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AN ANALYSIS OF SPECIFIC CONTRACTING ISSUES REGARDING THE DEVELOPMENT AND ACQUISITION OF EXPERT SYSTEMS

by

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December, 1990

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The increasing complexity of our every day jobs requires us to pursue flexible and more adaptive technologies with which to respond to our professional requirements. One such method is an expert system. This computer software "tool" is one means to augment and streamline ones professional decision making process. The expert system can be utilized as a means to assist new or inexperienced personnel to make informed decisions about their jobs. It can also assist in the decision making process when the technical expert is not present. Due to the fast paced, rapidly changing nature of computer software development, the need exists for a specific methodology to direct the development and acquisition of this technology within the Department of Defense (DoD)
This study will provide an objective summary and analysis of specific contractual considerations that need to be addressed with regard to the acquisition of an expert system. A selected review of DoD and industry responses to personal interviews, conference presentations and published papers, served as the basis for discussion of the problems and issues in this arena.

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An Analysis of Specific Contracting Issues Regarding the Development and Acquisition of Expert Systems

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ABSTRACT

The increasing complexity of our every day jobs requires us to pursue flexible and more adaptive technologies with which to respond to our professional requirements. One such method is an expert system. This computer software "tool" is one means to augment and streamline ones professional decision making process. The expert system can be used as a means to assist new or inexperienced personnel to make informed decisions about their jobs. It can also assist in the decision making process when the technical expert is not present. Due to the fast paced, rapidly changing nature of computer software development, the need exists for a specific methodology to direct the development and acquisition of this technology within the Department of Defense (DoD).

This study will provide an objective summary and analysis of specific contractual considerations that need to be addressed with regard to the acquisition of an expert system. A selected review of DoD and industry responses to personal interviews, conference presentations and published papers, served as the basis for discussion of the problems and issues in this arena.

TABLE OF CONTENTS

I. INTRODUCTION

A. GENERAL

The increasing complexity of our every day jobs requires us to pursue flexible and adaptive technologies with which to respond to our professional requirements. One such technology is an expert system, often referred to as a knowledge based system (KBS). An expert system is essentially a computer software application that assists, or in a number of situations makes decisions based on the problem solving capabilities of an expert. It actually manipulates knowledge. [Ref. 1:p. 24] This computer software "tool" is one means to augment and streamline one's professional decision making process. The expert system can be used as a means to assist new or inexperienced people to make informed decisions about their jobs. It can also assist in the decision making process when the technical expert is not present. Due to the fast paced, rapidly changing nature of computer software development, the need exists for a specific contracting methodology for use in the development and acquisition of this technology within the Department of Defense (DoD).

This study will provide an objective summary and initial analysis of specific contractual considerations that need to be addressed with regard to the acquisition of an expert system.

B. AREA OF RESEARCH AND OBJECTIVES

This research effort studies the varied and peculiar contracting issues regarding the acquisition of expert systems. For the purposes of this research, acquisition refers to the procurement of the total system. The total system or "life-cycle" approach encompasses the entire procurement action to include system design, specifications, solicitation, contract award, and system maintenance. The object of this research is to review current practices, and to explore options available to program managers and contracting officers, that may improve the success of the development and acquisition of expert systems.

C. RESEARCH QUESTIONS

1. Primary Question

What unique contractual considerations are involved in procuring an expert system for use in the DoD?

2. Subsidiary Questions

a. Of the expert systems currently acquired by the DoD, how satisfied are the agencies with these systems?

b. What were the contractual problems associated with the acquisition of these systems?

c. What are the observations of industry regarding satisfaction in the application and performance of expert systems, and any special considerations involved in the acquisition of these systems?

d. What are the specific issues regarding contract type, contract administration, research and development (R&D), prototype development, production, and maintenance as they apply to the acquisition of expert systems?

D. SCOPE

This thesis is limited to the survey and analysis of specific issues associated with the acquisition of expert systems. It will attempt to identify areas peculiar to the

development, acquisition, and contract management of an expert system. It provides an objective summary and analysis of specific contractual considerations that need to be addressed with regard to the development and acquisition of such a system.

E. METHODOLOGY

The research methodology used for this study included the topics discussed below.

1. Literature Search

A literature review was conducted in order to gain familiarity and insight into the area of expert systems, and to determine if there is, in fact, a need to identify any peculiarities involved in the acquisition of such a system. Initial sources of information for this research were various Federal and DoD documents addressing the acquisition of automated data processing equipment and software. Additional information was obtained from the Naval Postgraduate School Library, and the Defense Logistics Studies Information Exchange. The review consisted of both Government and non-government publications.

2. Professional Conference Attendance

Two professional conferences were attended in order to meet personnel versed in the area of expert system development, procurement, management, engineering and usage. The conferences attended are listed in Appendix A.

3. Interview

Interviews were conducted with both Government and non-government professionals. The interviews were obtained via personal and telephone conversations among people with varying degrees of experience. Expertise in the area of expert systems

ranged from program managers and contracting personnel, to software/system engineers, to research, development, test, and evaluation personnel, to end users. The interviews served as a means of supplementing and augmenting information obtained through the literature review and attendance at the professional conferences. A list of the people interviewed is contained in Appendix B.

F. LIMITATIONS

Although expert systems have been used for several years, there is virtually no concise documented guidance on the actual acquisition of such a system. While there is an abundance of information regarding software acquisition, little specifically addresses expert systems. The majority of information has been through interviews and interpretation of actual contracting experiences from Government and non-Government sources. Every attempt has been made to ensure objectivity and focus on specific development and acquisition contracting issues regarding expert system acquisitions.

G. ORGANIZATION

Chapter II presents background information and reviews current practices regarding expert systems within the DoD. Additionally, the level of user satisfaction with these systems, as well as any contractual problems associated with these systems, are identified and discussed.

Chapter III addresses current practices from industry regarding expert systems. The level of satisfaction with these systems, along with the contractual methodologies and problems associated with these systems, are identified and discussed.

Chapter IV presents the varied contract types available as outlined in the Federal Acquisition Regulation (FAR). A discussion of the importance of choosing the appropriate contract type for the situation at hand is addressed in terms of suitability and need. The contracting officer's role in this situation is also discussed.

Chapter V draws conclusions from the information gathered in this research effort. Recommendations on how to improve and enhance the procurement of expert systems for use within the DoD arena are proffered. Finally, the Chapter closes with recommendations for future research.

II. BACKGROUND AND CURRENT PRACTICES IN DoD

A. INTRODUCTION

In order to gain the appropriate perspective, it is relevant to note how this particular research topic was decided upon. Following this discussion, and prior to addressing current practices and applications, the expert system will be defined, and certain identifying characteristics addressed.

The initial focus was to consider the contracting requirements of an expert system titled Expert System Advisor for Aircraft Maintenance Scheduling (ESAAMS). This project is in the early stages of development by the faculty and students of the Naval Postgraduate School. Upon initial review, it became obvious that little research had been done in the area of expert system acquisition. For this reason, this research effort was altered to address the larger arena of expert system acquisition in general as opposed to a specific system. The broader scope of the research will be useful to expert system acquisitions, vice a particular application.

One way to define an expert system is to compare it with an ordinary software program. According to Waterman, "the most basic difference is that expert systems manipulate *knowledge* while conventional programs manipulate *data*." [Ref. 1:p. 24] Artificial intelligence (AI) researchers have concluded that expert systems have the following distinguishing characteristics:

* Expertise
* Symbolic Reasoning

* Depth
* Self-Knowledge

An expert system must contain "expertise". It must "achieve the same levels of performance in the domain of interest that human experts can achieve." [Ref. 1:p. 25] In addition to expert performance and skill, the system must have breadth or "robustness" as well. Waterman maintains that this area is one of the least developed characteristics in expert systems today, "but one that human experts can do easily." [Ref. 1:p. 25]

"Symbolic reasoning" means rather than using equations or algorithmic mathematical computations to solve problems, an expert system does so by emphasizing the choice of symbols. "An expert system manipulates these symbols rather than performing standard mathematical computations." [Ref. 1:p. 26]

"Depth" refers to its effective operating capability within a narrowly defined and challenging domain. Expert systems work in what AI scientists call "real-world problem domains." [Ref. 1:p. 26] In such a domain, "the problem solver applies actual data to a practical problem and produces solutions that are useful in some cost-effective way." [Ref. 1:p. 27]

"Self-knowledge" or "metaknowledge" indicates a "knowledge about knowledge." [Ref. 1:p. 28] This is an inherently important characteristic of an expert system. Such knowledge allows an expert system to understand its own operation in addition to containing a built in structure that facilitates this reasoning process. This type of knowledge is important to expert systems for the following reasons:

* Users tend to have more faith in the results, more confidence in the system.

* System development is faster since the system is easier to debug.

* The assumptions underlying the system's operation are made explicit rather than being implicit.

* It is easier to predict and test the effect of a change on the system operation. [Ref. 1:p. 29]

As stated previously, the purpose of this research effort is to focus on the acquisition aspects of an expert system as opposed to the technical aspects of the system itself. Given the above definition and characteristics of an expert system, the following section will address current applications within the DoD.

B. CURRENT PRACTICES IN DoD

Current approaches to software design and development in DoD tend to be one of two widely used methods. The classical approach known as the "waterfall method" lends itself quite well to current Government practices. The waterfall development method requires preliminary definitions of requirements and detailed specifications or statement of work. While being specifically delineated, the rigid design specifications often serve to hinder or reduce the flexibility needed by the contractor in developing a software system. The real world application of the waterfall method tends to greatly inhibit the flexibility in software development. The restriction stems from the rigid and clearly defined sequence indicative of the waterfall model. These same restrictions hold true in contracting for an expert system developed using a waterfall methodology. [Ref. 2:pp. 34-35]

Today, the generally accepted approach to contracting for a software system development is known as "rapid prototyping." This is an iterative process which allows

greater user-developer interface. The user provides initial guidance to the developer. These specifications are often ambiguous. The user remains in constant contact with the developer throughout the system development. Initial concepts and specifications change. A prototype, however, is able to be developed rapidly based upon initial guidance from the user. Because of the user-developer interface throughout the process, the inevitable changes that occur are easier to respond to by the developer, and the prototype can be changed and altered as necessary. The prototype serves as a working example for the user to see if the system really works as intended. Multiple prototype iterations are made, each expanding the scope of the system. The close coordination and communication between the ultimate end-user and the developer ensure that the final system is in fact what the user intended. [Ref. 2:pp. 35-37]

While rapid prototyping seems an efficient means of developing a software system, it is not necessarily in line with current Government acquisition methodologies. These methodologies are predominantly hardware oriented. Present regulations require that specifications be delineated in the contract prior to contract award. The rapid prototyping method calls for initial "broad functional descriptions to loosely define the end product's objectives" vice the work to be performed. [Ref. 2:p. 37] Given the disparity between what method is most efficient, and what the system calls for, Government acquisition personnel are attempting to fit the rapid prototyping method into the present hardware system. At the same time, they are looking at ways to make the development process for expert systems adapt to the peculiar needs of conventional software development and acquisition.

So far, this discussion has focused on the methodologies used for developing and fielding computer software programs in the Federal Government. Because expert systems are software, their development and acquisition would seem to be of a similar nature. Although there are similarities between the accepted methods for procuring expert systems and common software applications, there are also differences. Before addressing the differences, however, it is necessary to note a few of the recognized myths and facts regarding expert systems projects.

Mr. A.F. Umar Khan, Program Analysis Division, 7th Communications Group (United States Air Force), has done extensive research into streamlining the development and acquisition of expert system applications. His findings and current DoD trends in the development and acquisition of expert systems have been noted in several papers and presentations. At an Institute of Electrical and Electronics Engineers, Inc. (IEEE) conference on "Managing Expert System Programs and Projects" held on September 10-12, 1990 in Bethesda, Maryland, he addressed his current findings. He has identified myths and facts regarding expert system development and acquisition. They are listed in Table 2-1.

Given these myths and facts about expert systems, it becomes evident that expert systems development and acquisition techniques are in fact similar to conventional software methodologies. Mr. Khan noted that "a recurring point" in his research was that expert system development and acquisition projects are essentially software engineering efforts. By viewing these projects as software engineering efforts, "lessons learned building software over the past decades still apply." [Ref. 4:p. 33] He also stressed that

TABLE 2-1

MYTHS AND FACTS
Source: Ref. 3: 3

MYTHS:	*	Expert system development should not be managed by the traditional management information system (MIS) department.
	*	Expert system development is radically different from conventional software development, i.e., existing standards cannot be applied.
	*	Expert system development varies too much and is dependent on the application, i.e., it is impossible to establish a single model.
FACTS:	*	Expert system development projects are software engineering efforts, i.e., lessons learned building software over the past decades can be applied.
	*	Most peculiarities of expert system development which have been much publicized in the popular literature are not totally unique to expert system projects.
	*	Failure to provide familiar, comfortable management controls contributes to low acceptance of expert systems.

these "lessons learned" can also be applied to expert systems. He indicated that expert systems should be viewed in a similar context as conventional software.

Prior to addressing the recommended methodologies for acquiring an expert system, it should be noted that there are essentially two ways to acquire a system regardless of system size. One method is to acquire a standard commercial "off the shelf" program "shell". Depending upon the application, funding constraints, and time

requirements, the requiring organization may opt to purchase a ready made commercial expert system "shell". The "shell" allows the requiring organization to tailor the expert system to their specific organizational needs. It provides the problem solving capabilities of an expert system at less cost than if the organization sought to develop its own system.

Another option is to program the expert system from scratch. In this instance, additional considerations need be addressed. Along with cost, application, time and funding constraints, the requiring activity will have to consider the availability of trained MIS personnel, resident "experts", a focused and specialized application, and maintenance over the life of the system.

Mr. Khan's study primarily addresses medium to large scale expert system projects, and proffers a life-cycle approach to the development and acquisition process. His recommended approach attempts to merge expert system development and acquisition to the DoD life-cycle model. [Ref. 5:p. 16] He identifies the importance of this approach in that these systems "require more documentation and control during development than the smaller, well defined, highly constrained, stand-alone systems." [Ref. 4:p. 32] He adds, however, that "it is preferable that small systems comply with the same life-cycle model as larger systems and that they adhere to similar control processes." [Ref. 4:p. 32] An explanation of the recommended life-cycle approach will be given later in the Chapter.

C. COMMONLY CITED PROBLEM AREAS IN EXPERT SYSTEM DEVELOPMENT AND ACQUISITION

Throughout this research effort, there have been recurring references to certain areas of concern. Both in personal interviews and conference presentations, similar concerns have been raised regarding problems associated with the acquisition and

development of expert systems. Similarly related concerns have been addressed in the papers, reports, and books reviewed in conjunction with this research. The following discussion presents the commonly noted areas of concern from the Federal Government perspective. The interview techniques used in obtaining this information were face to face and telephone type interviews. A discussion of industry's concerns and conclusions follows in the next Chapter.

1. Five Most Cited Problems Regarding Expert System Acquisition and Development In DoD

A study on software contracting conducted by Major Henry Attanasio in 1990 was used as a reference in helping interviewees to identify their concerns. [Ref. 2: p. 49] The five most commonly cited problems for expert systems development from the DoD personnel perspective are listed in Table 2-2.

2. Recommended Rationale And Possible Solutions To The Problems

Based on the interviews, two major issues were raised in linking the cited problems with a cause and potential solution. The two issues are:

* Development and acquisition methodology
* Training qualified and experienced personnel

As previously discussed, the currently preferred method of rapid prototyping is one method in which currently perceived problems can be addressed. By using the rapid prototyping methodology, requirements issues are responded to as part of the development process. Additionally, concerns regarding reliability and maintainability are addressed as a normal part of the development process. The interface between the user and contractor throughout the process ensures these issues are addressed. [Ref. 6]

TABLE 2-2

COMMONLY CITED PROBLEMS FROM DOD
Source: Ref. 2: 49

*	Lack of qualified Government technical personnel
*	Unclear user requirements
*	Lack of understanding regarding expert system design and development
*	Difficulty in measuring reliability and maintainability of expert systems
*	Too many changes to initial requirements

In order for the rapid prototyping method to work, there exists a need for qualified and trained people. The user has to be familiar with software terminology and the technical aspects of computer systems applications, as well as willing to learn about expert systems. The user should not only be well versed in determining the specifications or statement of work, but must decide on who will maintain the system. The interviewees agreed that the more knowledgeable the user is, the easier the development, acquisition, and implementation will be.

D. CONTRACTING ISSUES REGARDING EXPERT SYSTEMS

Specifically addressing expert systems acquisition and development in terms of contracting issues is of paramount importance. The contract is perhaps the single most important document in the acquisition process. It addresses the issues of cost, schedule,

technical performance, and maintenance support, not to mention the question of risk, legal requirements, and administration. The contract serves as the guiding document by which the entire acquisition is conducted. It is not just a legal basis for performance, but a vehicle through which responsibilities are delineated for both the contractor and the Government. This section will address the issues stated above. The contract type, which plays an important role in assigning the level of risk to either party, is discussed in Chapter IV.

1. Cost

Cost plays an important role in that it determines what the total price of the system will be. Price is the sum of cost plus a fair and reasonable profit. It is easy to see the importance of cost because profit is largely based on it.

For expert systems, cost can be a difficult issue to understand. Cihan H. Dagli of the University of Missouri-Rolla, identified two kinds of expert system costs: "One Time" and "Ongoing". The following "one time" costs were identified:

* Software shell purchase
* Software development
* Other software purchase
* Hardware lease or purchase
* Communication equipment
* Office space and furnishings
* Training and documentation

In addition to the "one time" costs, the following "ongoing" or "recurring" costs were also identified:

* Operating personnel
* Communication lines
* Hardware maintenance

* Software upgrades
* Office space and utilities [Ref. 7:p. 119]

While not specifically stated in the above terms, most of the DoD people interviewed were aware of the above costs. The key areas that DoD people seem to focus on regarding cost of a system were software development, training and education, operating personnel, and software upgrades. Regardless of the costs, and the fact that AI technology is a new and rapidly changing field, an understanding of costs associated with expert systems acquisition by contracting personnel can help reduce these costs to the Government.

By understanding the costs associated with expert system development and acquisition, the Government can realistically deal with contractors. According to Mr. Khan, by following the iterative rapid prototyping approach for development and acquisition, many costs can be significantly reduced. Inherent in the rapid prototyping methodology are management controls. Such controls govern the user-developer interface in addition to any design, development, and change actions. Because of the degree of user involvement throughout the process, the user will likely be satisfied with the end product at final delivery. The likelihood of a large number of changes and modifications after final delivery is lower in this process as opposed to one which requires rigid specifications up-front. [Ref. 6]

2. Schedule

The primary discussion of schedule as a part of the contract terms was in relation to the rapid prototyping methodology for expert system development and acquisition. Rapid prototyping combined with the life cycle approach recommended by

Mr. Khan seemed to be the widely accepted vehicle for controlling the development as well as delivery schedule.

Mr. Khan noted the varying degrees of schedule risk associated with different stages of the system development process. The degree of schedule risk tends to decrease as the process changes from concept development, to design, to prototype development. As will be discussed in Chapter IV, when combined with an incentive type contract, the Government tends to have greater control over the contractor. Similarly, the contractor is incentivized to deliver on time. [Ref. 6]

3. Technical Performance

Performance of the system, as described in the contract is obviously a key ingredient of the overall procurement. While the specific performance requirements will vary depending on the system usage, the unique performance requirements for a specific application should be specified in the contract. In accordance with the currently accepted rapid prototyping methodology, preliminary performance is based upon "broad functional descriptions that loosely define the end product's objectives." [Ref. 2:p. 37] By allowing the contractor a certain degree of latitude in developing an expert system, the system prototype can be viewed as a test bed for the user. The prototype allows the user to actually see if the system will meet given requirements. The prototype also allows the user to specify further requirements, and the contractor to implement and respond to suggested changes.

Mr. Jay Griesser, Technical Application Branch, Navy Finance Center, Cleveland, Ohio, specifically addressed the issue of technical performance. While the

finance center has conducted its expert system development "in house", Mr. Griesser stressed the importance of technical performance. He indicated that the users were able to remain in continuous contact with the knowledge engineers and system developers throughout the development process. In a similar vein as the user-contractor relationship in the rapid prototyping methodology, the ability for the user to evaluate the system from a technical performance aspect is not only necessary, but "should be required." [Ref. 8] This system evaluation by the user is inherent within the rapid prototyping process. By requiring the evaluation as part of the terms and conditions of the contract, and effective management control by the program manager and contracting officer, technical performance can be reasonably assured.

4. Maintenance Of Expert Systems

While largely ignored in literature as well as professional conferences, and paper presentations, the issue of expert system maintenance is important. Maintaining the system, or undertaking "a set of software engineering activities that occur after software has been delivered to the customer and put into operation", is one way of looking at the maintenance issue. [Ref. 9:p. 1] Current estimates indicate software maintenance entails as much as seventy percent of the overall software life-cycle costs for any given software project. [Ref. 9:p. 1] Knowledge in an expert system must be current if the system is to be used. It will require constant updating. The potential for expert system maintenance costs to be as great or even greater than software development expenses is real.

One way of reducing or controlling maintenance costs was to "do all of the maintaining in house." [Ref. 8] In doing so, an activity could save on the costs of

contracting out for maintenance support. Due to the nature and complexity of the varied applications of expert systems, the interviews indicated that in-house maintenance was the exception and not the norm. Training and education for experienced and qualified personnel will be required to conduct in-house maintenance. [Ref. 8]

A final problem stemming from the issue of expert systems maintenance is cost. Not the cost of contracting for the required maintenance, but the cost incurred in the development and implementation stage of the acquisition process. In considering this issue, Professor Martin J. McCaffrey, Naval Postgraduate School, Monterey, California, suggests that because of the "significant costs of future maintenance, these issues are often ignored in development and implementation." Program managers or contracting officers may not be adequately addressing this issue. [Ref. 9:p. 5] Prof. McCaffrey states that failure to address maintenance issues during development is a "significant impediment to both the growth of expert systems in the future and the life cycle management of these systems." [Ref. 9:p. 8]

E. EXPERT SYSTEM DEVELOPMENT PROCESS AND THE DoD LIFE-CYCLE MODEL

The following section presents the DoD life-cycle process for automated information systems (AIS) as outlined in DoD Directive 7920.1. The expert systems (ES) development process is then "mapped" onto the DoD model. [Ref. 5:p. 16]

The various phases as outlined in the DoD model for AIS development are identified in Table 2-3. These phases are for the development of conventional software systems, and are not peculiar to the development of expert systems.

TABLE 2-3

DOD MODEL FOR AIS DEVELOPMENT
Source: Ref. 5: 16

Needs-Justification Phase
Milestone 0 (Decide WHAT is wanted.)
Concepts-Development Phase
Milestone I (Decide HOW to do it.)
Design Phase
Milestone II (Decide if DESIGN is OK.)
Development Phase
Milestone III (Decide if SYSTEM is OK.)
Deployment Phase
Milestone IV (Decide if successful.)
Operations Phase
Milestone V (Decide if new system is needed.)

The development process for expert systems, as identified by Mr. Khan, is portrayed in Table 2-4. This process is based on the rapid prototyping methodology, and applies specifically to expert systems. It addresses the expert system development from initial design, through the prototype iterations, and on to actual deployment.

Table 2-5 portrays the DoD model for AIS development and the proposed ES development model "mapped" together.

TABLE 2-4

PROPOSED ES DEVELOPMENT PROCESS
Source: Ref. 5: 16

Initiation Phase
Concept Prototype
Demonstration Prototype
Testbed Prototype
Operational Prototype
Deployment Phase
Post-Deployment Phase

TABLE 2-5

ES PROCESS "MAPPED" ONTO THE DOD MODEL
Source: Ref. 5: 16

AIS		ES
Needs-Justification Phase		Initiation Phase
	Milestone 0	
Concepts-Development Phase		Concept Prototype
	Milestone I	
Design Phase		Demonstration Prototype
		Testbed Prototype
	Milestone II	
Development Phase		Operational Prototype
	Milestone III	
Deployment Phase		Deployment Phase
	Milestone IV	
Operations Phase		Post-Deployment Phase
	Milestone V	

The basic premise of "fitting" the rapid prototyping model to the DoD model is to:

* Work with the model currently followed throughout DoD for AIS procurement.

* Ensure that rapid prototyping is the method of choice for expert system development and acquisition.

Although expert systems to date tend not to be as large as the systems addressed in the DoD model, the expert systems model "can be mapped straightforwardly into the AIS life-cycle management phases of 7920.1." [Ref. 5:p. 15] By following this recommended process, issues of integration, user participation, and dynamic documentation are more adequately addressed in the realm of the total or life-cycle approach to expert systems development and acquisition.

F. SUMMARY

This Chapter has presented an overview of the background, current practices and applications, and specific contracting related issues regarding expert system development and acquisition. While not addressing specific expert systems, this Chapter focused on commonly cited problems and contracting issues deemed significant to understanding current trends. By identifying the problems, as well as presenting pertinent contracting issues, the researcher is attempting to set the stage for presenting various conclusions and recommendations in Chapter V.

III. CURRENT PRACTICES IN INDUSTRY

A. INTRODUCTION

In order to gain an accurate picture of current endeavors in the acquisition of expert systems, it is important to contrast the efforts of the Government with a look at industry. The previous Chapter discussed the concerns from DoD representatives. This Chapter will present areas of concern from industry as well as particular contracting issues deemed important by industry professionals. Interviews were the primary source of findings.

B. COMMONLY CITED PROBLEM AREAS IN EXPERT SYSTEM DEVELOPMENT AND ACQUISITION

Similar to their DoD colleagues, industry professionals were specific and direct in determining and identifying problems associated with the development and acquisition of expert systems. The majority of comments solicited from industry representatives dealt with expert systems that were designed, developed, and acquired for a specific application as opposed to commercial "off-the-shelf" shells.

1. Five Most Commonly Cited Problems From Industry Regarding Expert Systems Acquisition

The five most commonly cited problems from industry regarding expert systems acquisition are identified in Table 3-1. As with the Government personnel interviewed, Major Attanasio's list of problems was used as an aid.

TABLE 3-1

COMMONLY CITED PROBLEMS FROM INDUSTRY
Source: Ref. 2: 49

*	Unclear user requirements
*	Too many changes to initial requirements
*	Too many Government regulations
*	Too many Government specifications
*	Inadequate Government specifications

2. Recommended Rationale and Possible Solutions To The Problems

While somewhat different from the problems identified in the Government perspective, there were two striking similarities. The issues of unclear user requirements, and the number of changes to the initially stated requirements, appeared as significant areas of concern in both the public and private sector. These two problems were linked together because preliminary user requirements are often unclear. Changes are required further on in the expert system development and acquisition process.

While the link between the two problems seem evident, the recommended solutions are not. Industry professionals feel that better training and education on the part of the ultimate "end-user" would aid users in identifying requirements. In a similar vein, industry feels that closer coordination with the user is essential to developing a system that will be "everything the user intended." [Ref. 10] By using the rapid prototyping methodology, industry representatives feel that the "necessary" level of user-developer "interface" would be ensured.

The remaining commonly identified problems refer to various issues regarding specifications and regulations. Most people interviewed understood that the Federal Government was involved in steps to streamline the acquisition process. Taking a hard look at the "over-abundance" of regulations is viewed as a step in the right direction. Although the issue of Government regulations was identified as "problematic" and "cumbersome", no specific regulations were identified.

The issue of specifications is the area industry people emphasized as being most problematic. Although not an industry representative, Mr. Khan, who regularly deals with industry professionals, indicated that identifying and reviewing specifications is where the majority of time and effort should be spent. He emphasized the importance of including such information as the purpose and scope of the system, as well as a description of the development and delivery environment. [Ref. 6]

Specifications, as described by Major Attanasio "are complete and detailed descriptions of products which are either military in nature, or are modified commercial products requiring special features to satisfy military mission needs." [Ref. 2:pp. 18-19] Given this description, industry people felt that the technical specifications tend to be problematic. It is this area where developers tend to have a lot of difficulty due to specifications not being complete or detailed enough. On the other end of the spectrum, contractors tended to feel that specifications were sometimes too restrictive in nature thereby limiting the development process, although no specific examples were cited.

The question of adequate training and familiarity on the part of the Government in determining system specifications seemed to be a recurring theme. Mr. Jim Crossen,

of TRW, Sunnyvale, California, stressed the importance of adequate education by Government people associated with the procurement of expert systems and software in general. Such education should include familiarity with basic computer hardware and software terminology. In addition to being familiar with the terminology, procurement personnel must be able to envision or conceptualize what it is they are dealing with. While the discussion with Mr. Crossen addressed contract types and contracting issues, he did indicate a concern that contracting officers "get up to speed" when dealing with highly technical procurements such as expert systems. [Ref. 11] In other words, they need to understand what exactly it is that they are contracting for. Through both formal and informal education, the requisite level of understanding and familiarity can be attained.

In a similar vein, Mr. Conner, of Intellicorp, mentioned not only the importance of adequate technical familiarity, but also a concern over the number of Government specifications and standards. [Ref. 10] While not being specific, he did indicate that a number of regulations and standards for the management of DoD software projects are redundant. A review of the standards and regulations identified by Major Attanasio seemed to reflect this point. For example, even though DoD-STD-2167A addresses "all aspects of software design, development and testing", DoD STD-1467 and DoD-STD-1703 address software acquisition from a program manager's and life cycle perspective. [Ref. 2:pp. 19-21] While being important topics to be looked at, there exists certain degrees of redundancy and overlap between these standards. A review of the Government standards and handbooks presented by Major Attanasio indicates that industry's feeling

regarding Government regulations, specifications, and standards has some merit. Both Government and industry tend to feel that these areas should be looked at more closely.

Industry representatives felt that streamlining the Government acquisition process, as well as emphasizing rapid prototyping for expert systems and software in general, is the right direction to be heading. By not only streamlining the acquisition organization, but the rules and regulations governing the system, a lot of time and effort can be saved in the Government as well as industry. Mr. Crossen directly related this streamlining to savings in "cost, schedule, and management" areas. [Ref. 11]

C. CONTRACTING ISSUES REGARDING EXPERT SYSTEMS

Of the industry professionals interviewed, Mr Crossen was by far the most outspoken representative. As indicated in the previous section, he specifically stressed the importance of "cost, schedule, and management control." [Ref. 11] For this reason, and in keeping with the format followed in the previous Chapter, the contracting issues regarding expert systems will be broken down into the areas of cost, schedule, technical performance, and maintenance support. Management control will be linked directly to each of these areas throughout the discussion.

1. Cost

Cost is an important issue in any contract. In the area of expert systems development and acquisition, it is just as important. Based upon the "one-time" and "recurring " costs identified in the previous Chapter, industry representatives viewed these as being accurate and realistic. The industry perspective differed somewhat from the Government. The Government placed emphasis on costs associated with software

development, training and education, operating personnel, and software upgrades. The industry perspective, however, tended toward software development, maintenance, acquisition method, and contract type. The maintenance issue will be addressed in the appropriate section.

While closely related, software development and acquisition methods were generally discussed as two separate issues, although a link was always drawn between the two.

2. Schedule

The delivery schedule is widely recognized as a significant part of the contracting process. Largely linked with the development method, industry representatives indicated that during the development phase, it is important to concentrate on "common sense and rationality." [Ref. 11]. In later stages of the system development, a concise and restrictive schedule can often be agreed to with the assurance that delivery will be on time. Industry professionals seemed to be unanimous in the belief that rapid prototyping combined with the DoD life cycle approach as presented by Mr. Khan is the preferred method.

Similar feelings regarding the link between schedule and the development methodology were discovered between industry representatives and DoD people. This sense of agreement between the private and public sectors was not surprising in that the two conferences which were attended as part of this research consisted of DoD and industry representatives alike.

3. Technical Performance

Industry representatives seemed to stress the importance of technical performance. Technical performance refers to not only the physical performance of the system, but the interface with the user and maintenance technicians. This interface is a direct result of how well the system meets the specifications requirements as identified in the contract. The performance of the proposed system was viewed as an essential concern for both parties involved. Because of the rapidly growing technology in the AI field, industry people seemed to stress the current technological advances in this area. Again, the iterative process of developing expert systems, or software in general, lends itself to being vulnerable to technology change at every phase of design, development and production. Because of this vulnerability, it is important to note that depending upon the intended application of the system, the latest technology may not necessarily be the best alternative.

Mr. Francisco J. Cantu-Ortiz, of the Instituto Tecnologico y de Estudios Superiores de Monterrey, Monterrey, Mexico, specifically addressed the importance of technology transfer from the university to industry. At the Managing Expert Systems (MES) 90 conference, he proposed several strategic goals for the furtherance of AI technology. Among his list of proposed strategies are: applied research and development, an annual program of seminars and symposiums on expert systems, and research agreements with industry. [Ref. 12:p. 70] These suggested strategies stress the importance of technology. These and similar efforts in the U.S. indicate the rapidly changing pace of expert systems technology. Because of the changing environment, it becomes even

more important for the Government and industry to maintain a close working relationship or interface throughout the development process. This relationship thereby ensures acceptable technical performance of the final product through the iterative development process.

4. Maintenance Support

When discussing the aspects of maintenance support, industry representatives viewed this as a concern, but never really addressed the issue in detail. Most agreed with the need for some kind of post delivery maintenance such as consultants, knowledge engineers, in-house maintenance and/or contracted-out type maintenance support, however, no specific recommendations were made. In acknowledging maintenance support problems like documentation, user requests for changes, and quality of the software, Mr. Ed Hoffman of Intellicorp suggested that it was a cost issue. He indicated that the type of maintenance effort that is established and contracted for, will probably be driven by cost. [Ref. 13] This comment seemed to fall in line with the point raised by Mr. McCaffrey in the previous Chapter that maintenance costs account for 60-70% of the total software resources. [Ref. 9:p. 2]

D. SUMMARY

This Chapter has presented an overview of the current practices and applications, and specific contracting related issues regarding expert system development and acquisition in the public sector. In presenting the expert systems development and acquisition issues raised by representatives from industry, it is evident that there are striking similarities between the public and private sectors. As alluded to earlier in this Chapter,

one reason for the similarities between Government and industry is that the two sectors often combine resources through conferences, papers, and research. While not addressing specific expert systems, this Chapter focused on commonly cited problems and contracting issues industry professionals deemed significant to understanding current trends. A combined private and public sector discussion will be presented in a number of conclusions, derived from the information gathered as a result of this research, in Chapter V.

IV. CONTRACT TYPES IDENTIFIED AND DISCUSSED

A. INTRODUCTION

According to Major Attanasio, "the single most important document in the procurement of custom designed software is the contract itself." [Ref. 2:p. 26] Not only does the contract serve as a basis for explicitly stating what is intended, but it is also "one of the major pricing aids available to a buyer" due to the varied contract types available. [Ref. 14:p. 181] The contract is essentially a collective legal agreement between the buyer and seller (Government and industry), clearly delineating the responsibilities for both parties.

Government and industry use two broad contract categories: fixed-price, and cost-*reimbursement type contracts*. The Federal Acquisition Regulation (FAR) outlines each contract type, as well as the various factors involved in selecting and applying them. [Ref. 15: Part 16] The specific contract types contained in these two categories range from firm-fixed-price, to a cost-plus-fixed-fee. The firm-fixed-price type contract places full responsibility for performance costs and profit on the contractor. The cost-plus-fixed-fee type contract places minimum responsibility on the contractor for performance costs, and the ensuing profit fee is fixed. The contract types, as listed in the FAR, are identified in the following sections.

This Chapter will provide a discussion of the two categories of contract types, and how each contract type applies to software, and more importantly, expert systems acquisition.

B. FIXED-PRICE TYPE CONTRACTS

According to the FAR, "fixed-price types of contracts provide for a firm price or, in appropriate cases, an adjustable price." [Ref. 15: 16.201] In a fixed-price type arrangement, the contractor is required to make delivery of the goods and/or services for a given price, on time, and in accordance with the specifications of the contract, regardless of costs incurred. In doing so, the Government agrees to pay the contractor a fixed-price. The following discussion addresses four general categories of the fixed-price type contracts, as presented by Major Attanasio, as they apply to software. Their application to expert systems development and acquisition will be presented throughout based on input from Mr. Crossen and Mr. Khan.

1. Firm-Fixed-Price (FFP)

As previously indicated, the FFP contract presents the least amount of risk to the Government. The FFP contract "provides for a price that is not subject to any adjustment on the basis of the contractor's cost experience in performing the contract", and imposes "a minimum administrative burden upon the contracting parties." [Ref. 15: 16.202-1] According to Mr. Crossen, a FFP contract is appropriate for commercial off-the-shelf type purchases, but not for expert systems in the design or development stage. He felt that a FFP or even a FPIF type contract would be appropriate only after the operational prototype expert system was developed, and the process was beginning to enter the deployment phase of the life cycle process. [Ref. 11]

2. Fixed-Price with Economic Price Adjustment [FPE]

The FPE type contract allows for upward or downward price adjustments to the contract based on the following three economic factors:

(1) Established Prices

(2) Actual Costs of Labor or Material

(3) Cost Indexes of Labor or Material

In allowing for such adjustments, the Government and the contractor are seeking a certain level of protection from these economic factors. [Ref. 15: 16.203] While not routinely used for software acquisition or development, it is possible according to Major Attanasio, and therefore should be included.

3. Fixed-Price-Incentive (FPIS or FPIF)

"A fixed-price-incentive contract is a fixed price contract that provides for adjusting profit and establishing the final contract price by a formula based on the relationship of final negotiated total cost to total target cost." [Ref. 15: 16.204]

FPI type contracts are used as a means to "incentivize" the contractor to control costs. If the final cost is greater than the target cost, then the contractor loses profit. If, however, he manages to complete the contract with the final cost being less than the target cost, his profit will be greater. As indicated previously, Mr. Crossen felt that a FPI type contract would be appropriate when the contractor is in the production phase, and sufficient cost or pricing data were not available to negotiate a FFP. [Ref. 11]

4. Firm-Fixed-Price, Level of Effort (FFP,LOE)

A FFP,LOE type contract requires the contractor to perform a specified "level of effort", for a specified amount of time. The work to be performed is stated in general terms thereby allowing the contractor a certain degree of flexibility. The Government is then required to pay a fixed dollar amount to the contractor for the work performed. [Ref. 15: 16.207-1] Regarding software acquisition and development, the FFP,LOE is "typically used for feasibility type study in a research or development effort." [Ref. 2:p. 31] In the expert system arena, the FFP,LOE or even a CPFF,LOE was recommended for maintenance efforts. The FFP,LOE contract was recommended by Mr. Crossen for situations where the "customer", or user, would have to "stay out of the system." The CPFF,LOE would be appropriate for situations where the user had to "get into the system." [Ref. 11] In other words, when the user can actually enter the system and manipulate data, there is a greater potential for requiring the maintenance technician to be involved in more troubleshooting than he normally would be. When the user has no need to enter and manipulate the system data, there is less potential for problems to arise as a result of outside interaction.

C. COST REIMBURSEMENT TYPE CONTRACTS

Cost type contracts are best suited for use when uncertainties exist in being able to accurately estimate costs. The contractor is allowed to recover payment for all "allowable and allocable" costs. The FAR describes these type contracts in the following manner:

> These contracts establish an estimate of total cost for the purpose of obligating funds and establishing a ceiling that the contractor may not

exceed (except at its own risk) without the approval of the contracting officer. [Ref. 15: 16.301-1]

The following discussion presents the various cost reimbursement type contracts, and applies them to the development and acquisition of expert systems software.

1. Cost-Sharing (CS)

Although not discussed in great detail, the cost-sharing type contract was mentioned as an alternative. In this type contract, the contractor receives no fee, and only gets reimbursed for an agreed upon portion of his allowable costs. In this instance, the contractor generally agrees to absorb a certain portion of his costs in expectation of receiving compensating benefits in the future. [Ref. 15: 16.303] While not widely used in expert systems development and acquisition, the possibility exists for its potential use. A firm that is largely in the research and development business could view this type contract as a stepping stone to other business ventures. [Ref. 6]

2. Cost-Plus-Incentive-Fee (CPIF)

The CPIF type contract is a cost-reimbursement contract that provides for an initially negotiated fee that is adjusted based on the total allowable costs and the total target costs. Initially, the target cost, target fee, maximum and minimum fee, and the adjustment formula are generally agreed upon. Depending on the cost-share ratio, the fee is adjusted upward or downward depending upon whether or not the contractor completes the contract below or above the target cost. The key is to reach an accord with the contractor based on the target cost and fee adjustment formula likely to motivate him to manage effectively and efficiently. The CPIF is appropriate for development and test type programs. [Ref. 15: 16.404-1]

3. Cost-Plus-Award-Fee (CPAF)

In this cost-reimbursement type contract, the contractor is allowed an agreed upon base amount fixed at the inception of the contract. In addition to the base, an award is authorized that the contractor may or may not be eligible for. The eligibility is based on the Government's evaluation of the contractor's performance in pre-determined areas such as quality, timeliness, technical ingenuity, and cost-effective management. The general criteria for the contractor's performance are stated in the terms of the contract. By monetarily rewarding the contractor for his performance in given areas, he is incentivized to maintain a reasonably high level of performance standards in order to gain the maximum reward. [Ref. 15: 16.404-2] As addressed in the previous section, both the CPIF and the CPAF type contracts are ideally suited for the early stages of the rapid prototyping process.

4. Cost-Plus-Fixed-Fee (CPFF)

A CPFF contract allows for the contractor to be paid a fixed fee negotiated and agreed upon at contract inception. While adjustments can be made based on changes in the work to be performed, the fee is generally fixed. In this type of cost-reimbursement arrangement, the contractor is allowed the fee due to the potential risks involved in the performance of work. This type of arrangement does not, however, provide a great deal of incentive for the contractor to control costs. Under the CPFF type contract arrangement, the Government assumes the majority of risk. [Ref. 15: 16.306] In the expert systems arena, the CPFF is one vehicle recommended for use in the research and development phase of the DoD life-cycle acquisition process. [Ref. 6] Because of the

greater risk assumed on the part of the contractor in this phase, the CPFF arrangement ensures a certain fee in addition to the allowable and allocable costs. [Ref. 11]

D. CHOOSING THE APPROPRIATE ALTERNATIVE

The contract types previously discussed are available to the Government and contractors as a means to "provide needed flexibility in acquiring the large variety and volume of supplies and services required by agencies." [Ref. 15: 16.101] The selection of the proper contract arrangement is basically a matter for negotiation and the application of sound judgement. The application of sound judgement throughout every phase of the process is essential to a successful project. The key of contract selection is to negotiate a contracting arrangement, and either price or estimated cost and fee:

> ...that will result in reasonable contractor risk and provide the contractor with the greatest incentive for efficient and economical performance. [Ref. 15: 16.103]

By selecting the appropriate contracting arrangement, a reasonable level or share of the cost, schedule, technical, and support risk is assigned to each party. The ideal arrangement is one that has the Government and the contractor walking away feeling like they both received a fair and reasonable deal; essentially a "win-win" situation.

Management control emerged as the key ingredient throughout the entire development and acquisition process. Both Government and industry identified the need for management involvement and control in <u>every</u> area of the acquisition process.

The industry feeling is that a CPIF or a CPAF is appropriate for the concept, definition/design, and development stages of the DoD life-cycle management process for automated information systems. These stages of the rapid prototyping process are the

times when the contractor is likely to incur unanticipated costs. While the iterative process entailed in rapid prototyping tends to significantly reduce overall costs, any developmental stage will have unforseen expenses. According to Mr. Khan, the iterative process tends to reduce costs by foregoing a great number of the changes and modifications that software systems developed under non-iterative methodologies tend to experience. For this reason, and to reward the contractor for efficiency and effectiveness, the CPIF and the CPAF are recommended. [Ref. 6]

E. SUMMARY

By presenting the various contract arrangements outlined in the FAR, this Chapter is meant to provide a basic understanding of the primary contract types available. In applying the contracting arrangement to the development and acquisition of expert systems, the popular opinion of Government and industry is to award a cost type contract in the early stages of research, concept definition, design, and development. Whatever the contracting arrangement, the key is to ensure appropriate allocation of risk, a quality product or service for the Government, and a fair and reasonable profit for the contractor.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This research has lead to specific conclusions regarding the development and acquisition of expert systems. The following conclusions will be addressed individually and then followed in the next section by recommendations.

The first point, and possibly the most significant, is the question of what an expert system really is. Within the computer software community there exist areas of specialization. One such area is artificial intelligence or AI. Expert systems fall within the purview of AI. Within the AI community, there are those who believe that expert systems are unique in and of themselves, and should be treated differently vis-a-vis typical computer software applications. The research indicated that expert systems should in fact be treated as software, and that similar approaches be taken in the areas of research, design, and development. The development and acquisition of these software systems is addressed in the DoD Directive 7920.1 regarding life-cycle management of automated information systems. [Ref. 5:p. 16] Program managers and contracting officers have to remember that they are essentially dealing with software issues.

Another point brought about as a result of this research is the methodology used in the development of expert systems. The traditional or "waterfall" approach does not fit well with the peculiarities of expert systems development. It requires firm specifications or statements of work early on in the development process. Because of the iterative, or growing and re-defining type of developmental approach in expert system development,

the waterfall development approach does not work for developing expert systems. The need for up-front specifications restricts the developer in crafting a system that will properly meet the needs of the user. DoD documentation standards such as DoD Standard 7935.1, *Automated Data Systems (ADS) Documentation Standards* (April 1984), tend to emphasize hardware vice software requirements. Because of the different characteristics of expert systems as opposed to conventional software, i.e., expert systems attempt to model human thought processes, and the emphasis on hardware, the developer cannot effectively document the expert system application as it would appear to the user. [Ref. 4:p. 33] The waterfall approach essentially removes the user from the development process, thereby restricting the developer from being able to meet the specific user needs. [Ref. 16: 88,102]

Documentation of the expert system development process is important, however, and should be required throughout the process. A recommended approach is that of a "Progress Notebook" that would entail a "historic trace" of the entire expert system development process. The "Progress Notebook" would tend to "fill in the gaps left by the standard documents." [Ref. 4:p. 38]

The popular and preferred method of expert system development is known as the "rapid prototyping" approach. This method allows for the user to remain closely involved throughout the development process. The contractor develops a prototype system that is tested against the user's requirements. Because the initial system is defined in "broad functional terms" as identified in Chapter II, the contractor is afforded greater flexibility in meeting the user's requirements. [Ref. 2:p. 37] Such descriptions could be in terms

of what the system is expected to do, as opposed to looks and language requirements. By describing the system in functional as opposed to design type terms, the developer is afforded the latitude to adequately respond to the users needs throughout the iterative process. If described in specific design type terminology, the developer is then restricted in developing the proposed system. Specific issues of integration, the continuous need for user and domain expert system participation, and the need for dynamic documentation throughout the process are easily managed in the context of the rapid prototyping model. [Ref. 5:p. 15]

While varying somewhat in the identification of specific problem areas, industry and Government seem to be in general agreement regarding questions concerning contract type, cost, schedule, technical performance, and maintenance. Continued Government and industry interaction through conferences, publication of professional papers, and communication, will ensure these concerns and problem areas will continue to be addressed and potential solutions attained.

B. RECOMMENDATIONS

As a result of this research, the following recommendations are made:

1. Continuous Correlation Between Expert Systems and Conventional Software

Although expert systems are a unique application of a software system, they are in fact software. [Ref. 4:p. 33] This research has shown that conventional software, and expert systems development and acquisition methodologies, are essentially the same. Issues of concern in the software development field are virtually mirrored in the expert systems arena. Issues such as requirements changes, specifications, technical

performance, cost and management control ring clear in both fields. As indicated previously in Chapter IV, the question of software maintenance is not only a concern, but significantly impacts life-cycle cost control in each phase of the process. Because of the similarities brought forth in this research effort, it would stand to reason for the two fields to maintain open lines of communication. Industry and Government recognition of these issues in software development and acquisition projects is essential.

2. Use of the Rapid Prototyping Methodology

In contracting for the development and acquisition of expert systems, the iterative rapid prototyping process should be used. Currently the preferred method throughout industry and the Federal Government, the rapid prototyping process facilitates the necessary management control in developing and acquiring expert systems. Rapid prototyping additionally ensures that the needs of the user will adequately be met. A common theme throughout this research has been the link between the various problems encountered in developing and acquiring an expert system, and the process used. Both industry and Government professionals tend to agree that application of the rapid prototyping method can significantly reduce the problems currently encountered. Concerns with requirements changes, specifications, and user-developer interaction are addressed throughout this process. The rapid prototyping methodology allows for coordination of user requirements throughout the process. Because coordination, communication, and management control are inherent to the rapid prototyping process, the Government and contractor reap the benefits of schedule and cost control measures.

3. Education and Training of Users, Contracting Officers, and Program Managers

Viewing expert systems from a software perspective, and adequately applying the management techniques involved in the rapid prototyping methodology, can only be brought about through education and training. From a managerial viewpoint, knowledge and understanding of the proposed system is just a small part of the overall understanding required. In order to properly apply judgement, and make informed decisions about the program or acquisition, the manager and contracting officer have to understand the industry as well as the proposed system. From a user and developer perspective, a thorough knowledge and understanding of the system, system operating environment, applications, and alternatives will greatly benefit the overall process. Through educational courses and professional conferences and journals, people involved at each level of the development and acquisition process will be better able to respond in this dynamic environment.

4. Continuous Revision and Updating of Government Regulations and Specifications

Current trends in both the Federal Government and industry reflect concern for revising and updating acquisition regulations and Government specifications. In offering the views of the Aerospace Industries Association (AIA) regarding the Secretary of Defense's "Defense Management Report" of July 1989, Mr. Don Fuqua, President of AIA, recommended that "industry should be required to participate in the initial development of future regulatory changes." [Ref. 17:pp. 1-1, 2-11] This recommendation falls directly in line with the sentiment from both industry and Government interviewees;

that not only should acquisition streamlining continue, but the Government and industry should work together. By working together, issues regarding the abundance of regulations and specifications, and contracting arrangements best suited for the situation can be addressed and responded to. As indicated previously in this paper, communication between Government and industry is not just a good idea, but essential to the effective and efficient application of the development and acquisition process.

C. ANSWERS TO RESEARCH QUESTIONS

1. What unique contractual considerations are involved in procuring an expert system for use in the DoD?

As indicated throughout this research, there are few "unique" considerations regarding the acquisition of expert systems. On the contrary, it is important to note that expert systems should be viewed in the purview of software development and acquisition. The primary difference between expert systems and conventional software, as discussed previously, is that expert systems "manipulate knowledge" vice "data." [Ref. 1:p. 24] Expert systems should be acquired based on the factors of need, scope, application, and estimated cost of the specific project at hand. Questions regarding whether to purchase a commercial shell, or develop the system from scratch, are a function of these factors. While the results of this research stress the use of rapid prototyping for expert system development and acquisition as opposed to the waterfall method, further research could be conducted to determine other feasible variations or alternatives. Other concerns and problems identified as a result of this research virtually mirrored those brought up in previous research in software development.

2. **Of the expert systems currently acquired by the DoD, how satisfied are the agencies with these systems?**

The people interviewed throughout this research effort indicated satisfaction with the different expert systems at their disposal. Because of the abundance of information regarding other significant problems in the expert system development and acquisition arena, the actual systems themselves were not addressed. The interviewees reflected satisfaction with the actual systems, however, they were specific in identifying problem areas as were discussed in Chapters II and III.

3. **What were the contractual problems associated with the acquisition of these systems?**

From the Government perspective, the five most commonly identified problem areas in expert systems development and acquisition were identified in Table 2-2. The primary recommendations to remedy these problems, or at least lessen their impact are:

* Use of rapid prototyping development and acquisition methodology
* Training qualified and experienced personnel

By applying the rapid prototyping methodology to the development and acquisition of expert systems, user and developer interaction can be managed. By ensuring early and continuous user interaction throughout the process, requirements can be responded to, and adapted, thereby limiting the level of confusion over what the user actually wants and needs.

As addressed in the recommendations section, education and training of the personnel involved in the development and acquisition of expert systems is essential.

Improved management, communication, and coordination can be assured through ensuring that these people have an adequate understanding of the system, system environment, acquisition methodology, and available alternatives.

4. **What are the observations of industry (both user and producer) regarding satisfaction in the application and performance of expert systems, and any special considerations involved in the acquisition of these systems?**

While the problem areas identified by industry varied somewhat from those of the Government, their major concerns were essentially the same. Additionally, industry expressed satisfaction with the general application of currently used expert systems. The predominant concerns of industry regarding expert systems development and acquisition were presented in Table 3-1.

Industry sentiment seems to be in line with the Government's in that unclear requirements, as well as requirements changes, often lead to cost and schedule overruns. Industry representatives, like their Government colleagues, felt that both education and use of the rapid prototyping development and acquisition methodology would significantly enhance the overall process.

In discussing the issues of Government regulations and specifications, the words "burdensome", "confusing", "over-abundance", and "ambiguous" often came up. Industry professionals agreed that the Government needed to pay particular attention to regulations and specifications. By continually reviewing these, and even including industry in the process, the overall system could incur substantial savings in the areas of cost, technical performance, schedule, and maintenance support.

5. What are the specific issues regarding contract type, contract administration, research and development (R&D), prototype development, production, and maintenance of expert systems?

The primary contracting issues were broken down into the areas of cost, schedule, technical performance, maintenance support, and contract type. Contract administration, while being an area of concern, was too broad in scope to include in this research effort. For this reason, contract administration issues such as warranties, contract changes, contract interpretation, disputes, and legal implications, are recommended for future research efforts.

Each of the areas identified above is linked to management and methodology. The methodology issue is continually referred to as being the key to a program manager's or contracting officer's ability to adequately handle the situation. Proper planning, and appropriate acknowledgement of the contracting issues identified above, throughout every phase of the development and acquisition process, is one means to reasonably ensure success.

D. RECOMMENDATIONS FOR FUTURE STUDY

1. Contract Administration Issues

Examine pertinent contract administration issues such as warranties, disputes, contract interpretation, contract changes, adjustments, and legal questions from an expert system acquisition perspective. As previously indicated, contract administration is definitely an area of concern in the overall development and acquisition process. A review of the various studies, and literature on these topics for conventional software acquisition can be directly related to expert systems. An interesting question is that of

liability and risk associated with an expert system, i.e., responsibility for inaccurate decisions or results based on the information provided by an expert system. Issues of legal responsibility may or may not be addressed in the warranty. If addressed, then how are the issues enforced? The answer may lie in the realm of contract interpretation, or clearly delineating within the context of the appropriate contract clauses what is intended by the Government and the contractor.

2. Formalized Education and Training in Software Development and Acquisition

Examine the current system of education and training in the area of software development and acquisition. Compare the current system with various alternative approaches such as formal training for procurement personnel regarding software and hardware terminology and applications. The focus of such training would be in the area of expert system design, development, and production techniques as they apply to expert systems. Alternatives can be obtained through interviews with Government and industry professionals. As identified throughout this research effort, the need for formal education and training at every level of the software development and acquisition process is essential.

3. Review Development and Acquisition Methodologies for Specific Expert Systems Applications

Analyze and compare various expert systems applications from a development and acquisition perspective. Through in-depth analysis of selected expert systems projects, an accurate assessment of the development methodologies used can then be made. By studying actual expert systems projects, the various methodologies can be

assessed as to their effectiveness and efficiency. This type of research effort would provide professionals in the field of expert systems development and acquisition with the appropriate understanding of the best suited methodology to apply.

4. Review of Government Regulations and Specifications

Examine current Government regulations, specifications, and standards for appropriate application to expert systems development and acquisition. By identifying those Government regulations, specifications, and standards that are ambiguous or repetitive, measures can then be made to clarify, update, or possibly delete applicable items. A joint project including Government and industry representatives could be initiated as a means to potentially identify possible issues of concern. Government standards such as those identified in Chapter III may be able to be condensed, combined, updated, or possibly even deleted. By working with industry and Government on this project, the concerns regarding redundancy and overlap can be addressed.

E. SUMMARY

As a result of this research, certain key areas of concern from the Government and industry perspective were brought to light. Education and training, redundant Government regulations, specifications, and standards, and development methodology, were frequently discussed. Both industry and Government personnel tended to agree that these areas must be addressed from user to program manager to contractor.

Understanding that expert systems are software, and that they should be developed and acquired in a similar fashion is a paramount concern. By understanding this correlation, use of the rapid prototyping methodology arises as the natural vehicle for

acquiring an expert system. Rather than change the Government approach to software development, a proposed method to work within this system has been recommended in Table 2-5. This method allows for the iterative prototype development process required for expert systems, as well as the DoD requirement to follow the AIS development process via the milestone approach. By "mapping" the two processes together, efficiencies in time, schedule, and cost can be attained by ensuring an adequate level of user-developer interface throughout.

The remaining two areas of concern were contract type and maintenance. Most interviewees agreed, as does the author, that a cost type contract for the early stages of expert system design and development is advantageous for industry as well as the Government. In this type arrangement, industry is rewarded for assuming a greater portion of the cost risk associated with early development phases. In a similar vein, as the development process leads to an operational prototype, and enters the deployment phase of production, the level of risk changes. Because of the shift in risk, the type of contract should also shift to reflect the change by assuming a fixed-price type of contracting arrangement. Whether by agreeing to one contract that will change according the stage of development, or by contracting for each phase of development separately, these types of contracting arrangements should be pursued. The decision to go with one contract or a series of contracts depends primarily on time, cost, and competition.

While being an important issue of concern, the area of maintenance is often overlooked. Because of the large proportion of cost involved in maintenance throughout the life-cycle of the system, maintenance should be required to be addressed and planned

for from the earliest stages of concept design and development. By starting early on in the rapid prototyping process, the user and developer can begin to respond to the questions of contractor maintenance, in-house maintenance, or a combination of the two. The need for maintenance may require that not only a clause be added to the contract addressing this issue, but that the proposed "mapping" of the DoD AIS model and the ES life-cycle model be changed to reflect this need throughout each stage of development.

Finally, as discussed in the previous section, it is important to continue addressing the areas of contract administration, education and training, development and acquisition methodologies, and Government regulations, specifications, and standards. The rapidly changing and growing field of artificial intelligence will continue to raise new concerns over these areas.

APPENDIX A

LIST OF CONFERENCES ATTENDED

1. *Forum on Artificial Intelligence in Acquisition Management.* Sponsored by the Defense Systems Management College, Fort Belvior, VA. Hosted by the Naval Postgraduate School, Monterey, CA, 14-17 May 1990.

2. *IEEE Managing Expert System Programs and Projects Conference.* Sponsored by the IEEE Computer Society Technical Committee on Expert Systems Applications. Hosted by the Holiday Inn, Bethesda, MD, 10-12 September 1990.

APPENDIX B

LIST OF PEOPLE INTERVIEWED

1. Burks, Shiela. Artificial Intelligence Program Analyst, ALD/JTI, Wright Patterson Air Force Base, OH, Interview, May 1990.

2. Conner, Dave. Procurement, Intellicorp, Washington, D.C., Interview, September 1990.

3. Crossen, Jim. TRW, Sunnyvale, CA, Interview, September 1990.

4. Davis, Laura. Information Technology Division, Naval Research Laboratories, Washington, D.C., Interview, September 1990.

5. Feinstein, Jerald. Mitre Corporation, McLean, VA, Interview, September 1990.

6. Griesser, Jay. Technical Application Branch, Navy Finance Center, Cleveland, OH, Interview, August 1990.

7. Hoffman, Ed. Telesales Representative, Intellicorp, Mountain View, CA, Interview, September 1990.

8. Khan, A. F. Umar. 7th Communication Group, Program Analysis Division, United States Air Force, The Pentagon, Washington, D.C., Interview, August - October 1990.

9. Kim, Hun. Artificial Intelligence Program Manager, Naval Supply Systems Command, Washington, D.C., Interview, August 1990.

10. Klahr, Phil. Inference Corporation, El Segundo, CA, Interview, October 1990.

11. Siegel, Harry. JAYCOR, Vienna, VA, Interview, October 1990.

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9. McCaffrey, Martin J., *Maintenance of Expert Systems - An Initial Analysis*, Paper presented at the 3rd International Conference for Expert Systems for Business, Finance and Accounting, sponsored by the University of Southern California, Laguna Niguel, CA, September 28, 1990.

10. Interview between Mr. Dave Conner, Procurement, Intellicorp, Washington, D.C., and the author, September 1990.

11. Interview between Mr. Jim Crossen, TRW, Sunnyvale, CA, and the author, September 1990.

12. Cantu-Ortiz, Francisco J., "A Strategy for Transferring Expert Systems Technology To Industry," *IEEE Conference on Managing Expert System Programs and Projects*, (Los Alamitos, CA: IEEE Computer Society Press, September 1990).

13. Interview between Mr. Ed Hoffman, Telesales Representative, Intellicorp, Mountain View, CA, and the author, September 1990.

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17. Mr. Don Fuqua, President, Aerospace Industries Association of America, Inc. Letter to The Honorable Donald J. Atwood, Deputy Secretary of Defense, Subject: AIA Initiative, dated 28 September 1989.

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