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Evolution of a knowledge system for project consulting /

Deborah A. Hagerman
Lehigh University

EVOLUTION OF A KNOWLEDGE SYSTEM

FOR PROJECT CONSULTING

by

Deborah A. Hagerman

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John C. Wyman

PROFESSOR IN CHARGE

S. E. Kane

CHAIRMAN OF DEPARTMENT

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ABSTRACT

In any information system development effort, whether large or small, there is a need for guidelines, policies, procedures, and standards in order to ensure the development of a quality system. The degree of structure and the number and types of tasks necessary to produce a quality system vary with the size and complexity of the project.

This thesis deals with the evolution of a knowledge system which assists in the project planning process and provides measures for insuring the development of a quality information system. The ultimate benefit of this system is to have central repository of project planning knowledge available to all project managers within MIS.

This knowledge system has been constructed on the foundation provided by two prototypes known as PROCON I and PROCON II. The functionality provided by these prototypes include development approach selection, risk assessment, and estimating.

In order to ensure the development of a quality system which meets the needs and expectations of the customer, several additional factors needed to be addressed in the project planning and development process. These factors include Standard Deliverables, the project initiation process, and the determination of the current phase of development. PROCON provides a framework for integrating the concepts of development

approach selection, risk assessment, and estimating with these new factors.

The knowledge base which has been developed consists of facts and heuristics for determining the need for a project authorization along with its associated attachments and required signatures; required standard deliverables by phase based upon the chosen development approach; and the current and subsequent phases of development.

The scope of this thesis also encompasses the refinement of the processes of development approach selection, risk assessment, and estimating techniques in order to streamline the rule structure and incorporate new features.

The process of building, refining and testing this knowledge system is documented in this thesis. Several project cases are provided to illustrate the functionality of PROCON.

I. INTRODUCTION:

The primary goal of System Development and Services (SD&S) within Air Products' MIS organization is to provide quality information systems for the customer within the given time and cost estimates. Our definition of quality is "consistent conformance to customer expectations." The development of a quality information system requires the use of a well-defined development methodology, project planning and control tools, a competent staff, and an effective organizational structure and proper management practices to support this structure. Within SD&S, a staff function known as Project Planning and Control is responsible for providing support services in all facets of the system development process.

In 1985 the Manager of Project Planning and Control identified a need to capture the knowledge used in the project planning process for purposes of sharing that knowledge among all project teams in SD&S. A knowledge system prototype (PROCON I) was developed to assist in the selection of an appropriate development approach and assess the risk of a given project. An enhancement prototype (PROCON II) was subsequently developed to address certain aspects of the estimating process used in the development of an information system.

Several additional components of the project planning process were defined. First, there is the task of initiating a project. This task

requires the preparation of a document known as the Project Authorization (PA). Additionally, PA's are required for each funding stage or phase of the project. Second, each phase of a project requires that certain deliverables, or tangible work products, be completed in order to ensure a quality system is delivered to the customer.

In order to have a consulting tool which addressed the project planning process in total, a major enhancement to the existing knowledge system was needed. This enhanced knowledge system will be known simply as PROCON (PROject CONsultant). PROCON will provide a framework for integrating the concepts of development approach selection, risk assessment, and estimating with the guidelines and procedures which should be followed throughout the system development life cycle.

The new functionality which has been added to PROCON includes the process of project initiation, the determination of the current phase of development, and the Standard Deliverables required by phase for each type of project development approach. In addition, PROCON has enhanced the processes of development approach selection, risk assessment, and estimating in order to streamline the rule structure and incorporate new features.

The primary objective of this thesis is to develop a consulting tool to assist both the project planning consultant and the project manager in every aspect of the project planning process in order to increase productivity and improve the quality of the project plans. This thesis

describes the development of the new features and enhancements and provides an overall discussion of the evolution of PROCON.

The author assumes the reader is familiar with the concepts of knowledge systems in general, and particularly, PROCON I developed by F.M. Lesusky and PROCON II developed by C.B.A. Freed for fulfillment of their respective thesis requirements.

II. BACKGROUND:

The project development process is a meticulous one with many factors affecting its success or failure. A well-defined development methodology, project planning and control tools, a competent staff, an effective organizational structure and proper management practices are all critical factors in the system development process.

A staff function known as Project Planning and Control was established within the SD&S organization at Air Products and Chemicals, Inc. with the intent of providing the development staff with assistance in the system development process. The Project Consultant's primary functions are:

* to provide consultation and assistance in the preparation of development strategies, risk assessments, and project plans

* to develop and maintain methods and procedures governing SD&S development and support activities

* to administer the System Development Methodology

* to research and evaluate new methods to support the system development process

The methods and procedures which are used in the system development

process are embodied in an overall Project Management Framework or Model. The five major components of the Project Management Framework are:

* PLAN the work to be performed

* ORGANIZE the required work to be performed most effectively

* PERFORM the work based on the plans and in accordance with pre-established standards and procedures

* MEASURE and EVALUATE PERFORMANCE against the established plans to determine progress and assure proper direction

* CONTROL the process by taking corrective actions that will result in meeting the planned objectives

The scope of this thesis deals with the first two components - PLAN and ORGANIZE. The remaining components will not be addressed.

During the preliminary planning stage of the system development process, a document known as an MIS Project Authorization (PA) is required to initiate the project. The primary purpose of the PA is to provide a standard document for authorizing MIS projects which exceed certain limits. The PA also serves several other purposes:

* Provides the basis for subsequent project status reporting for major projects

* Provides the milestones, costs, and schedules against which project performance can be measured

* Expedites the approval process by clearly identifying the information required by management to evaluate a potential project

* Ensures MIS projects receive an appropriate level of management recognition and internal MIS support

Not all MIS projects require a Project Authorization. A set of comprehensive guidelines aid in determining the need for a PA. The Project Consultant assists the project manager in determining: when a PA is required, what approvals are needed, and any necessary attachments required to supplement the PA.

Several other topics are typically addressed in the preliminary planning session. These topics include:

* selection of an appropriate development approach

* assessment of project risk

* the use of ESTIMACS (PC-based software) to determine initial planning estimates for the total project

* the extent of SDM/70 (System Development Methodology) usage based upon project characteristics, such as size, risk, or development approach

III. PROBLEM STATEMENT:

In any information system development effort, whether large or small, there is a need for guidelines, policies, procedures, and standards in order to ensure the development of a quality system. The degree of structure and the number and types of tasks necessary to produce a quality system vary with the size and complexity of the project.

The MIS organization at APCI has a development methodology, project control tools, policies, and procedures in place. These are all necessary ingredients in producing an effective system which meets the customers needs and expectations.

Quality has recently become an important issue in the development of information systems. Most people would agree that quality is a key factor in the success of a system. The question is, "Do we all take the time to plan for it?"

Air Products and Chemicals, Inc. has recently initiated a "Total Quality Management" process to be used by all organizations throughout the corporation. SD&S has begun to address the issue of quality in the system development process.

Quality is not a quick "fix" that can be added at the completion of a development project. It must be built into the project from its inception. A plan must be developed to ensure quality. As part of the

quality plan, the concept of Standard Deliverables has been introduced within the system development process.

A Standard Deliverable is a tangible work-product which is required for a given project task based upon project size and development approach. The purpose of Standard Deliverables is to define the tasks to be completed in each development phase. The system development methodology provides the framework for Standard Deliverables. Each type of development approach will have its own corresponding set of Standard Deliverables, although many of the same deliverables may be required in each development approach.

The consulting tools developed in the initial PROCON prototypes were designed with the idea of increasing productivity in the project planning process. With the "quality" emphasis becoming an important issue in system development, there became a definite need to expand the tool.

In order to ensure a quality system, several additional factors needed to be addressed in the consulting tool. First, the project initiation process which involves preparing a Project Authorization and various planning documents needed to be incorporated. Second, as a part of a quality plan, there should be periodic checks throughout the development process in order to ensure that all requirements have been met before proceeding to the next phase. Standard Deliverables provide a checklist of tasks which must be completed within each phase of

development. They also provide a means of determining the current and subsequent phases of a project for purposes of preparing a PA.

Not only does this enhancement incorporate Standard Deliverables, project initiation, and determination of the current phase of development, but also provides a framework for integrating the concepts of development approach selection, risk assessment, and estimating. The final result is a consulting tool which addresses the total project planning process.

IV. PROBLEM SOLUTION: WHY A KNOWLEDGE-BASED SYSTEM

The project planning process is a decision-making process. Information about the project size, project cost, functionality, complexity, user commitment, interdependencies among existing systems and many other factors affect the project plan. Standards and procedures assist the project manager in the planning process. The project consultants also provide guidance when preparing a project plan. However, there are currently only two individuals providing support to approximately 170 SD&S staff members. The task of project planning is a complicated one and it is the responsibility of the project manager to ensure that all factors have been considered.

Thus, a tool was needed to organize this decision process for consistency and to reduce the possibility of oversight. Also, since only two individuals are assigned to provide project planning consultation, a need for a vehicle designed to collect and disseminate the knowledge was identified.

Knowledge-based system technology was chosen to develop a consulting tool for the project planning and development process. Knowledge-based systems emulate the rational decision processes based upon the knowledge contained in its knowledge base. The objective of a knowledge-based system is to capture knowledge of the expert(s), efficiently represent the information in a modular, expandable structure, and to transfer the knowledge to the users (in this case, the project managers).

Knowledge-based systems are different from traditional computer systems in that they integrate and analyze large amounts of information and produce a small amount of quality information pertinent to the particular situation. This method is known as convergent analysis. Traditional systems, on the contrary, use divergent analysis where small amounts of data are input and large volumes of data are created as output.

Knowledge-based systems, much like the human expert, make decisions or recommendations by evaluating the information, drawing inferences from it, and subsequently creating high-quality conclusions. Such knowledge systems are adept at decision-making. They are structured around sets of rules, simple declarative "if/then" statements that assess the situation, in effect, mimicking the human decision-making process.

Several key factors were addressed in the determination of the appropriateness of the use of knowledge-based system technology for this application. First, of course, is that the application involves a complex decision-making process which evaluates large amounts of information. Second, the project planning and consulting function is handled primarily by two key individuals who service the entire development department. Third, the nature of decision-making is quite complex, and is not easily handled via traditional development. Finally, there is a definite need to disseminate this knowledge to all project managers within MIS in a consistent and timely manner.

If any one of these factors is characteristic of an application, then knowledge-based system technology becomes a viable solution. In the case of this application, all four factors characterized the project planning process.

There are many benefits attributed to the use of knowledge-based systems. One benefit is that they provide a means to retain knowledge and protect against its loss. Knowledge systems provide a way of preserving a previously intangible asset, human knowledge. Once the knowledge is captured in a knowledge-based system, it can be used to transfer the knowledge to assist in daily activities or to provide training. Also, the knowledge system can assist in improving manpower utilization by increasing the expert's availability for other responsibilities. The use of knowledge systems also provides consistent and timely information due to the structure of the knowledge base. Finally, knowledge-based systems faciliate the accumulation of knowledge for purposes of creating more knowledge, i.e. continually learning and improving our knowledge of a given process.

V. SOFTWARE SELECTION:

INSIGHT is a knowledge engineering "shell" which provides a framework for developing a knowledge-based system. INSIGHT simulates the human decision-making process by using an accumulation of knowledge, or knowledge base, to evaluate, reason, and provide conclusions or solutions to problems normally requiring human expertise.

INSIGHT 1.2 was originally selected as the knowledge engineering shell for development of PROCON I and PROCON II for reasons of cost, flexibility and availability. This tool uses a backward chaining goal-driven inference engine which pursues a selected goal by searching for those conditions which support that goal. When building a knowledge system using this tool, the engineer specifies a goal or hierarchy of goals which are subsequently proven or disproven based upon a network of interdependent rules.

Since the completion of the two prototypes, the Knowledge Systems group at Air Products and Chemicals, Inc. has purchased an enhanced version of INSIGHT known as INSIGHT 2+ which contains several advanced capabilities. Such features as numeric data manipulation using boolean, arithmetic, and higher mathematic operations have been incorporated in the package. INSIGHT 2+ provides the capability of linking to other knowledge bases and transferring and updating global facts or parameters among the activated knowledge bases. INSIGHT 2+ also provides a means of activating external programs from within the knowledge base. In

addition, a PASCAL language known as DBPAS provides direct access to dBASE II and dBASE III from within the knowledge bases. Significant advances in the reporting capabilities have also been incorporated into this release of INSIGHT.

INSIGHT 2+ provides several capabilities which were essential to the development of PROCON. First, the mathematical capabilities provided the ability to assign values to various degrees of risk. In this way, a total risk factor could be accumulated throughout the consultation session and the total risk value could be used to determine the appropriate risk category. Second, the software provides the ability to export data from the knowledge base to the external environment via the FILE, WRITE, and PRINT commands. These features provided a means of capturing the Standard Deliverables determined by the consultation session within the knowledge system.

In developing a knowledge system to incorporate all aspects of the project planning process, it was determined to use INSIGHT 2+ as the knowledge engineering shell. The advanced features met all the needs of PROCON and also provided many opportunities for the expansion of the knowledge system. Some potential enhanced applications evaluated were the capturing of project planning data in an external file or data base for historical purposes. Also, the possibility exists to expand the knowledge system to interface with spreadsheet software for project management purposes such as project tracking and analysis.

VI. METHODOLOGY:

The development of a knowledge-based system is an evolutionary process. Information is acquired from the expert, refined, and then translated into the language of the knowledge system. Several sample cases are used to test the accuracy and consistency of the conclusions reached by the knowledge system. The rule structure is refined to adjust any imperfections and the testing is repeated.

Knowledge system development is an iterative process in which no absolute methodology exists. However, there are two major phases within the development process. Phase I addresses the identification and conceptualization of the problem. In the identification stage of Phase I, the knowledge engineer selects and acquires an expert, knowledge sources and resources, and clearly defines the problem and scope. In the conceptualization stage, the key concepts, relations, and information flow necessary to describe the problem-solving process are defined.

Phase II of the development process addresses formalization, implementation, and testing of the knowledge system. Initially, the knowledge is formalized or represented manually in a chosen structure, such as decision trees. This model subsequently provides a framework for transferring the decision process to the selected knowledge system tool (INSIGHT 2+). The final stage is the testing of the knowledge system for performance and consistency. Reformulation and refinement of

the rule structure is performed to correct any weaknesses in the system.

PROCON was developed in a similar fashion. Appendix A outlines the methodology used in the development of PROCON. This appendix also contains the questions addressed during the knowledge acquisition process. In using this methodology, a subproblem was initially selected to focus on the knowledge acquisition process and to familiarize the team with the knowledge system shell known as INSIGHT 2+. Once the subproblem was implemented, new goals were added along with the representative rule structures. These rules were then tested and refined, and the implementation process progressed in an iterative fashion.

VII. BUILDING THE KNOWLEDGE SYSTEM: SUBPROBLEM

In order to examine the capabilities of INSIGHT and become familiar with the knowledge acquisition process, the area of Project Authorization requirements was focused on as a subproblem.

The initial goal of this subproblem was to determine when a Project Authorization is required. Through a series of question-and-answer sessions with the Manager of Project Planning and Control, a set of conditions were generated which required the preparation of a PA. These conditions are:

* total project cost > $10,000
* ongoing MIS production and support cost > $25,000
* technology risk is high
* structure risk is high
* project is highly sensitive

If any one of these attributes characterize a project, then a Project Authorization is required.

Once these conditions were determined, flow diagrams and decision trees were used to represent the decision process (refer to Appendix B to review decision trees and flow diagram). The next step was to transfer this model to the source language of INSIGHT 2+. The source language needed to be structured in a manner in which all remaining rules would

be bypassed as soon as one of the above conditions was found to be true.

The following rules were created using INSIGHT's Production Rule Language (PRL):

```
RULE  For total project development cost
IF    total project development cost greater than 10000
THEN  PA is required

RULE  For ongoing MIS production and support cost
IF    ongoing MIS production and support cost greater than 25000
THEN  PA is required

RULE  For technology risk
IF    technology risk is high
THEN  PA is required

RULE  For structure risk
IF    structure risk is high
THEN  PA is required

RULE  For highly sensitive project
IF    project is highly sensitive
THEN  PA is required
ELSE  DISPLAY project authorization is not required
AND   PA is not required
```

Once the production rule language was compiled, the execution of the knowledge system did indeed only question the user about the PA conditions until one of the conditions had been met and subsequently, concluded that a PA was or was not required.

The implementation of this initial subproblem provided a means of familiarizing the team with the knowledge acquisition process and the production rule language. It also provided a foundation for building the necessary rule structures for addressing the project planning process.

In the pages which follow, the author will address each goal of the Knowledge System and the rule structures which support these goals. Included in these sections will be a discussion of the evolutionary process of knowledge engineering, the INSIGHT 2+ capabilities employed, and the strategies and debugging techniques used to test and implement PROCON.

VIII. GOAL STRUCTURE

As previously mentioned, it is the intention of this development effort to create a consulting tool which addresses the project planning process in total. In evaluating the project planning process, five key goals were determined to be essential:

1.0 Project Authorization Can Be Determined

2.0 Project Development Approach Can Be Determined

3.0 Project Phase and Deliverables Can Be Determined

4.0 Project Risk Can Be Determined

5.0 Project Estimating Tools And Techniques Can Be Determined

By subdividing the problem domain into multiple goals, the knowledge system provides the user with the flexibility of pursuing only those goals which are pertinent to the individual's project.

As PROCON evolved, each of the goals was refined and in some cases, subgoals were developed to incorporate the appropriate level of detail into the knowledge system.

The sections which follow describe the details of each of the five goals. Three cases will be used to illustrate each of the goals within PROCON.

IX. STRUCTURE OF THE CONSULTATION SESSION

The use of PROCON will begin in the preliminary planning session with the assistance of the project consultant. The intent is to have the project consultant involved as early as possible when a new project effort is undertaken. In this particular session, all parameters initiating the project are reviewed. The determination of the applicability of PROCON is made at this time. Once the determination has been made to use PROCON, the remaining goals can be pursued.

The project consultant will assist the project manager in using the knowledge system. PROCON provides a means of structuring the consultation session so all issues can be addressed.

The cases which follow describe three separate and distinctly different projects. In each case, PROCON is used to pursue all five goals in order to illustrate the various conclusions which can be reached based upon variations in project parameters.

X. CASE 1A: SCENARIO

The first project is an enhancement to an existing database system where the project manager is relatively new to the project planning process. The project is considered to be small, and will cost approximately $8000 (based on a preliminary "bottom-up" estimate of the effort involved).

GOAL #1: Project Authorization Requirements Can Be Determined

In order to determine the applicability of PROCON to the current project GOAL #1 was pursued. The questions addressed in order to achieve this goal were prompted in the following order:

Is it true that ...

1. total project development cost greater than 10000
2. ongoing MIS production and support costs greater than 25000
3. project is highly sensitive

Since the project was initially estimated at a total cost of $8000, the answer was false to question one. The support costs associated with this project are minimal, therefore the response to the second question was also false. The question concerning project sensitivity needed some further explanation for clarification. By entering the EXPAND key, the

following explanation was given by PROCON:

> "We are trying to determine if the project is highly sensitive. A highly sensitive project is any project which is expected to receive a high degree of user management visibility, which involves substantial business or technical risks, or which is strategically important to MIS or the users that sponsor the project."

Since the project is a relatively small enhancement to an existing system with little management visibility, it was determined to be not highly sensitive.

Because all three questions were answered false, the determination was made that a PA is not required. Since the foundation of the project planning process is based upon the need for a PA, it was determined that further use of PROCON would be of marginal value.

This case was used to illustrate how PROCON determines if its use is applicable to the current project under evaluation.

XI. CASE 1B: SCENARIO

In order to examine each of the goals, a variation was made to CASE 1A for total project cost to be greater than $10000. The project is still a small enhancement to an existing data base system. The project manager is relatively new to the project planning process. The development effort will require approximately 200 man-hours to complete.

GOAL #1: Project Authorization Requirements Can Be Determined

As exemplified in the previous case, the first question asked is if the total cost is greater than $10000. Since the total project cost will exceed this specified limit, PROCON reached an intermediate conclusion that a PA is required.

The fact that a PA is required is also a condition used to trigger the line of reasoning for determining PA attachments and PA approvals. Thus, the following questions used to determine PA attachments are posed:

IS IT TRUE THAT ...

"a capital expenditure is required"

"total project hours are greater than or equal to 1500"

Since the project is an enhancement to an existing system, no software or hardware will be purchased. Therefore, no capital expenditure is

required. Also, the total project is estimated to require only 200 man-hours to develop the proposed system. Thus, the second question is also responded as false.

Based upon the answers provided, PROCON has determined the PA attachments required and will display the following:

The following PA attachments are required:

* Risk Assessment Summary
* Total Project Schedule and Gantt Chart
* Total Project Cost Summary
* Phase Schedule and Resource Plan
* Standard Deliverable Review Plan

Although PROCON specifies the required PA attachments, the level of detail comprising each of these attachments is determined at the discretion of the project consultant and project manager.

Once the PA attachments have been concluded, PROCON pursues the line of reasoning to determine the PA approvals. The questions which follow comprise the total rule set for determining PA approvals:

IS IT TRUE THAT ...

1. Project will require exceptions or changes in MIS policy
2. Approval required by another VP or Corporate Officer

3. Project provides services to any APCI subsidiary

4. Total estimated development cost is greater than 144000

5. Supplemental funding of budget overrun is greater than 25000

6. Project is highly sensitive

7. Total project cost greater than or equal to 72000

8. Total project cost greater than or equal to 36000

9. Computing services staff resources are committed to in PA

10. Purchased software will run on CS environment

11. Software beta testing is involved

12. Service levels impacting Computing Services committed to in PA

Questions one through six are directed at determining if the Vice President of MIS must sign the PA. If any one of the responses is true, the remaining questions concerning the VP approval will not be posed to the user. In this case, however, each question (1 through 6) was answered false. Therefore, the Vice President of MIS is not required to sign the PA.

Question seven is used to determine if the Manager of System Development and Services (SD&S) must sign the PA. The need for the Section Manager's approval is determined by question eight. Again, since the responses to these two questions are false, these two approvals are not required.

The final four questions are directed towards determining the need for

the approval of the Manager of Computing Services. Since all the user responses for this particular case are false, PROCON determined that no high level management signatures are required to approve this PA.

This case was used to illustrate the variety of questions that could be posed to the project manager to determine the PA requirements. If the questions had been answered differently, the paths pursued by the knowledge system would have been quite different.

PROCON was structured to pursue the shortest path necessary to achieve the selected goal. Questions which acquired the most information were posed first, causing a conclusion to be reached more quickly without asking any unnecessary questions.

Also, at several points throughout the knowledge system, multiple premises were used to reach the same conclusion. As in the determination of the Vice President's approval, if any one of six conditions was found to be true, PROCON would have concluded that the VP must sign the PA. At that point, no further questions concerning the determination of this approval would have been asked.

GOAL #2: Project Development Approach Can Be Determined

At this point the project manager has identified the necessary PA attachments and approvals to initiate the project with the assistance of PROCON. The next step in the project planning process is to evaluate alternative development approaches. By selecting Goal #2 from the main menu, PROCON will evaluate each type of development approach (i.e. Purchased Software, Experiment or Pilot, Prototyping, Customer Development, Evolutionary Development, Traditional Life Cycle) and identify which approaches are suitable for the given project. Depending on the characteristics of the project, it is possible for PROCON to identify more than one approach as being a viable solution.

The first approach which PROCON evaluates is Purchased Software. Two conditions are necessary for Purchased Software to be considered a viable approach. First, purchased software must be commercially available. Second, the project must be categorized as new development. In this particular case, purchased software is not commercially available. Therefore, PROCON concludes that Purchased Software is not a viable solution.

The next approach evaluated is Experiment or Pilot. Three conditions must be met if an Experiment or Pilot is to be recommended as a feasible development approach:

* Customer procedural change is feasible with a significant impact

* Two or more customer organizations are involved
* MIS experience with the chosen technology is limited

If all three of these conditions are true, then Experiment or Pilot is a viable approach. In this particular case, the project is an enhancement to an existing system which has no impact on the customer's procedures. Thus, an Experiment or Pilot is not a viable approach.

Prototyping is recommended as a viable solution if all of the following characteristics describe the project:

* Processing is predominantly online
* Application involves transaction processing
* External design has not been completed
* MIS has significant experience with chosen technology
* Customer expectations are not well-defined or unknown

In this enhancement project, the processing is predominantly online and involves transaction processing. However, the External Design has been completed. Thus, PROCON concludes that Prototyping is not a recommended approach.

Customer development is another potential alternative approach for project development. The conditions which justify the use of this approach focus mainly on the customer's experience with the chosen technology and the complexity of the project. The following premises

must be true in order for Customer development to be considered an acceptable approach:

* Project is small
* System interfaces are not required
* Project is not dependent on another project
* Customer has appropriate technology experience OR
* Purchased software will be supported by customer

Although the present project is small, with no system interfaces or dependencies, PROCON has determined Customer development to be an inappropriate alternative. Since the project is an enhancement to an existing mainframe system, the customer does not have the necessary experience to develop the system as perhaps, in a PC-based application or an application using a Fourth Generation language. This condition caused PROCON to recommend that Customer development is not a viable development approach.

Evolutionary development can be used when the project is very large (>= 3000 hours) and requires more than 24 months to complete. Also, the application must have two or more subsystems, or involve two or more customer organizations. This small enhancement project does not meet any of these criteria, and thus, Evolutionary development is not a viable solution.

The final development approach evaluated is Traditional Life Cycle. This

approach is the most frequently used development approach and is a viable alternative for most situations. PROCON will recommend Traditional Life Cycle as a viable approach in every situation except where Evolutionary development has been recommended. In the present case, Evolutionary development was determined to be inappropriate. Therefore, PROCON recommended Traditional Life Cycle as a viable approach.

GOAL #3: Project Phase and Deliverables Can Be Determined

The next step in the project planning process is to determine what deliverables are required to complete the project. Each development approach will ultimately have its own associated set of Standard Deliverables by phase of development. The Standard Deliverables for Purchased Software and Traditional Life Cycle are currently in place within the MIS organization and have been incorporated into the knowledge system. The Standard Deliverables for Prototyping, Experiment/Pilot, Customer Development, and Evolutionary Development are currently under development, but will not be included in PROCON within the scope of this thesis.

PROCON is structured to prompt the project manager to select the development approach which has been determined as the viable solution from the menu. It is assumed that the project manager has previously identified the best development alternative prior to selecting this goal.

In order to identify the deliverables required, PROCON attempts to determine the status of the project by first determining the most recent phase completed. The user is asked to select which is the most recently completed phase of the project from the following list:

Project Initiation

Requirements Definition

Design Alternatives

External Design

Internal Design

Unknown

If the user selects "Unknown", PROCON will lead the user through a series of questions to identify the most recently completed phase. Once this phase has been identified, PROCON will first display the Standard Deliverables for this phase. The project manager can then use this list to assure that all deliverables have been completed for the present phase. As PROCON continues, it will display the Standard Deliverables for each of the remaining phases of the project.

In the current session, Traditional Life Cycle is the chosen development approach and the most recent phase completed is External Design. As a result, PROCON displays the following:

EXTERNAL DESIGN DELIVERABLES

System external specifications report

Hardware, software configurations

Logical data base design

File and table layouts

Layouts of input forms and screens

Layouts of reports and inquiry screens

Detailed functional flowchart

Data control requirements

Security requirements

Definition of system processing

Data entry and error correction procedures

System backup and recovery procedures

System acceptance criteria

Preliminary test, conversion, implementation plans

INTERNAL DESIGN DELIVERABLES

System internal specification report

Technical system flowchart

Jobstream flowchart and narrative

Final layouts of input forms and screens

Final layouts of reports and inquiry screens

Program specifications

Revised test, conversion, implementation plans

Physical data base design

SYSTEM CONSTRUCTION AND IMPLEMENTATION DELIVERABLES

Coded programs

JCL

Program documentation

Final test plan

Test case specifications

Test data

Test results

Final conversion plan

Final implementation plan

User documentation

Operations documentation

User training material

Production turnover and startup plan

Production turnover packages

User acceptance and parallel test results

System documentation

Management security memo

Project close memo

Thus, PROCON has provided the project manager with a checklist which can be used to verify that all necessary project deliverables have been completed. This list can be formatted into a working document to be

used in planning sessions and quality assurance reviews. In this way, PROCON has provided a mechanism for insuring the adherence to the system development methodology.

GOAL #4: Project Risk Can Be Determined

The next factor which must be evaluated in a system development project is risk. There are currently five different categories of risk which must be evaluated to determine a total risk factor for the project:

* Size
* Complexity
* Structure
* Organizational Impact
* Technology

PROCON determines a risk value for each of these categories by assigning points to various aspects of each risk category. Each time a factor is considered to represent the given project, PROCON adds a corresponding risk value to the total risk variable. After all factors have been evaluated, PROCON compares the risk parameter to a given scale and determines the degree of risk in terms of high, medium, or low.

Typical questions associated with the size risk category address project size, duration, dependence, and manager's experience. Depending on the

answers provided by the user, PROCON will add a risk value to the total risk parameter for the project size risk category. In this particular case, the project is small, with a duration of approximately five months. The project is not dependent on another project. However, the project manager is fairly new to the project management process. PROCON added the following values to the total size risk:

size	0
duration	0
dependence	0
manager's experience	5
total size risk	5

PROCON then uses this value to determine the degree of size risk. The following ranges have been used to assign a degree of size risk to the project:

size risk < 3	then size risk is low
size risk >= 3 and < 7	then size risk is medium
size risk >= 7	then size risk is high

In the current case, the size risk was evaluated to be medium based upon the above criteria.

PROCON follows a similar process for arriving at a total risk value for each of the four remaining risk categories. The results of the summary

risk analysis for the current case are as follows:

size risk	= 5	medium
complexity risk	= 0	low
structure risk	= 0	low
organizational impact	= 0	low
technology risk	= 0	low

Further details on the risk categories can be found in the source listing provided in the attachments to this thesis.

GOAL # 5: Project Estimating Tools and Techniques Can Be Determined

The final goal that PROCON pursues will aid in determining the best estimating approach suitable for the given project.

Air Product's presently has two tools available for assisting in the estimating process. An automated estimating worksheet was designed to aid in developing preliminary estimates for small projects requiring less than 750 MIS man-hours of effort.

The second tool, known as ESTIMACS, is used for estimating larger, new development or enhancement projects. This tool is subdivided into the ESTIMACS Development Estimator module and the ESTIMACS Maintenance Effort Estimator module. The Maintenance module addresses projects considered to be enhancements to existing systems which provide less

than fifty percent new functionality. Any project which requires more than 750 hours of effort and provides greater than fifty percent new functionality should use the Development Estimator module for preparing preliminary estimates.

PROCON has incorporated the logic to first determine which estimating technique is appropriate for the project at hand. If the recommended technique is determined to be the Estimating worksheet, PROCON will abandon the line of reasoning for other estimating techniques and end the consultation session. If, however, ESTIMACS has been determined as the viable estimating technique, PROCON will determine whether the Development Estimator or the Maintenance Estimator module should be used.

Once the appropriate module has been determined, PROCON will then proceed to ask a series of twenty-five questions corresponding to the estimating module selected. The user is provided with an ESTIMACS worksheet to record the responses to each question. These responses can then be entered into ESTIMACS to determine the preliminary estimates. PROCON does not presently provide a direct interface to the ESTIMACS software package. It does, however, provided an intelligent front-end to this PC-based software by providing detailed explanations of each of the ESTIMACS questions. A detailed discussion of ESTIMACS and estimating techniques is described in the thesis entitled "The Development and Integration of a Knowledge-Based System for Information Systems Project Development and Estimation Consultation" by C.B.A. Freed

for fulfillment of her Master's of Science Degree from Lehigh University.

In the current case under discussion, PROCON did not recommend the use of ESTIMACS since the project required less than 750 hours of effort. Thus, the estimating worksheet was determined to be the appropriate estimating tool.

XII. CASE 2: SCENARIO

The second application is a large project involving the replacement of an obsolete system using online transaction processing. The system will be developed using new hardware. Also, commercially available software has been chosen as the development tool. Because purchased software is involved, a capital expenditure must be prepared. Since this system is the replacement of an obsolete technology, there will be a significant impact on the customer's procedures. In addition, the customer is inexperienced with MIS procedures since this is the first system development effort which they have undertaken. Therefore, the customer's expectations and scope of the project are not well-defined.

GOAL #1: Project Authorization Requirements Can Be Determined

PROCON will first determine if a Project Authorization is required for the given project. Since this project is a sizeable development effort which will incur a cost in excess of $10,000, PROCON determines that a PA is required.

In order for a Project Authorization document to be complete, there are several attachments which must accompany the PA through the approval process. PROCON poses a series of questions in order to determine the necessary attachments. The attachments for the present project are as follows:

* Risk Assessment Summary

* Total Project Schedule and Gantt Chart

* Total Project Cost Summary

* Phase Schedule and Resource Plan

* Capital Expenditure Authorization

Once the appropriate attachments have been determined, PROCON determines the managers required to approve the Project Authorization. Since the proposed system is a replacement of an obsolete technology which will require significant changes in the customer's procedures, the Vice President of the customer organization is required to sign the PA. The MIS guidelines specify that the Vice President of MIS must sign all PA's which require the signature of another VP. The Manager, SD&S, must also approve the PA when the Vice President's approval is required.

Based upon the fact that a capital expenditure is required for the hardware and purchased software, the MIS Controller and Manager of Computing Services must also approve the Project Authorization in order for the project development to proceed.

GOAL #2: Project Development Approach Can Be Determined

As mentioned in the previous cases, PROCON will evaluate all the various development approaches as potential solutions to the given project. In this particular case, PROCON determines three viable development approaches based upon specific facts obtained through the consultation

session. The Purchased Software development approach is determined to be a viable solution based upon the following two conditions:

1. Purchased software is commercially available for the application
2. Project type is new development

PROCON concluded that the project was new development based upon the fact provided that the existing automated system will be replaced.

The second approach suggested as a viable solution is Prototyping. Five facts must be true of the project in order for Prototyping to be considered a viable solution:

1. Type of processing is predominantly online
2. Application involves transaction processing
3. External Design has not been complete
4. MIS has significant experience with chosen technology
5. Customer expectations are not well-defined or unknown

Customer Development was concluded to be an inviable solution since the project size is very large. This development approach is feasible only in systems which are small with no system interfaces, and the customer has the appropriate technology experience.

Evolutionary Development was also considered to be an inviable solution in this case. In order for this solution to be considered feasible, the

project must be very large, with a duration greater then 24 months. The application must also involve more than two subsystems, and two or more customer organizations must be involved. None of these attributes are characteristic of the given project. Therefore, Evolutionary Development was not chosen as a viable alternative.

The final development approach and the most commonly used approach is known as Traditional Life Cycle. Until a few years ago, Traditional Life Cycle was the only recommended approach available. With the onset of new technologies, the aforementioned development approaches evolved. PROCON is structured in a way which evaluates all the other alternatives before Traditional Life Cycle is evaluated. The only situation in which Traditional Life Cycle is not considered a viable approach is if Evolutionary Development is a recommended solution to the development process. Since Evolutionary Development was determined to be inviable in this case, PROCON concluded that Traditional Life Cycle is a viable alternative.

GOAL #3: Project Phase and Deliverables Can Be Determined

Although PROCON recommended three viable development approaches, it is the decision of the project manager and project consultant to determine the best approach. In this case, Purchased Software is the chosen approach. Based upon this fact, PROCON will pursue the line of reasoning to determine the Standard Deliverables for a system using the Purchased Software development approach.

In a consultation session PROCON first prompts the user to specify the most recent phase of development completed, if it is known. Since the project manager is experienced only with projects small in size and has no prior experience with this particular development approach, the user selects unknown. PROCON will then attempt to determine the most recent phase completed by posing some key questions to the project manager. These questions are directed towards determining if certain key deliverables have been completed. Each of these deliverables is associated with a particular phase within the development process. PROCON begins its questioning at the highest level of the development process and works backwards through the phases (i.e. Internal Design, External Design, Design Alternatives, Requirements Definition, Project Initiation). Based upon the status of these key deliverables, PROCON determines the most recently completed phase of the project.

PROCON first tries to determine if the Internal Design phase has been completed by ascertaining the status of the program specifications. In the current system, program specifications have not yet been defined. Therefore, PROCON concludes, the Internal Design phase has not been completed.

If the status of the input and output layouts is complete, then PROCON determines the most recently completed phase to be External Design. In this case, however, the layouts have not been completed. Therefore, the External Design is determined to be incomplete, and PROCON questions if

the design alternative has been selected. In this situation the design alternative has been selected. PROCON subsequently determines that the most recent phase completed is Design Alternatives and displays the deliverables for this phase and for all the remaining phases in the development process.

Prior to displaying the Standard Deliverables, PROCON displays the estimate classification associated with the given project. Estimate classification is used to convey the degree of project scope definition and the potential for variation in the total project estimate at a given point in the development process.

PROCON has determined this project's estimate classification to be Class 2. This class of estimates is developed when the scope of the project has been defined in the System Requirements Definition phase of development. Although the reports, screens, programs, and data requirements have not been defined to the lowest level of detail at this stage of development, the estimates are based upon more detailed requirements specifications than Class 1 estimates which are most frequently developed during the Project Initiation phase.

GOAL #4: Project Risk Can Be Determined

As mentioned in the previous cases, PROCON evaluates five categories of risk; size, complexity, structure, organizational impact, and technology by assigning a weighting value to each factor which affects the degree

of risk. The conclusions reached for this case are summarized in the table which follows:

size risk	= 5	medium
complexity risk	= 2	low
structure risk	= 6	medium
organizational impact risk	= 3	medium
technology	= 6	medium

In the size risk category a value of three was assigned to the fact that the project will require between 1500 and 3000 MIS hours to complete the system. A value of two was assigned to the fact that the project manager is experienced with projects small in scope. Thus, a total of five was arrived at, which placed the project in a medium risk category.

The only two factors affecting the degree of the complexity risk for this project were that system interfaces are required and customer knowledge of MIS is limited. Each of these factors caused the complexity risk to be incremented by one. PROCON then concluded the complexity risk to be low.

Two conditions caused the structure risk to be evaluated as medium. First, the project scope and objectives are not well-defined. Second, the customer's expectations are also not well-defined. Each of these factors was weighted with a value of three, thus causing the total structure risk to be evaluated with a total of six.

Only one factor played a role in the organizational impact risk. The fact that the system is a replacement of an obsolete technology, caused PROCON to conclude that the system will have a significant impact on the customer's procedures. The weighting factor associated with this characteristic is three.

Finally, technology risk was evaluated to be medium based upon two factors. The first factor is that the system will be implemented on new purchased hardware unfamiliar to the development team. The second factor is that purchased software has been selected as the development tool. Each of these factors was assigned a value of three.

GOAL #5: Project Estimating Tools and Techniques Can Be Determined

As previously mentioned, the key factor which determines the applicability of ESTIMACS for a given project is the size of the development effort. In this particular case, the project is large and therefore, the use of ESTIMACS is recommended. Also since the project has been categorized as new development, the Development Effort Estimator module of ESTIMACS should be used with Purchased Software selected as the development approach option.

XIII. CASE 3: SCENARIO

In this case, the proposed system is a first-time automated replacement of an existing manual system. The size of the project is very large and the system will be distributed to several field locations. The completion of this project is dependent upon another project. The project manager is experienced in developing projects with a similar scope.

GOAL #1: Project Authorization Attachments Can Be Determined

This project will require a Project Authorization since the project will cost more then $10,000.

Since the project will replace a manual system with online processing, new equipment such a terminals, printers, and controllers must be purchased for all the field locations affected by the system. Thus, the project will require a capital expenditure.

Based upon the facts obtained through the consultation session, PROCON concludes that the following PA attachments are required:

* Risk Assessment Summary
* Total Project Schedule and Gantt Chart
* Total Project Cost Summary
* Phase Schedule and Resource Plan

* Standard Deliverable Review Plan

* Capital Expenditure Authorization

The final subgoal which PROCON attempts to achieve is that the PA approvals can be determined. The first question posed to the user is if the system will require exceptions or changes in MIS policy. The response given was true, therefore, PROCON concluded that the Vice President of MIS must approve the PA. Since the VP of MIS must approve the PA, PROCON concludes that the Manager of SD&S must approve the PA.

Based upon the fact that the project will require a capital expenditure, PROCON concludes that the MIS Controller and the Manager of Computing Services (CS) must approve the Project Authorization.

GOAL #2: Project Development Approach Can Be Determined

In its evaluation of all the potential development approaches, PROCON has concluded that both the Experiment/Pilot approach and the Evolutionary approach are viable strategies.

PROCON disregarded Purchased Software as a viable approach since the fact was provided that a commercial software package was not available which satisfied the customer's requirements.

The first viable approach reached by PROCON was the Experiment/Pilot approach. The project attributes which caused PROCON to reach this

conclusion are:

1. Customer procedural change is feasible significant impact
2. Two or more customer organizations are involved
3. MIS experience with chosen technology is limited

PROCON determined that Prototyping was an inappropriate development approach since the External Design Phase has already been completed for this project.

The next approach PROCON evaluates is Customer Development. This approach was ruled out as a viable solution since the project is large. This is the first attribute which PROCON evaluates to prove or disprove the viability of Customer Development. Had the project been small in size, PROCON would have continued with the line of reasoning to determine if this approach was a viable alternative.

Evolutionary Development was also considered a viable approach since the project was estimated to require more than 3000 hours to complete.

As mentioned in the previous case, PROCON is structured to recommend Traditional Life Cycle in most cases except when Evolutionary Development is recommended. Thus, PROCON concludes that Traditional Life Cycle is not a viable approach for this project.

GOAL #3: Project Phase and Deliverables Can Be Determined

Again, the final selection of the development approach is made at the discretion of the project manager and project consultant. In this particular system, the manager chose Traditional Life Cycle as the most suitable approach.

Based upon this fact, PROCON will pursue the line of reasoning to determine the deliverables required for the Traditional Life Cycle Approach.

Through the consultation session, PROCON obtains the fact that the most recently completed phase of development is the External Design Phase. PROCON then displays the deliverables for this phase so that the project manager can assure that all tasks have truly been completed within this phase. PROCON then displays the remaining phases within the development process along with their corresponding Standard Deliverables.

GOAL #4: Project Risk Can Be Determined

The results of the risk analysis performed within this goal are:

size risk	= 10	high
complexity risk	= 6	medium
structure risk	= 6	medium
organizational impact risk	= 9	high

technology risk = 8 high

There are three factors which led to the conclusion that the size risk is high. First, the project was determined to be very large since its total project hours will exceed 3000. PROCON assigned a value of five to this attribute. Second, the duration of the project is expected to exceed 24 months. A weight of three was given to this fact. Third, this project is dependent upon another project and the value assigned for this characteristic is two. Thus, PROCON evaluated this project to have a high size risk based upon a total size risk value of ten.

The five factors which resulted in a score of six for complexity risk are summarized with their assigned values in the following table:

1. application involves two or more subsystems	1
2. application processing logic is complex	1
3. system interfaces are required	1
4. MIS team is decentralized	1
5. customers are decentralized	2

Thus, PROCON concluded the complexity risk of this project to be medium for this project.

Structure risk was determined to be medium based upon two characteristics of the system. The fact that the scope of the project is not well-defined and that the customers' expectations are not

well-defined caused PROCON to compute a value of six for structure risk. Each of these attributes was assigned a weight of three by PROCON.

Organizational Impact risk was determined to be high based upon three key facts. First, the customer community has a negative attitude towards MIS because they feel they will be eliminating jobs by replacing the present manual system with a fully automated system. Second, the customer commitment is also very weak. Third, there will be a significant impact on the customers' procedures. Each of these factors was assigned a value of three to reach a final total of nine for the Organizational Impact risk factor.

Technology risk was also ranked high for this project. Since the technology is non-standard, a value of five was added to the total for technology risk. A value of three was added to the total because the hardware to be used for developing the system is new to the project team.

GOAL #5: Estimating Tools and Techniques Can Be Determined

The final goal used in assisting in the project planning process is to determine the most appropriate estimating technique for the project.

As mentioned in the prior cases, the fact that project requires more than 750 MIS hours to develop is justification for using ESTIMACS. In this particular case, the total development hours will exceed 3000.

Thus, PROCON recommends the use of ESTIMACS.

Also, since the project involves the replacement of an manual system, PROCON determines the project type to be new development. Based upon this fact, PROCON concludes that the Development Estimator module should be used to generate the estimates for this project.

XIV. TESTING TECHNIQUES

The knowledge engineering process is an iterative one in which foundation rules are first built and tested. Once these rules execute or "fire" correctly with the anticipated results, new rules can be added to expand the knowledge base. Thorough testing is required for each expansion of the knowledge base in order to identify any weaknesses in the knowledge base and inference structure.

There are several potential faults which may be identified during the testing process. One potential fault is the conclusions produced by the knowledge system may be inadequate. They may be inappropriately organized or ordered. There may be too few or too many conclusions with insufficient intermediate conclusions, or perhaps too many intermediate conclusions. The ultimate result of these faults is that erroneous conclusions are reached, or in some cases no conclusions are reached.

In INSIGHT 2+ the message "No further conclusions can be reached" is issued if the goals or subgoals can not be reached based upon the answers provided in the consultation session. Under certain circumstances, this is a valid result, such as where PROCON determines that a PA is not required. Within the goal "Project Authorization Requirements Can Be Determined," there are two subgoals which are dependent upon the fact that a PA is required. Because of this goal structure, PROCON will attempt to pursue the subgoals to determine PA

attachments and PA approvals. Since these two conclusions are based upon the fact that a PA is required, they cannot be reached if PROCON determines that a PA is not required. It does not make sense to determine the PA attachments and approvals if a PA is not required. Thus, the message is valid in this particular case.

In other cases, however, the message "No further conclusions can be reached " indicates the existence of a problem in the knowledge base. The problem could be the result of the omittance of an intermediate conclusion which is the premise for a subsequent conclusion. The problem could also be associated with simply misspelling a premise or conclusion. INSIGHT 2+ will recognize the interchanging of two words or letters within a conclusion or premise as being a separate rule or premise, although this was not the intention of the knowledge engineer.

A final possible cause of this problem is that the new rules added in the enhancement may contain intermediate conclusions which are also conclusions of the existing rules. Depending on how the rules are structured and organized, the knowledge system may pursue a different path than the anticipated line of reasoning when testing these newly added rules.

The dependencies which exist within the knowledge base complicate the testing procedure as the knowledge base expands. In testing PROCON, each time a new set of rules was added to the knowledge base, cases which had previously been tested were retested in order to ensure that the new rules had not invalidated existing logic. In addition, new test

cases were developed to ensure that all of the newly added lines of reasoning had been traversed in order to identify any existing flaws.

XV. INSIGHT 2+ CAPABILITIES EMPLOYED

Due to the restructuring and streamlining of the existing prototypes of PROCON and the addition of the new rule structures for determining PA requirements, current phase of development, and Standard Deliverables, the development team determined that confidence intervals were not required. Therefore, the THRESHOLD was set to 01 and CONFIDENCE was set "off". In this way, the only degree of confidence assigned is 100 for true responses and 0 for responses which are false.

In order to allow the user to proceed directly to the area specifically related to his/her project, PROCON allows the user to choose a specific goal by setting the GOALSELECT parameter on. By turning this parameter on, the user is prompted to select one of the five achievable goals within PROCON. In this way, the user is not prompted for any questions which have no impact on the present situation, thus making the knowledge system more user-friendly as well as efficient.

In many instances the level of detail provided by the questions posed to the project manager during the consultation is insufficient in providing a clear representation of the issue. Since the questions within INSIGHT 2+ are restricted to a total length of 60 characters, additional capabilities have been provided within the software for handling more detailed descriptions.

A feature known as EXPAND is to used to display more detailed

information on a specific subject at the command of the user. A function key is available to the user to request any additional information which may have been provided within the source code of the knowledge system. The EXPAND function is highlighted on the terminal whenever additional information is available within the knowledge system. This feature can be used in conjunction with goal displays, fact, numeric, and object queries, and also with conclusion displays.

A second feature known as the DISPLAY function will automatically present a body of text to the user without the user requesting to see it. This feature is employed a great deal throughout PROCON. Specifically, the DISPLAY function is used to immediately present the Standard Deliverables to the user as soon as they have been determined within the knowledge system. This automatic display provides immediate feedback to the user as conclusions are being reached. It also provides a more user-friendly atmosphere to the consultation session.

The DISPLAY feature is heavily employed in the goal to determine the appropriate estimating tools and techniques. This feature is actually used to display the twenty-five questions corresponding to each of the estimating modules within the ESTIMACS software package.

A feature which was initially employed in the subproblem at the beginning of the knowledge system development process is the FILE command. The FILE function is one of several features within INSIGHT 2+ which provides the capability of capturing information obtained during

the execution of the knowledge system. This particular function allows the knowledge system to create an external file for purposes of generating customized reports, forms, or documentation based upon the user's input.

The FILE function must be initially issued prior to the definition of the goal structure and can be used to define only one file. This will open the file to accept the ASCII output from FILE commands which can be issued throughout the rules of the knowledge base. A sample command used to create and open a file is described by the following syntax:

```
FILE  STANDARD.PRL
```

This command will create a file called STANDARD.PRL. A path can be optionally specified for the disk file.

Once the file is defined, data may be entered into the file from within any rule in the knowledge base by referencing the name of a DISPLAY or by specifying the exact information following the FILE command.

```
RULE  For determining PA attachments
IF    PA is required
AND   a capital expenditure is required
THEN  PA attachments can be determined
AND   DISPLAY PA Attachments 1
AND   FILE PA attachments 1
```

```
RULE   For determining PA attachments

IF     PA is required

AND    a capital expenditure is required

THEN   PA attachments can be determined

AND    FILE  Risk Assessment Summary
```

In the first rule, the file command will reference the DISPLAY named PA attachments 1, and write the entire set of information in the display to the external file.

In the second example, the phrase Risk Assessment Summary will be written to the file.

The data collected in the file can then be used by an external program, serve as a record of a user session, or be printed or edited from within the text editor. The data in the file is only available until the knowledge system is restarted. Once the restart occurs, all data in the file will be overwritten with data from the new session.

Initially, this FILE feature was employed within PROCON to capture Project Authorization attachments determined during a consultation session. The ultimate goal of using this feature was to create a working document of all attachments and deliverables required by a particular project. This document could subsequently be used in planning sessions and quality assurance reviews, thus providing a

mechanism for insuring the adherence to system development standards. The proposed idea has merit, however, the development team felt that further evaluation of the structure of the proposed document was necessary. Therefore, PROCON in its current state does not employ the FILE command to create such a document.

PROCON also employed arithmetic operations for purposes of calculating risk values for each of the five categories of risk. A parameter was designated for each risk category. These parameters were initialized to zero in the beginning of the source code with a command known as INIT. The use of the INIT function requires that the data type of the variable be pre-declared. Thus, each of the five variables was defined as numeric prior to issuing the INIT command.

Once these variables were defined, they were incremented throughout the knowledge system to accumulate a total risk value for each risk category. As mentioned in previous sections of this thesis, a numeric value was assigned to each factor which comprised each of the risk categories. As PROCON is executed, these values are added to the corresponding risk variables if the factor is representative of the current project under evaluation.

The arithmetic features provided a simple way of evaluating risk as opposed to the complicated structure used in the prototypes.

Two other features provided in the INSIGHT 2+ software were particularly

helpful as debugging tools in the knowledge system development process. The first feature known as the Line of Reasoning Report, provided a means of explaining why the conclusions were reached by showing the path of rules the knowledge system traversed based upon the answers provided by the user. This particular feature can be requested from within the actual consultation session or after the session has been completed. If the Line of Reasoning Report is requested from within the consultation session, INSIGHT 2+ will display the current line of reasoning for the question which the user is presently trying to answer. For example, if the user requests this report for the question: "Approval required by another VP or Corporate Officer," PROCON will display:

We are trying to determine the state of the fact:

Approval required by another VP or Corporate Officer

In order to determine If:

VP of MIS must approve PA

The knowledge system will then allow the user to return to the current question under evaluation and continue the consultation session.

If the Line of Reasoning Report is requested at the end of the consultation session, all the rules which have been "fired" during the session will be displayed along with the reason for triggering these

rules. This feature was most helpful in testing the accuracy of PROCON after each time new rules were added to enhance PROCON's capabilities. By capturing the reasoning process in this report, the task of identifying faults in the rule structure was simplified.

The second feature which was helpful as a debugging tool is the User Session Report. This report provided an audit trail of all the answers provided by the user during a consultation session along with any conclusions which were reached based upon those answers. This report was used to verify that the appropriate conclusions were reached based upon the answers provided during the consultation session. It also provided a means of documenting test cases. In this way, the knowledge engineer could verify that all possible rule combinations and outcomes had been tested.

XVI. FUTURE ENHANCEMENTS OF PROCON:

A. PRESENT USE:

Currently, PROCON is being used in consultation sessions with project managers during the initial planning stages of a project. The idea is to apply the knowledge system as early in the project development process as possible. By using PROCON early on in the development process, the project manager can obtain all the potential development options and leave the consultation session with some direction as to how to proceed with the development effort.

The knowledge system provides a structure for consistently evaluating potential factors which may affect the outcome of a given project. Most consultation sessions require an average of thirty minutes to evaluate a project. The project consultant is present during the consultation session to familiarize the user with PROCON and interpret any unclear information. The consultant is also present for purposes of accumulating knowledge which could eventually be used to enhance the knowledge systems capabilities.

PROCON is intended to be used at each funding phase of each project development effort, thus providing consistency and structure throughout the development process. The capabilities provided by PROCON allow the project manager to investigate only those goals which apply to the current stage of development.

B. FUTURE ENHANCEMENTS:

Through the use of PROCON in project consultation sessions, several potential enhancements were identified. One possibility is to refine the Project Authorization approvals to address required signatures at lower levels of management. This enhancement to the approval structure should also reflect any changes in the organizational structure of MIS.

Another potential embellishment is to refine the rules which address Standard Deliverables on a "deliverable by deliverable" basis as opposed to a phase basis. Because of the degree of variation among projects, deliverables which are applicable to one project may be inappropriate for others. The refinement of these particular rules would aid in determining those deliverables required specifically for a given project.

In addition, the possibility of integrating PROCON with spreadsheet software for purposes of project tracking and analysis was also identified as a potential enhancement to this consultation tool.

The field of computer technology is continuously changing. Existing software and hardware are being enhanced and new tools and techniques are being developed. PROCON will also need to be revised to incorporate changes is standards and procedures, as well as advances in software and hardware technology. Several enhancements to PROCON have already been

identified.

First, prototyping guidelines and Standard Deliverables are currently under development and will eventually be incorporated into PROCON. Second, a decision process for evaluating Change Impact is currently under development. The results of this research will be a set of rules which will subsequently be incorporated into the knowledge base. Third, alternative estimating techniques are presently under evaluation. Any new tools or estimating techniques should also be included in PROCON.

One final idea which has been generated is to capture project information from the consultation session in a data base for historical purposes. An application using a PC-based data base system is currently being developed to capture project information. Screens are being developed to enter this information into the data base. Since most of this information can be obtained through a consultation session with PROCON, the potential exists to develop an interface to this existing data base. INSIGHT 2+ does provide the capability of capturing information on an external media or passing the information to an external program. INSIGHT 2+ also provides an interface known as DBPAS which can write directly to a dBASE II or dBASE III data base.

XVII. GENERAL OBSERVATIONS

The project planning process is a knowledge-intensive judgment task which is an essential part of developing a quality information system. Knowledge system technology provided a means of centralizing this knowledge to consistently evaluate all potential factors affecting the success or failure of the project, and also provided a method of determining the most suitable approach for handling these critical factors.

Many benefits are attributed to the use of knowledge system technology. First, the knowledge system facilitates the transfer of project planning knowledge from the knowledge system to the project manager. It also provides a method for training new project consultants. Second, as the evolution of PROCON demonstrates, knowledge system technology provides a flexible framework for expanding the functionality of the knowledge system. Third, knowledge systems reduce information bottlenecks by supplying an accumulation of expert knowledge when it is required so as to improve performance and productivity.

PROCON is currently being used by the project consultants in project planning sessions with the project managers. Prior to instituting the use of PROCON, project managers within the MIS Industrial Gas Division (IGD) were asked to participate in a survey. This survey was designed to collect information regarding the amount of time devoted to the project planning process (See Appendix D). The results showed that the

average amount of time to evaluate and prepare all the planning documents for a project authorization is 45 hours. The largest percentage of this time is devoted to developing project or phase estimates, determining phase deliverables, evaluating and selecting the appropriate development approach, and actually packaging the PA attachments for management review.

Just through this preliminary survey it is evident that PROCON addresses the major issues in the project planning process. This survey will be circulated throughout all of MIS development groups to gain a larger sampling. Project managers will be asked to complete this survey again after they have used PROCON to assist in planning a project. In this way, statistics can be gathered on the actual productivity improvements attributed to the use of PROCON in the project planning and development process.

XVIII. SUMMARY

The development of PROCON has demonstrated the potential use of knowledge engineering concepts in understanding and managing business processes. In addition, PROCON has provided a framework which promotes consistency in the project planning process, thereby assuring the delivery of a quality system to the customer. It also facilitates a more efficient use of both the project consultant's and the project manager's time, thus increasing productivity. The development of PROCON has also increased the experience with knowledge system concepts and provided some essential ground rules for assessing the applicability of this technology to other business practices.

PROCON will continue to evolve as business practices change and new technologies become available. Enhancements addressing Change Impact Analysis and Prototyping guidelines and deliverables have already been targeted for implementation. As these and other enhancements are added to PROCON, the value and power of this tool will increase, thus setting the stage for future knowledge system applications.

XIV. LOCATION OF PROCON KNOWLEDGE SYSTEM

This application is located on the PC in the Project Planning and Control group, Management Information Services, Administration Building V, Air Products and Chemicals, Inc., Allentown, PA.

In compliance with the thesis preparation guidelines, the following:

a. two PROCON system object code diskettes,

b. two PROCON source code diskettes,

c. PROCON program source listings,

are on file in the office of the thesis advisor:

Professor John C. Wiginton

Department of Industrial Engineering

267c Packard Laboratory

19 Lehigh University

Bethlehem, PA 18015

XX. REFERENCES

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Appendix A.

METHODOLOGY TO DEVELOP PROCON

PHASE I: Identifying and Conceptualizing the Problem

A. Identification

1. Identify the problem area and the scope.

2. Identify the resources necessary to acquire the knowledge, implement and test the system:

time

knowledge sources

money

computing facilities

3. Identify the goals and objectives of building the Expert System.

a. separate the goals from the tasks

b. select a subproblem to focus on knowledge acquisition and to prototype

B. Conceptualization

1. Determine the key concepts, relations, information flow characteristics necessary to describe the problem-solving process.

2. Specify the subtasks, strategies, and constraints related to the problem-solving process.

PHASE II: Formalization, Implementation, Testing

A. Formalization

1. Design structures to organize the knowledge.

2. Map the key concepts and relations into the formal structure(i.e. frames, tree structures,etc)

B. Implementation

1. Map the formalized structure into the chosen Expert System tool (INSIGHT 2+).

2. Develop a prototype system using the formalized rules.

C. Testing

1. Evaluate the performance of the prototype by using several test cases.

2. Determine any weaknesses in the system.

3. Revise accordingly.

METHODOLOGY TO DEVELOP PROCON

QUESTION SET

A. Identification

1. Identify the problem area and the scope.

a. What is the definition of the problem?

b. Describe the characteristics of the problem.

c. Can we identify any subproblems?

d. What are the important terms used in describing and solving the problem?

e. What, if any relationships exist among these terms?

f. What does the solution look like and what concepts are used?

g. What aspects of human expertise are needed to solve the problem? (heuristics, facts, established guidelines, etc.)

h. What situations are likely to impede solutions?

RESULT: Identification of the key elements of the problem description. Identification of the reasoning process used to solve the problem.

2. Identify the resources necessary to acquire the knowledge, implement and test the system:

time

knowledge sources

money

computing facilities

3. Identify the goals and objectives of building the Expert System.

a. separate the goals from the tasks

b. select a subproblem to focus on knowledge acquisition and to prototype

RESULT: Goal statement

Subproblem definition and scope

Identification of constraints

B. Conceptualization

1. Determine the key concepts, relations, and information flow characteristics necessary to describe the problem-solving process

2. Specify the subtasks, strategies, and constraints related to the problem-solving process.

a. What types of data are available (facts, heuristics, etc.)

b. What is given and what is inferred?

c. Do the tasks/subtasks have names?

d. Do the strategies have names?

e. Are there any hypotheses commonly used?

f. How are objects related to each other?

g. Diagram a hierarchy and label causal relations.

h. What processes are involved in the problem solution?

i. What are the constraints on these processes?

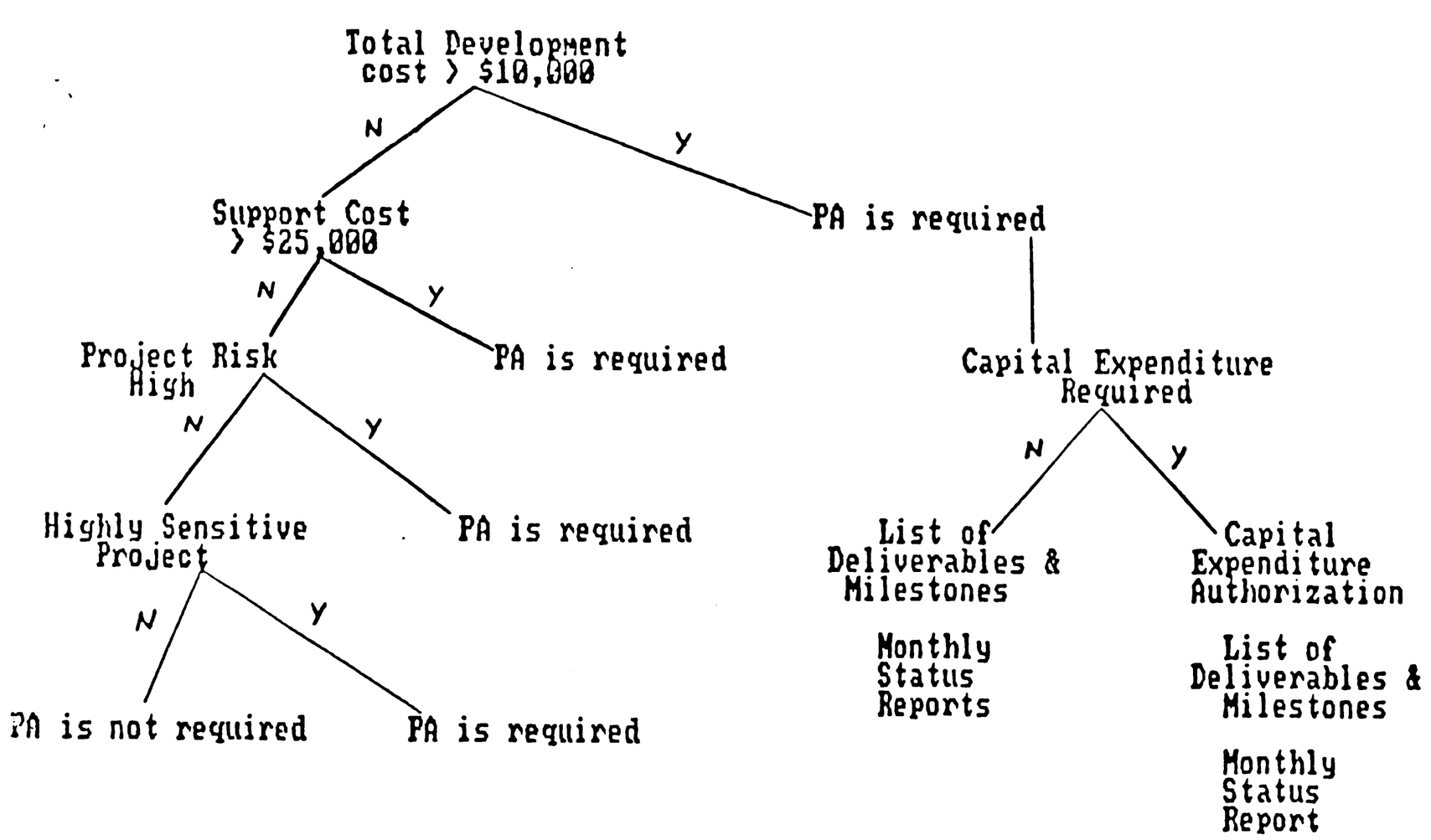
j. What is the information flow?

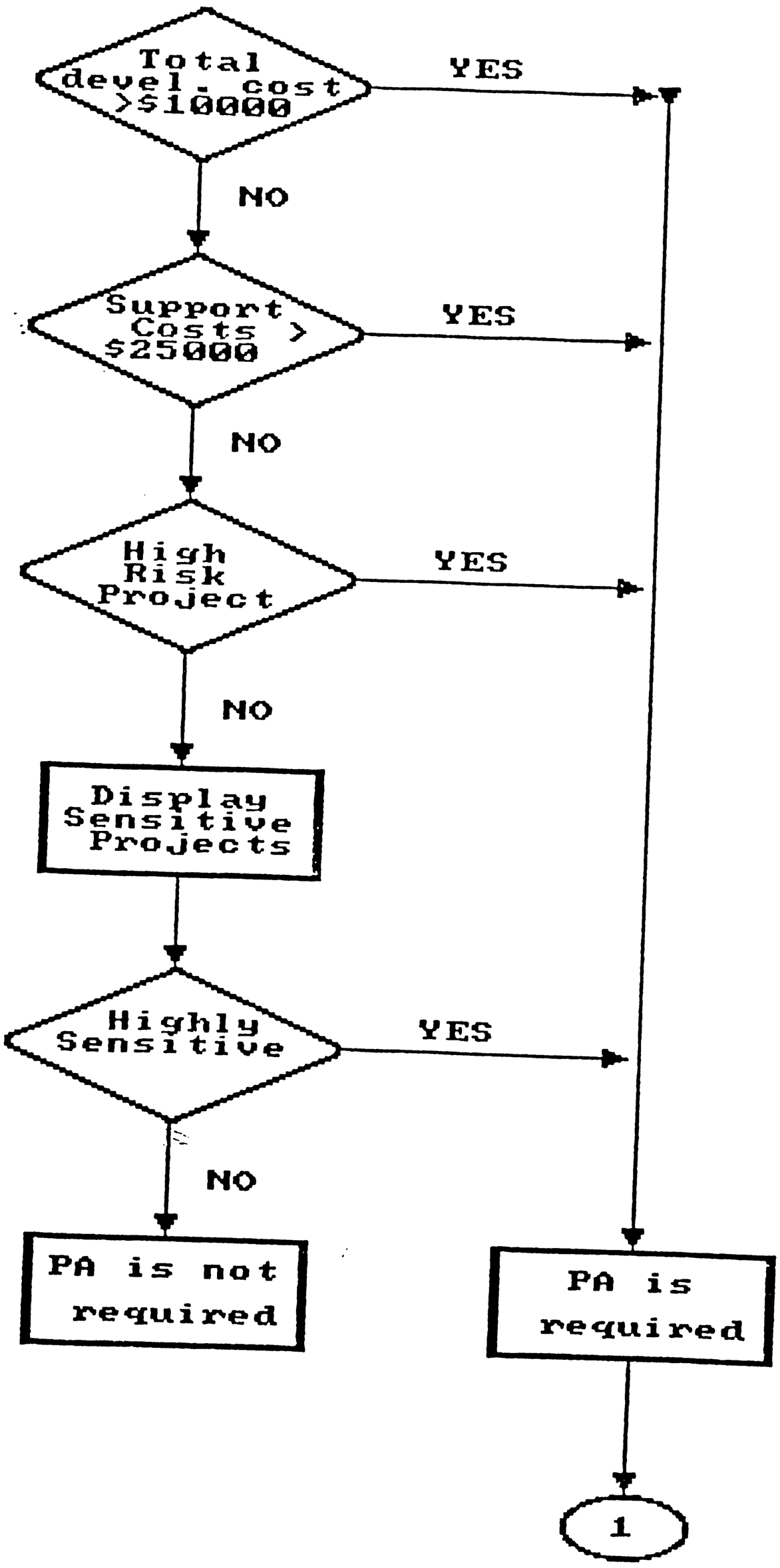
k. Can you separate the knowledge needed for solving the problem from the knowledge used to justify the solution?

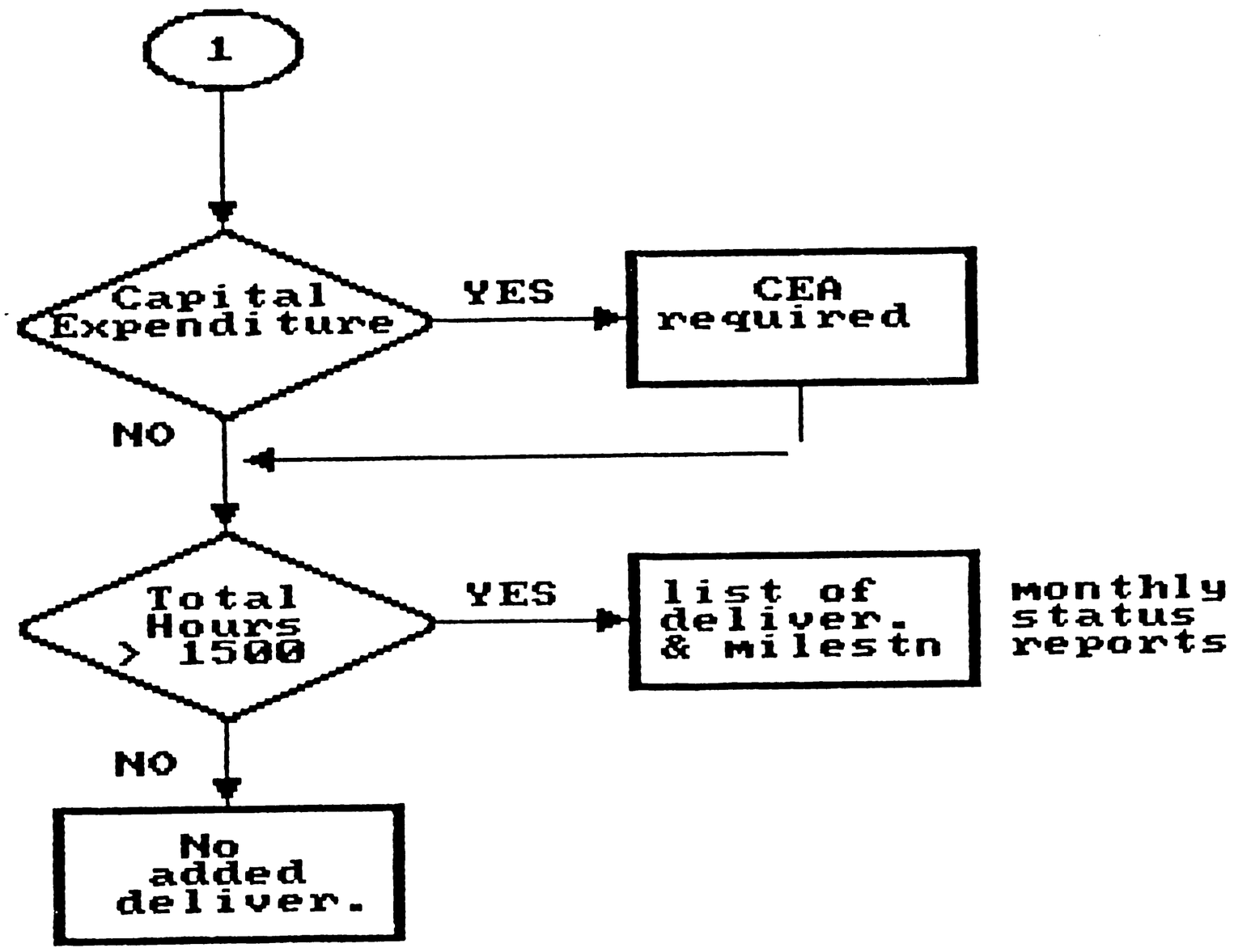
RESULT: Key concepts and relationships are identified.

Preliminary model of expert system is developed using the appropriate structure (frames, decision table, trees,etc)

APPENDIX B.


Total Development cost > $10,000
N
Y
Support Cost > $25,000
PA is required
N
Y
Project Risk High
PA is required
N
Y
Highly Sensitive Project
PA is required
N
Y
PA is not required
PA is required
Capital Expenditure Required
N
Y
List of Deliverables & Milestones
Monthly Status Reports
Capital Expenditure Authorization
List of Deliverables & Milestones
Monthly Status Report


Total devel. cost >$10000
YES
NO
Support Costs > $25000
YES
NO
High Risk Project
YES
NO
Display Sensitive Projects
Highly Sensitive
YES
NO
PA is not required
PA is required
1


1
Capital Expenditure
YES
CEA required
NO
Total Hours > 1500
YES
list of deliver. & milestn
monthly status reports
NO
No added deliver.

APPENDIX C.
STANDARD DELIVERABLE DEFINITIONS

*** PROJECT MANAGEMENT DELIVERABLES

Project Authorization (PA) for next phase(s)	Formal document which provides the standard format used to authorize MIS projects. Includes information summarizing project scope, benefits, risk, schedule, and funding.
Resource Plan	Document which indicates project tasks/ deliverables, resources assigned, and completion schedule. Recommended format is standard Gantt chart/resource summary from Project Manager Workbench.
PC70 Input	Standard input forms for establishing and maintaining new projects/segments in the MIS Project Control System (PC70).
List of Phase Deliverables	Standard document prepared for each project phase to indicate agreed upon project deliverables and who must review/approve each deliverable.
Risk Assessment Summary	Standard document which summarizes project risk by category (size/complexity, structure, and technology) and indicates factors contributing to risk and corresponding techniques for managing project risk.
Earned Value Report	Standard report which provides comparisons of actual versus planned project performance for project monitoring and control. Performance measurement/ forecasting is based on percent complete for each activity/deliverable.
Monthly Status Report	Formal document issued monthly to an appropriate distribution of user/MIS management. Used to communicate accomplishments, objectives, forecast changes, and project spending/schedule summary for major development projects (total MIS hours $\geq$ 1500).

*** PROJECT INITIATION

Project Initiation Report	Formal report or memo which documents the results of the initial project planning effort. Should include project objectives, scope, benefit areas, development approach, preliminary risk assessment and total project estimate/estimate classification.

*** SYSTEM REQUIREMENTS DEFINITION

Description/Flowchart of User Business Functions	High-level flowchart with corresponding description of user business functions. Used to define functional scope, organizational coverage, interfaces, boundaries for automation.
Identification of Problems/ Opportunities	Document which identifies problems/ opportunities with existing manual or automated system(s).
Summary of Existing System Inputs/Outputs/Files/ Inquiries	Document which summarizes the various system attributes of the existing system. Supporting appendix should include samples of existing source/input documents, reports, files, and screens.
Conceptual Data Base Design	Document which consists of conceptual data model and corresponding entity/attribute definitions.
Operational Considerations	Document which describes the operating environment (type of processing, types of hardware/software) plus security, control, backup/recovery, and performance considerations.
Definition of General Security Requirements	Document which describes general security requirements (i.e. type of data, access, people/groups involved, stewardship responsibility).
Description of Proposed System/Organization Interfaces	Document which describes the proposed system interfaces (manual or automated) and the organizational interfaces for cross-functional applications. Combination of schematic and narrative is recommended.
Prioritized List of System Requirements	List of system requirements indicating mandatory/optional system features to be used for assessing design alternatives.

System Requirements Definition Report	Formal report which documents the results of the SRD phase. Includes package of phase deliverables plus recommendations for proceeding, development plan (strategy, resource requirements, cost/schedule), and revised benefit/risk summaries.

*** SYSTEM DESIGN ALTERNATIVES

List of Assumptions/ Constraints	Document which identifies any assumptions and/or constraints that will influence the selection of the design alternative.
Description/Flowchart of Alternative Solutions	High-level flowchart with corresponding description of each proposed design alternative. Used to define scope, interfaces, boundaries for automation, and technologies to be employed.
List of Proposed System Attributes (Inputs/Outputs Files/Inquiries)	Document which lists for each design alternative the proposed inputs/outputs/ files/inquiries. Used to highlight differences in functionality provided by each alternative.
Description of Proposed Files/Data Bases	Document which describes the proposed system files/data bases and their general data content.
Description of System Functions	Narrative which describes system functions (from the user's viewpoint) performed to process input, outputs, files, and inquiries.
Alternatives for Security	Narrative which describes alternatives for security (ACF2, application, administrative/ custodial responsibility, special considerations, i.e. encryption, physical security, etc.)
Tangible/Intangible Benefits	Document which identifies tangible (quantifiable) and intangible benefits for each alternative.
Production Costs/Schedules	Document which identifies estimated production costs/schedules for each alternative.
Development Costs/Schedules	Document which identifies estimated development costs/schedules for each alternative.

System Design Alternatives Report	Formal report which documents the results of the SDA phase. Includes: • Evaluation Criteria used to select recommended alternative • Evaluation Summary which compares functionality, benefits, costs, and schedules for each alternative • Recommended alternative/plan for next phase(s).

*** SYSTEM EXTERNAL SPECIFICATIONS

Hardware/Software Configuration	Document which identifies items to be acquired/installed for the new system. Used to communicate lead times for planning and as source of information for initiating formal request for hardware.
Logical Data Base Design	Document which consists of logical data model and corresponding transaction definitions, record keys, indices or alternate keys.
File/Table Layouts	Document which identifies data content and record descriptions for each file/table.
Layouts of Input Forms/ Screens	Proposed physical layouts of each input form/screen.
Layouts of Reports/Inquiry Screens	Proposed physical layouts of each report/inquiry screen. Include report distribution and microfiche requirements.
Detailed Functional Flowchart	Comprehensive functional flowchart of the new system illustrating all the inputs, outputs, files, inquiries, interfaces with external systems, and manual procedures.
Data Control Requirements	Narrative which describes the manual and automated procedures for verifying the integrity of the system data.
Security Requirements	Narrative which describes the detailed security requirements to prevent unauthorized access to data and/or the physical system. Include security maintenance procedures (forms/approval for users, required reporting).

Definition of System Processing	Narrative which describes (from the user's viewpoint) validation, algorithms, file updating/retrieval, table-handling, and error processing. Explains WHAT the system will do in user terms.
Data Entry/Error Correction Procedures	Narrative which describes user procedures for data entry/error correction.
System Backup/Recovery Procedures	Narrative which describes procedures for backup/recovery in the event of a system failure. Include file/data retention and archival considerations.
System Acceptance Criteria	Document which identifies specific criteria for determining system acceptance (e.g. response time requirements, simultaneous update, specific functionality).
Preliminary Test/Conversion/ Implementation Plans	Proposed schedule of activities/tasks and resource requirements for test, conversion, and implementation efforts. Gantt chart is recommended to illustrate overall sequence/phasing/timeframe.
System External Specifications Report	Format report which documents the results of the SES phase. Includes package of phase deliverables plus development plan (resource requirements, costs/schedule), revised benefit/risk summaries, and revised list of assumptions/constraints.

*** SYSTEM INTERNAL SPECIFICATIONS

Technical System Flowchart/ Narrative	Detailed system flowchart with corresponding description of all planned programs, files, inputs/outputs, system interfaces, and jobstream relationships.
Jobstream Flowchart/ Narrative	Detailed jobstream flowchart with corresponding description (may be part of technical system flowchart).
Final Layouts of Input Forms/Screens	Finalized (physical) detailed layouts of each input form/screen. Include estimates of: • transaction volumes • data base I/O's for screens.

Final Layouts of Reports/ Inquiry Screens	Finalized (physical) detailed layouts of each report/inquiry screen.
Program Specifications	Document which describes the processing logic for each program using narrative, flowchart, pseudo-code, or combination.
Sort/Merge Specifications	Narrative which defines the sort/merge specifications for each file. State sort field name, length, and position.
Revised Test/Conversion/ Implementation Plans	Revised schedule of activities/tasks and resource assignments for test, conversion, and implementation efforts. Gantt chart is recommended to illustrate overall sequence/ phasing/timeframe.
Technical Security Requirements	Narrative which describes security considerations related to data bases, files, and subroutines.
Physical Data Base Design	Document which consists of the following: • Bachman diagram • Data base areas • Schemas/subschemas • Record description report • Data dictionary entries • Record elements • Record occurrences/volumes • Set definitions, relations, volumes • Test data base size
System Internal Specifications Report	Formal report which documents the results of the SIS phase. Includes package of phase deliverables plus system construction/ implementation plan (resource requirements, costs/schedule), revised benefit/risk summaries, and revised list of assumptions/constraints.

*** SYSTEM CONSTRUCTION/IMPLEMENTATION

Coded Programs	Programs which have been coded and compiled without errors (but have <u>not</u> been tested). Include special conversion programs.
JCL	JCL for program compilation, testing, production jobstreams, and conversion jobstreams.

Program Documentation	Standard format prepared for each program which defines program name, author, and general processing information.
Final Test Plan	Final schedule of testing activities, tasks, and resource assignments.
Test Case Specifications	Document which defines test cases and criteria for evaluating test results.
Test Data	Data to be used for testing programs, JCL, and system flow during unit, system, and user acceptance testing.
Test Results	Document which summarizes the results of unit, system, and user acceptance testing. Include cross-reference to actual test run output.
Final Conversion Plan	Final schedule of conversion activities, tasks, and resource assignments.
Final Implementation Plan	Final schedule of implementation activities (training, documentation, hardware installation/testing, production turnover/ startup) and resource assignments.
User Documentation	Document which defines user procedures for interfacing with the new systems.
Operations Documentation	Document which defines procedures for MIS Operations to run the system in production mode.
User Training Material	Instructional material for conducting user training in all aspects of interfacing with the new system. Include: • Data entry/error correction • Forms/security procedures • File maintenance • Output distribution/report usage • Problem reporting/system support
Production Turnover/ Startup Plan	Document which defines production turnover/system startup schedule and responsibilities.
Production Turnover Package(s)	Package of appropriate forms, programs, files, jobstreams, etc. for production turnover.

User Acceptance/Parallel Test Results	Document which summarizes the results of user acceptance/parallel testing.
System Documentation	Comprehensive manual of required system documentation (reference System Documentation Guidelines).
Management Security Memo	Formal memo issued to appropriate user/MIS management which summarizes the security policy/procedures for the system.
Project Close Memo	Formal memo issued to appropriate user/MIS management which officially closes the project. Include final project spending/schedule information.

TRADITIONAL (IN-HOUSE) STANDARD DELIVERABLES

PROJECT INITIATION PHASE:

- Project Initiation Report

SYSTEM REQUIREMENTS DEFINITION PHASE:

- Description/Flowchart of User Business Functions
- Identification of Problems/ Opportunities
- Summary of Existing System Inputs/Outputs/Files/Inquiries
- Conceptual Data Base Design
- Operational Considerations
- Description of General Security Requirements
- Description of Proposed System/ Organization Interfaces
- Prioritized List of System Requirements
- System Requirements Definition Report

TRADITIONAL (IN-HOUSE) STANDARD DELIVERABLES

SYSTEM DESIGN ALTERNATIVES PHASE:

- List of assumptions/constraints
- Description/Flowchart of alternative solutions
- List of Proposed System Attributes (Inputs/Outputs/ Files/Inquiries)
- Description of Proposed files/ data bases
- Description of system functions
- Alternatives for Security
- Tangible/Intangible Benefits
- Production Costs/Schedules
- Development Costs/Schedules
- System Design Alternatives Report

TRADITIONAL (IN-HOUSE) STANDARD DELIVERABLES

SYSTEM EXTERNAL SPECIFICATION PHASE:

- Hardware/Software Configuration
- Logical Data Base Design
- File/Table Layouts
- Layouts of Input Forms/Screens
- Layouts of Reports/Inquiry Screens
- Detailed Functional Flowchart
- Data Control Requirements
- Security Requirements
- Definition of System Processing
- Data Entry/Error Correction Procedures
- System Backup/Recovery Procedures
- System Acceptance Criteria
- Preliminary Test/Conversion/ Implementation Plans
- System External Specifications Report

TRADITIONAL (IN-HOUSE) STANDARD DELIVERABLES

SYSTEM INTERNAL SPECIFICATION PHASE:

- Technical System Flowchart/ Narrative
- Jobstream Flowchart/Narrative
- Final Layouts of Input/Update Forms/Screens
- Final Layouts of Reports/ Inquiry Screens
- Program Specifications
- Sort/merge Specifications
- Revised Test/Conversion/ Implementation Plans
- Physical Data Base Design
- System Internal Specifications Report

TRADITIONAL (IN-HOUSE) STANDARD DELIVERABLES

SYSTEM CONSTRUCTION/IMPLEMENTATION:

- Coded Programs
- JCL
- Program Documentation
- Final Test Plan
- Test Case Specifications
- Test Data
- Test Results
- Final Conversion Plan
- Final Implementation Plan
- User Documentation
- Operations Documentation
- User Training Material
- Production Turnover/Start-up Plan
- Production Turnover Package(s)
- User Acceptance/Parallel Test Results Signoff Memo
- System Documentation
- Management Security Memo
- Project Close Memo

PURCHASED SOFTWARE STANDARD DELIVERABLES

PROJECT INITIATION PHASE:

- Global System Objectives and Scope
- Identified Issues/Problems/ Needs
- Specific System Objectives
- Prioritized Broad System Requirements
- List of Potential Vendors*
- Benefit Areas
- Management Constraints and Assumptions
- Recommendations and Management Summary
- Project Initiation Report

* Indicates Deliverables which are unique to Purchased Software Approach.

PURCHASED SOFTWARE STANDARD DELIVERABLES

SYSTEM REQUIREMENTS DEFINITION PHASE:

- Description/Flowchart of User Business Functions
- Identification of Problems/ Opportunities
- Summary of Existing System Inputs/Outputs/Files/Inquiries
- Conceptual Data Model
- Operational Characteristics and Considerations
- Description of General Security Requirements
- Description of Proposed System/ Organization Interfaces
- Prioritized List of System Requirements
- List of Mandatory/Optional System Features*
- Request for Information (RFI) to Potential Vendors*
- Technology assessment (standard vs. non-standard)*
- Goals and Structure of Vendor Presentations*
- System Requirements Definition Report

* Indicates Deliverables which are unique to Purchased Software Approach.

PURCHASED SOFTWARE STANDARD DELIVERABLES

SYSTEM DESIGN ALTERNATIVES PHASE:

- List of Assumptions/Constraints
- Preliminary Evaluation of Packages using Features List and Technology Assessment*
- Presentation Agenda/Vendor Invitations*
- Vendor Financial/Contractual Information*
- List of Vendors' Current Clients with same Version of Software and Technical Environment*
- Documentation for Initial Vendor Presentations*
- Documentation from Client Reference Checks*
- Documentation from Financial Status Review*
- Final Vendor List*
- Request for Quotation (RFQ)*
- Non-disclosure Agreements (if required)*
- Training Requirements*
- Description/Flowchart of Alternative solutions

* Indicates Deliverables which are unique to Purchased Software Approach.

PURCHASED SOFTWARE STANDARD DELIVERABLES

- List of Inputs/Outputs/ Files/Inquiries (for each alternative)
- Description of Proposed Files/Databases (for each alternative)
- Description of System Functions (for each alternative)
- Security Requirements (for each alternative)
- Tangible/Intangible Benefits (for each alternative)
- Production Costs/Schedules (for each alternative)
- Development Costs/Schedules (for each alternative)
- Recommended Design Alternative
- Purchase Requisition and Capital Expenditure Authorization*
- Tax Status of Proposed Purchase*
- Purchased Software Contract*
- Purchase Order*
- System Design Alternatives Report

* Indicates Deliverables which are unique to Purchased Software Approach.

PURCHASED SOFTWARE STANDARD DELIVERABLES

SYSTEM EXTERNAL SPECIFICATION
PHASE:

- Hardware/Software Configuration
- Logical Data Base Design
- File/Table Layouts
- Layouts of Input Forms/Screens
- Layouts of Reports/Inquiry Screens
- Detailed Functional Flowchart
- Data Control Requirements
- Security Requirements
- Definition of System Processing
- Data Entry/Error Correction Procedures
- System Backup/Recovery Procedures
- System Acceptance Criteria
- Preliminary Test/Conversion/ Implementation Plans
- System External Specifications Report

PURCHASED SOFTWARE STANDARD DELIVERABLES

SYSTEM INTERNAL SPECIFICATION PHASE:

- Technical System Flowchart/ Narrative
- Jobstream Flowchart/Narrative
- Final Layouts of Input/Update Forms/Screens
- Final Layouts of Reports/ Inquiry Screens
- Program Specifications
- Sort/merge Specifications
- Revised Test/Conversion/ Implementation Plans
- Physical Data Base Design
- System Internal Specifications Report

PURCHASED SOFTWARE STANDARD DELIVERABLES

SYSTEM CONSTRUCTION/IMPLEMENTATION:

- Coded Programs
- JCL
- Program Documentation
- Final Test Plan
- Test Case Specifications
- Test Data
- Test Results
- Final Conversion Plan
- Final Implementation Plan
- User Documentation
- Operations Documentation
- User Training Material
- Production Turnover/Start-up Plan
- Production Turnover Package(s)
- User Acceptance/Parallel Test Results Signoff Memo
- System Documentation
- Management Security Memo
- Project Close Memo

Appendix D.

PROJECT AUTHORIZATION SURVEY

The purpose of this survey is to collect information on the amount of time which is devoted to preparing various portions of the Project Authorization document. This information will be used to establish a benchmark measure of the effort involved in preparing PA's. The results will be documented in my thesis entitled "The Evolution of a Knowledge System for Project Planning."

I would deeply appreciate your effort in completing the following questions. Please return the survey to me by Friday, March 6. Thank you for your effort.

Deborah Hagerman

NAME (OPTIONAL):_____

INSTRUCTIONS: Please review the following list of tasks typically performed in the preparation of an MIS Project Authorization (PA). Estimate the average number of hours you spend performing each task. Note that if a given task takes less than an hour, enter 1 for the estimated hours.

	TASK	ESTIMATED HOURS
1.	Determine if a PA is required	____
2.	Determine MIS approvals required	____
3.	Determine appropriate PA attachments (do not include actual time to prepare attachments)	____
4.	Evaluate alternative development approaches and select appropriate approach	____
5.	Evaluate alternative funding phases and select phasing strategy	____
6.	Determine phase deliverables	____
7.	Perform project risk assessment	____

8. Evaluate/select appropriate estimating tools/techniques	----
9. Develop project and/or phase estimates of cost and schedule	----
10. Package PA and attachments for management review	----
Total Hours	----

VITA

The author was born in Allentown, Pennsylvania on February 5, 1958, the daughter of William Joseph and Mary Bankos Feiertag. Upon graduating from Whitehall High School in June of 1976, she attended Lehigh University, Bethlehem Pennsylvania. She graduated in June of 1980 with a B.S. in Computer and Information Science. After graduation she was employed by Bethlehem Steel Corporation, Bethlehem, Pennsylvania, where she was a systems analyst in the Information Services department. Since March of 1986, she has been employed in the Management Information Services department of Air Products and Chemicals, Inc., Allentown, Pennsylvania, where she has developed and supported project management systems for the Industrial Gas Division. She currently holds the title of systems analyst.