Program_Management AND
    Adv_ed = Budgeting AND
    Adv_ed = Relevant&Approp_Rqmt
  THEN Recommended_Course = None
     RPM_level = Advanced;
```

RULE 2.8
IF RPM_level = Advanced AND
Desire_area = Legal AND
Adv_ed <> Advanced_Legal_Issue
THEN Recommended_Course = LE45
RPM_level = Advanced;

RULE 2.9
IF RPM_level = Advanced AND
Desire_area = Legal AND
Adv_ed = Advanced_Legal_Issue
THEN Recommended_Course = None
RPM_level = Advanced;

RULE 2.10
IF RPM_level = Advanced AND
Desire_area = Technical_Engineering AND
Adv_ed <> Monitoring_Site_Char
THEN Recommended_Course = TE35
RPM_level = Advanced;

RULE 2.11
IF RPM_level = Advanced AND
Desire_area = Technical_Engineering AND
Adv_ed = Monitoring_Site_Char AND
Adv_ed <> Contaminant_Fate
THEN Recommended_Course = TE36
RPM_level = Advanced;

RULE 2.12
IF RPM_level = Advanced AND
Desire_area = Technical_Engineering AND
Adv_ed = Monitoring_Site_Char AND
Adv_ed = Contaminant_Fate
THEN Recommended_Course = None
RPM_level = Advanced;

```
RULE 2.13
  IF RPM_level = Advanced AND
  Desire_area = Program_Management or
  Desire_area = Technical_Engineering or
  Desire_area = Legal or
  Desire_area = Health_&_Safety or
  Desire_area = Regs_&_Community_Rel AND
  Adv_ed = None
  THEN Recommended_Course = PM26
     RPM_level = Advanced;

! ***************************** DISPLAY BLOCK ***********************

RULE 3.1
  IF Recommended_Course = HS10 or
    Recommended_Course = HS11 or
    Recommended_Course = PM20 or
    Recommended_Course = TE30 or
    Recommended_Course = LE40 or
    Recommended_Course = CR50 or
    Recommended_Course = PM21 or
    Recommended_Course = TE31 or
    Recommended_Course = CR51 or
    Recommended_Course = HS16 or
    Recommended_Course = HS15 or
    Recommended_Course = PM25 or
    Recommended_Course = PM26 or
    Recommended_Course = LE45 or
    Recommended_Course = TE35 or
    Recommended_Course = TE36
 THEN message = displayed
    GET Recommended_Course = C_NUMBER, Course, ALL

    DISPLAY "The Course you should take is:

Course #:{C_NUMBER}  Title: {C_TITLE}

Description: {C_DESCRIPT}

Length of Course: {C_DATE} ~"
    ;
```

```
RULE 3.2
 IF Recommended_Course = None
 THEN Message = No_Course
   DISPLAY "There are no additional courses in {Desire_Area}
available for educational advancement at this time.

       Please check another area. ~"
   ;

RULE 3.3
  IF Recommended_Course = Level_0
  THEN Message = Non_RPM

    DISPLAY "Individual is not an RPM, Thus this is NOT
the proper tool for educational assistance.~"
    ;

! ************************* QUESTION BLOCK *************************

ASK RPM_Status: "Is the individual currently a Remedial Project Manager
  (RPM) in the Air Force?";
CHOICES RPM_Status:  Yes, No;

ASK Intro_ed: "Select the course(s) which you have already successfully
   completed.";
CHOICES Intro_ed: OSHA_Training, Risk_Assessment, Remedial_Proj_Mgt,
   Treatment_Tech, IRP_&_Enviro_Law, Communication_Skill, Contract_Admin,
   Hazardous_Mat_Chem, Comm_Relations, None;

ASK Desire_Area: "Select the area of concentration which you would like
   additional education";
CHOICES Desire_Area: Program_Management, Technical_Engineering, Legal,
   Health_&_Safety, Regs_&_Community_Rel;

ASK Adv_ed: "Select the course(s) which you have already successfully
   completed.",
CHOICES Adv_ed: Budgeting, Ecological_Risk_Asmt, Radiation_Safety,
Community_Relations, Relevant&Approp_Rqmt, Advanced_Legal_Issue,
Monitoring_Site_Char, Contaminant_Fate, None;

PLURAL: Intro_ed, Adv_ed;
```

Knowledge Base Code - Remedial Project Manager Certification

```
!*************************************************************************
!*
!*          REMEDIAL PROJECT MANAGER CERTIFIER
!*
!*************************************************************************

ENDOFF;
RUNTIME;
ACTIONS
   WOPEN 1,4,3,15,70,4
   WOPEN 2,5,5,15,70,0
   ACTIVE 1
   Color = 15
      Display "    THE REMEDIAL PROJECT MANAGER CERTIFIER

                     After answering a number of questions about
                       your qualifications, you will be given a
                              certification level
                           (zero, one, two, or three)

                          Throughout this consultation,
                      use arrow keys to select answers
                               and press return

     * Press any key to continue ~"

   WCLOSE 1
   WCLOSE 2
   CLS

   FIND education_level
   FIND technology_level
   FIND area_of_concentration
   FIND Academic_degree

   SAVEFACTS tempone
   CHAIN experience

   ;
```

```
! ------ Rule to determine if user has an advanced degree -----

RULE Qualification_question
   If Qual_question = No
   Then education_level = not_educated;

RULE Qualification_question2
   If Qual_question = No
   Then technology_level = old_technology;

RULE Qualification_question3
   If Qual_question = No
   Then area_of_concentration = none;

! --------- Rule set to find EDUCATION LEVEL ---------

RULE 1
   IF degree = Associates or
     degree = Bachelors
   THEN education_level = educated;

RULE 1a
   IF degree = Masters or
     degree = Doctorate
   THEN education_level = highly_educated;

RULE 1b
   IF degree = Other
   THEN education_level = not_educated;

! ------ Rule set to find YEAR OF EDUCATION ----------

RULE 2
   IF year = Before_1970
   THEN technology_level = old_technology;

RULE 2a
   IF year = 1970_-_1985
   THEN technology_level = recent_technology;
```

```
RULE 2b
   IF year = After_1985
   THEN technology_level = new_technology;

! --------- Rule set to find AREA OF CONCENTRATION ---------

RULE 3
   IF specific_RPM = All
   THEN area_of_concentration = RPM;

RULE 3a
   IF specific_RPM = None or
     specific_RPM = Two_or_less or
     specific_RPM = Three and
     general = All
   THEN area_of_concentration = general_env;

Rule 3b
   IF specific_RPM = None or
     specific_RPM = Two_or_less or
     specific_RPM = Three and
     general = None or
     general = Two_or_less or
     general = Three and
     support = All or
     support = Three
   THEN area_of_concentration = env_support;

RULE 3c
   IF specific_RPM = None or
     specific_RPM = Two_or_less and
     general = None or
     general = Two_or_less and
     support = None or
     support = Two_or_less
   THEN area_of_concentration = none;
```

```
RULE 3d
   IF specific_RPM = Three and
     general = Three or
     general = None or
     general = Two_or_less and
     support = Three or
     support = Two_or_less or
     support = None
   THEN area_of_concentration = general_env;

ASK Qual_question: "Have you earned an advanced degree?";
CHOICES Qual_question: Yes, No;

ASK degree:  "What type of degree do you have? (if you have more than one,
        choose the one you completed last)";
CHOICES degree: Associates, Bachelors, Masters, Doctorate, Other;

ASK year: "When did you receive your last degree?";
CHOICES year: Before_1970, 1970_-_1985, After_1985;

ASK specific_RPM: "Of the following courses, how many have you taken?
            Remedial Trianing        Risk Assessment
            Emergency Response       Contaminant Training";
CHOICES specific_RPM: All, None, Two_or_less, Three;

ASK general: "Of the following courses, how many have you taken?
            Radiation Safety         Hazardous Waste
            Groundwater Basics       IRP laws";
CHOICES general: All, None, Two_or_less, Three;

ASK support: "Of the following courses, how many have you taken?
            Public Communications    Budgeting
            Negotiations             Data Management";
CHOICES support: All, None, Two_or_less, Three;


! -------- Rule set to combine all to an Academic degree finding ----

RULE 4
   If education_level = highly_educated and
     technology_level = new_technology or
     technology_level = recent_technology and
     area_of_concentration = RPM
   THEN Academic_degree = highly_prepared;
```

```
RULE 4a
   If education_level = highly_educated and
     technology_level = old_technology and
     area_of_concentration <> none
   THEN Academic_degree = prepared;

Rule 4b
   If education_level = highly_educated and
     area_of_concentration = none
   Then Academic_degree = unprepared;

Rule 4c
   If education_level = educated and
     technology_level <> old_technology or
     area_of_concentration <> none
   THEN Academic_degree = prepared
   Else Academic_degree = uprepared;

ENDOFF;
RUNTIME;
ACTIONS
   FIND RPM_exper
   FIND IRP_support
   FIND ENV_staff
   FIND Experience
   SAVEFACTS temptwo
   CHAIN training;


! ----- Rule set to determine RPM experience -------

RULE 1_Qualifying_question
   If RPM_qual_ques = No
   Then RPM_exper = none;

RULE 1
   If RPM_years = Less_than_one and
     site_no = Zero
   Then RPM_exper = none;
```

```
RULE 1a
   If RPM_years = 1_to_3 and
     site_no = 1_to_3 or
     site_no = 4_to_8
   Then RPM_exper = little;

RULE 1b
   If RPM_years = 1_to_3 and
     site_no = Over_8
   Then RPM_exper = good;

RULE 1c
   If RPM_years = 3_to_5 and
     site_no = 1_to_3 or
     site_no = 4_to_8
   Then RPM_exper = good;

RULE 1d
   If RPM_years = 3_to_5 and
     site_no = Over_8
   Then RPM_exper = above_average;

RULE 1e
   If RPM_years = Over_5 and
     site_no = 1_to_3 or
     site_no = 4_to_8
   Then RPM_exper = above_average;

RULE 1f
   If RPM_years = Over_5 and
     site_no = Over_8
   Then RPM_exper = excellent;

RULE 1g
   If RPM_years <> Less_than_one and
     site_no = Zero
   Then RPM_exper = none;

ASK RPM_qual_ques: "Have you ever worked as a Remedial Project Manager?";
CHOICES RPM_qual_ques: Yes, No;

ASK RPM_years: "How many years have you worked as a Remedial Project Manager?";
CHOICES RPM_years: Less_than_one, 1_to_3, 3_to_5, Over_5;
```

```
ASK site_no: "How many Installation Restoration Sites have you managed?";
CHOICES site_no: Zero, 1_to_3, 4_to_8, Over_8;

! ----- Rule set to determine IRP support experience ------

RULE 2_beginning_question
   If qual_ques = no
   Then IRP_support = none;

RULE 2
   If IRP_exper = None and
     IRP_years = Less_than_one
   Then IRP_support = none;

RULE 2a
   If IRP_exper = 1_to_3 and
     IRP_years = 1_to_3 or
     IRP_years = 3_to_7
   Then IRP_support = little;

RULE 2b
   If IRP_exper = 1_to_3 and
     IRP_years = 7_to_10
   Then IRP_support = focused;

RULE 2c
   If IRP_exper = 4_to_7 and
     IRP_years = 1_to_3
   Then IRP_support = average;

RULE 2d
   If IRP_exper = 4_to_7 and
     IRP_years = 3_to_7 or
     IRP_years = 7_to_10
   Then IRP_support = excellent;

RULE 2e
   If IRP_exper = 1_to_3 or
     IRP_exper = 3_to_7 and
     IRP_years = Zero
   Then IRP_support = none;
```

```
RULE 2f
   If IRP_exper = None and
     IRP_years = Less_than_one or
     IRP_years = 1_to_3 or
     IRP_years = 3_to_7 or
     IRP_years = 7_to_10
   Then IRP_support = none;

ASK qual_ques: "Have you ever worked in support of an Installation
  Restoration Program in a position other than an RPM?";
CHOICES qual_ques: yes, no;

ASK IRP_exper: "How many of the listed IRP areas do you have
       experience?

      Legal Affairs      Risk Assessment
      Communications     Management
      Budgeting          Contracting
      Emergency Response";
CHOICES IRP_exper: None, 1_to3, 4_to_7;

ASK IRP_years: "How many years experience do you have working with the
          Installation Restoration Program?";
CHOICES IRP_years: Less_than_one, 1_to_3, 3_to_7, 7_to_10;


! ---- Rule set to find Environmental Staff Experience ----

RULE 3_beginning_question
   If ENV_qualify_question = No
   Then ENV_staff = none;

RULE 3
   If Staff_experience = None and
     Staff_years = Less_than_one
   Then ENV_staff = none;

RULE 3a
   If Staff_experience = 1_to_3 and
     Staff_years = 1_to_3 or
     Staff_years = 3_to_7
   Then ENV_staff = little;
```

RULE 3b
If Staff_experience = 1_to_3 and
Staff_years = 7_to_10
Then ENV_staff = focused;

RULE 3c
If Staff_experience = 4_to_7 and
Staff_years = 1_to_3
Then ENV_staff = average;

RULE 3d
If Staff_experience = 4_to_7 and
Staff_years = 3_to_7 or
Staff_years = 7_to_10
Then ENV_staff = excellent;

RULE 3e
If Staff_experience = 1_to_3 or
Staff_experience = 3_to_7 and
Staff_years = Less_than_one
Then ENV_staff = none;

RULE 3f
If Staff_experience = Less_than_one and
Staff_years = 1_to_3 or
Staff_years = 3_to_7 or
Staff_years = 7_to_10
Then ENV_staff = none;

ASK ENV_qualify_question: "Have you ever worked in the Air Force Environmental Headquarters?";
CHOICES ENV_qualify_question: Yes, No;

ASK Staff_experience: "With how many of the following headquarter level environmental staff functions have you had experience?

Risk Assessment    Planning    Negotiations
Management    Law Implementation    Budgeting
Trouble Shooting
";
CHOICES Staff_experience: None, 1_to_3, 4_to_7,

```
ASK Staff_years: "How many years experience do you have working with the
 environmental headquarters staff?";
CHOICES Staff_years: Less_than_one, 1_to_3, 3_to_7, 7_to_10;


! ------ Rule set to find Experience ------------

RULE 4
   If RPM_exper = above_average or
     RPM_exper = excellent
   THEN Experience = Excellent;

RULE 4a
   If RPM_exper = good and
     IRP_support = excellent or
     ENV_staff = excellent
   THEN Experience = Excellent;

RULE 4b
   If RPM_exper = good
   THEN Experience = Good;

RULE 4c
   If RPM_exper = little and
     IRP_support <> none and
     ENV_staff <> none
   THEN Experience = Good;

RULE 4d
   If RPM_exper = little and
     IRP_support = none and
     ENV_staff = none
   THEN Experience = Poor;

RULE 4e
   If RPM_exper = none
   THEN Experience = Poor;
```

```
ENDOFF;
RUNTIME;
ACTIONS
   LOADFACTS tempone
   LOADFACTS temptwo
   FIND Intro
   FIND Advanced
   FIND Training
   FIND Certification_level
   CLS
   WOPEN 1,8,3,8,70,4
   WOPEN 2,9,5,8,70,0
   ACTIVE 1
   COLOR = 15
     DISPLAY "   Your Remedial Project Manager certification level is:

               {Certification_level}

  * Press any key to continue.~"

   Close 1
   Close 2
   CLS
   WOPEN 1,8,3,8,70,4
   WOPEN 2,9,5,8,70,0
   ACTIVE 1
   COLOR = 15

   DISPLAY"   To find out how to advance to the next level of certification,
     contact the RPM (AFIT/CEV-EEC) education office, WPAFB
               at DSN 785-0381.

  * Press any key to end this consultation~"

  Close 1
  Close 2
;
```

```
! ------ Rules to find INTRODUCTORY levels ------

RULE 1-Introquestion
   If Intro_question = no
   Then Intro = Not_Qualified;

RULE 1a
   If Stat = 6 and
     Human = 2 and
     Tech = 4 and
     Comm = 2
   Then Intro = Fully_Qualified;

RULE 1b
   If Stat = 4_to_5 or
     Stat = 6 and
     Human = 1 or
     Human = 2 and
     Tech = 2_to_3 or
     Tech = 4 and
     Comm = 1 or
     Comm = 2
   Then Intro = Partially_Qualified;

RULE 1c
   If Stat <> 0 and
     Human <> 0 and
     Tech <> 0 and
     Comm <> 0
   Then Intro = Basic
   Else Intro = Not_Qualified;

ASK Intro_question: "Have you had any official introductory environmental
training in the past five years?";
CHOICES Intro_question: yes, no;

ASK Stat: "In how many of the listed areas have you been trained?

     Contract Administration      Administrative Records
     Work Assignment Mngt         Project Management
     Overview of IRP laws         Budgeting
";
CHOICES Stat: 0, 1_to_3, 4_to_5, 6;
```

```
ASK Human: "In how many of the listed areas have you been trained?

     Personal Protection and Savety
     Risk Assessment
";
CHOICES Human: 0, 1, 2;

Ask Tech: "In how many of the listed areas have you been trained?

     Treatment Technologies          Groundwater Fundamentals
     Overview of Hazerdous Materials    Emergency Response
";
CHOICES Tech: 0, 1, 2_to_3, 4;

ASK Comm: "In how many of the listed areas have you been trained?

     Communication Skills
     Community Relations at Federal Facilities
";
CHOICES Comm: 0, 1, 2;

! ----- Rules to find ADVANCED levels ------

RULE 2-Advancedquestion
   If Adv_ques = no
   Then Advanced = Not_Qualified;

RULE 2a
   If AStat = 4 and
     AHuman = 2 and
     ATech = 4 and
     AComm = Yes
   Then Advanced = Fully_Qualified;

RULE 2b
   If AStat = 2_to_3 or
     AStat = 4 and
     AHuman = 1 or
     AHuman = 2 and
     ATech = 2_to_3 or
     ATech = 4 and
     AComm = Yes or
     AComm = No
   Then Advanced = Partially_Qualified;
```

```
RULE 2c
   If AStat <> 0 and
     AHuman <> 0 and
     ATech <> 0
   Then Advanced = Basic
   Else Advanced = Not_Qualified;

ASK Adv_ques: "Have you had any official advanced environmental
training in the past five years?";
CHOICES Adv_ques: yes, no;

ASK AStat: "In how many of the listed areas have you been trained?

    Regulatory Requirements        Negotiations
    IRP Scheduling                 Legal Issues
";
CHOICES AStat: 0, 1, 2_to_3, 4;

ASK AHuman: "In how many of the listed areas have you been trained?

    Principles of Ecological Risk Assessment
    Radiation Safety
";
CHOICES AHuman: 0, 1, 2;

Ask ATech: "In how many of the listed areas have you been trained?

    Monitoring and Site Characterization    Containment Transport
    Data Quality Objectives                 Data Quality Management
";
CHOICES ATech: 0, 1, 2_to_3, 4;

ASK AComm:  "Have you had advanced community relations training?";
CHOICES AComm:  Yes, No;


! --- Rule set to determine Training ------

RULE 3
   If Advanced = Basic
   THEN Training = Intro_level;
```

```
RULE 3a
   If Advanced = Fully_Qualified or
     Advanced = Partially_Qualified
   THEN Training = Advanced_trained;

RULE 3b
   If Advanced = Not_Qualified and
     Intro = Not_Qualified or
     Intro = Basic
   THEN Training = Novice;

RULE 3c
   If Advanced = Not_Qualified and
     Intro = Fully_Qualified or
     Intro = Partially_Qualified
   THEN Training = Intro_level;


!--- Rule set to combine all three KBSs to determine certification level---

RULE 4
   If Academic_degree = highly_prepared or
     Academic_degree = prepared and
     Experience = Excellent and
     Training = Advanced_trained
   THEN Certification_level = Three;

RULE 4a
   If Academic_degree = highly_prepared or
     Academic_degree = prepared and
     Experience = Good and
     Training = Intro_level or
     Training = Advanced_trained
   THEN Certification_level = Two;

RULE 4a-1
   If Academic_degree = highly_prepared or
     Academic_degree = prepared and
     Experience = Good or
     Experience = Excellent and
     Training = Intro_level
   THEN Certification_level = Two;
```

```
RULE 4c
   If Academic_degree = unprepared and
     Experience = Poor and
     Training = Novice
   THEN Certification_level = Zero
   ELSE Certification_level = One;
```

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## Vita

Captain Roger R. Ouellette was born on 30 October 1966 in Kittery, Maine. He graduated from Highland High School in Albuquerque, New Mexico in 1984 and attended New Mexico State University, graduating with a Bachelor of Science in Biology and a Bachelor of Art in Chemistry in May 1988. Upon graduation, he received a commission in the USAF and entered active duty on 31 December 1988. He reported to Keesler AFB MS to attend the Administration Officer Course and was a distinguished graduate. His Air Force career directed him to Wright-Patterson AFB in February 1989 where he became a personnel officer within the Personnel Utilization Division of the Aeronautical Systems Division, Air Force Systems Command until March 1992. During his tour with the Aeronautical Systems Division, Roger was elected the Vice President and then President of the Company Grade Officer Council. He was chosen to work retention issues within the Air Force Logistics Command until entering the School of Logistics and Acquisition Management in the Graduate Information Resource Management degree program, Air Force Institute of Technology, in May 1992. Upon completion, he became the Information Manager for the 2nd Mission Support Squadron, Barksdale AFB LA.

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## Vita

Captain Bruce K. Lyman was born on 23 May 1966 at Loring Air Force Base, Maine. He graduated from Brindisi American High School, San Vito Air Station, Italy in 1984 and attended Ohio University, graduating with a Bachelor of Science in Interpersonal Communications in 1988. Upon graduation, he received a commission in the United States Air Force and entered active duty on 29 May 1989. He was assigned to Little Rock AFB as an executive officer for the 314th Field Maintenance Squadron. In October of the same year, he reported to Keesler AFB, MS to attend the Administration Officer Course. In March of 1990, he was transferred at Little Rock AFB to the 314th Aircraft Generation Squadron where he was the Squadron Section Commander. In October of 1991, he was transferred to the position of Squadron Section Commander of the 314th Supply Squadron. At the end of 1991, Captain Lyman was selected as the Outstanding Officer Information Manager of the Year. In May of 1992, he attended the School of Logistics and Acquisition Management to earn a masters degree in Information Resource Management. Upon completion, he was assigned to SAF/AAIP, Bolling AFB, MD to work Air Force publishing issues.

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By the end of Fiscal Year 1991, the Air Force had identified 4,354 contaminated sites. Much like the 177 toxic sites at McClellan AFB, bases across the country and throughout the world are filled with chrome, lead, paint solvents and many other toxics that are rendering water supplies unusable and endangering the health of millions of people living in and around these bases. Air Force officials continue to identify contaminated sites with no end in sight. Since the cleanup of these toxic materials involves diverse, complex activities, the Air Force created the duty position of Remedial Project Manager to manage site cleanup efforts. In order for these site coordinators to effectively act as team leaders for project groups charged with site cleanup, they must be provided with relevant education and training.

This study defined the process by which Air Force environmental course managers provide education to environmental professionals, including RPMs. Once defined, the process was used to create a prototype relational database to enhance the course managers' ability to operate efficiently. This research also created two prototype computer knowledge-based systems (KBS) to prove that KBS technology could be used to provide RPMs with a career education program and certification process..

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