9. Conclusions

It seems that the present expert system technique for micro computers is already suitable for building small knowledge based systems for interpreting the collective agreement and other similar applications in the legal field. Systems covering the whole collective agreement should also be feasible if they are built up of smaller subsystems.

As better expert system shells are coming to the market so the building of systems becomes easier. This shouldn't however deter one from embarking upon development work now, since the present shells already offer a viable means and systems built now may be transferred to improved shells in the future. Present systems provide a firm basis for further developments.

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EXPERT SYSTEM FOR DIFFERING SITE CONDITION CLAIMS OF CONSTRUCTION CONTRACTS

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1. INTRODUCTION

In recent years, research in the field of artificial intelligence has had many important successes. the most significant these Among of has been the development of powerful new computer systems known as These programs are designed to represent expert systems. and apply factual knowledge in specific areas of expertise and to provide problem-solving capabilities of recognized experts. For example, collaborative efforts by human experts and systems developers have resulted in systems which diagnose diseases, configure computer systems, diagnose welding defects, provide legal advice and etc. Because these systems enhance problem-solving capabilities and overall job performance for a wide range of personnel, they can save both time and money. The potential power of these systems has led to a worldwide effort to extend and apply this technology.

Recently, expert systems development shells have become available on microcomputers. Today's expert system technology makes it possible to address a significant problem facing the construction industry - the need for construction claim analysis expertise at the field level. Construction in the 1980's has become a very complicated industry, with many intertwined relationships and intense competition. For contractors, this has meant that bid margins are low and claims have multiplied in size and number. For owners, this has meant more disputes and greater exposure to large claims. There seems to be a great potential for the application of state-of-the-art knowledge in expert system technology to the practical areas of construction. One promising area is to use an expert system to help minimize some of these problems by providing field personnel guidance in handling various types of potential claims.

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Researchers at the U.S. Army Construction Engineering Research Laboratory have been developing an expert system called Claims Guide System (CGS) to provide claims analysis expertise at the field level. The CGS was designed using an expert system shell -- Personal Consultant Plus by Texas Instruments -- for IBM compatible microcomputers. The first module of the CGS deals with differing site condition (DSC) claims. The objectives of developing the CGS for DSC claims are to: (1) provide project engineers with pre-legal assistance in the analysis of differing site condition claims and (2) serve as a training device for new personnel in field offices by familiarizing them with the legal reasoning process.

Unknown subsurface or latent physical conditions at the work site represent a very significant risk inherent in many construction contracts. The "Differing Site Condition " contract clause is an effort by the U.S. Government to reduce the construction contractors' risk of such unknown or unanticipated conditions. The purpose of this clause is to allow contractors to submit their bids based on reasonably foreseeable conditions, without contingencies to cover the unexpected or unusual. In return, the bidder is provided assurance that, in the event conditions prove different than should have been anticipated, an equitable adjustment will be made in the contract price and/or time. Without this clause, contractors, in order to meet the requirement for submitting a fixed price, would have no alternative but to include contingency allowances in their bids to cover the cost of coping with possible subsurface difficulties, which in fact may not occur during fulfillment of the contract. This situation can result in the payment of more than the actual work is reasonably worth.

Studies by Mogren (1986) and Diekmann & Nelson (1985) have shown that DSC claims are one of the most frequent and costly reasons for construction contract U.S. Army Corps of Engineers (USACE) field changes. engineers faced with these claims need to understand the involved so that they can legal issues supply the appropriate information to legal counsel and avoid lengthy litigations caused by incorrect decisions. Personnel who are unfamiliar with this process must rely on experienced engineers for help in analyzing a claim. Providing analytical assistance for potential claims through an expert system would help Government employees to handle DSC claims more efficiently and consistently.

Specifically, an expert system for the analyzing potential claims insures that a rigorous evaluation is performed consistently. It provides a written document of analysis for claim future reference, the which is especially useful if the claim must be defended. In addition, repeated use of the expert system sharpens the field engineers' claims evaluation skills which will help them identify potential claims sooner, avoid conflicts if support their position with and adequate possible, documentation.

This paper describes development of the CGS and a prototype consultation session.

2. DEVELOPMENT OF CLAIMS GUIDE SYSTEM

For creating the CGS, we followed the development process of all expert systems. These include:

- Deciding What the System Should Do
- Selecting an Expert System Shell
- Selecting Differing Site Condition Claims
- Acquiring Expert Knowledge
- Validating and Enhancing of the System

2.1 Deciding What the System Should Do

The original objective of the system was to provide assistance to field engineers in analyzing and evaluating potential claims. However, as we progressed with the development, another objective became as important as the original one. Namely, to provide a tool for documenting all relevant information in the claims analysis for future reference. Therefore, the expert system not only analyzes potential claims but also collects all necessary information and provides a record of the collected information. It also became clear this system will be a very useful training tool for new personnel in the field offices.

In order to reach these objectives - as a tool for evaluating potential claims, for collecting relevant information and for training new personnel, the system should be easy-to-use, user-friendly, interactive and able to run on IBM compatible microcomputers readily available at the Corps field offices. By their nature, expert systems are serious consumers of computer power, and they function more efficiently using specialized hardware (i.e., LISP machines). Specialized hardware offers the added advantage of providing user-friendly software environments that are particularly productive in the context of rapid prototyping of expert system functions. However, considering the issue of a delivery environment of the CGS for the Corps field offices, we had to restrict ourselves to the systems that run on IBM compatible microcomputers.

2.2 Selecting an Expert System Shell

There is a significant number of commercial expert system development shells to choose from. Richer (1986) has presented a set of criteria for evaluating these tools. Criteria include an evaluation of basic features, the development environment, how easy it is to learn and use, efficiency of the development and run-time environment, how much it costs, and how well it is supported.

Considering these criteria, we selected Personal Consultant Plus by Texas Instruments. Since most of the Corps field offices are equipped with IBM compatible microcomputers, where the CGS will be used, it was necessary to select a shell that will run on these computers.

When the project for CGS started (fall 1985), the best shell available appeared to be the Personal Consultant. It provided a friendly user interface, an acceptable knowledge-base editor, why/how capabilities, and acceptable speed of execution. Also it was easy to use and reasonably priced (\$2995). Later, in spring of 1986, Texas Instruments enhanced the program to form "Personal Consultant Plus," providing capabilities to use more than 640K memory for developing the knowledge-base and access to other programs/files, with a graphics interface and a better editor.

During development of the knowledge base, we needed to use more than 640K memory. However, for running a consultation session, it is not necessary to have more than 640K memory. Therefore, the minimum requirements to run the CGS are: (1) an IBM compatible microcomputer with 640K memory and 10 megabytes hard disk and (2) the Personal Consultant Plus Runtime system by Texas Instruments.

The runtime system must to be purchased separately from the development tool, for the distribution of the CGS to field offices. The price for one runtime disk is about \$50 when 20 copies are bought at once. This is a very reasonable price compared with other currently available shells, considering that hundreds of copies will be needed for distribution of the CGS.

2.3 Selecting Differing Site Condition Claims

The first module for CGS deals with differing site condition (DSC) claims. Of all the types of construction claims, the DSC clause was selected for the following reasons:

- It is a concise and well written clause, making it less open to differing interpretations than other types of claims.
- (2) It is a very independent clause, rarely referenced by or linked to other clauses. Thus it can be treated as a self-contained legal concept, reducing the complexity of the analysis.
- (3) DSC litigation is intended to show that a contractual right to recover exists, whereas the litigation resulting from many other construction claims is intended to show that some form of breach has occurred. Since it is easier to prove the existence of a contractual

right than to prove the occurrence of a breach of contract, the analysis of DSC claims is less complex than that of many other construction claims.

- (4) Studies have shown that DSC claims are among the most frequent and costly reasons for construction contract changes.
- Diekmann & Kruppenbacher (1984) have demonstrated (5)is significant potential that there for the application of artificial intelligence to claims analysis. They identified the need for more developmental work in this area to make this a viable tool technology for construction professionals in claims Following analysis. their suggestion and taking advantage of their knowledge acquisition, work on the DSC clause was selected for an expert system that will be used in the real-time environment at the Corps field offices.

2.4 Acquiring Expert Knowledge

Knowledge acquisition for the CGS-DSC is based on the work of Diekmann and Kruppenbacher. They developed a prototype system that performs analysis of differing site conditions claims on a mainframe computer. Their system is based on the expertise incorporated in decisions by the Board of Contract Appeals and on the expert knowledge obtained from discussions with an experienced lawyer.

The logic diagram of Kruppenbacher's (1984) study was reviewed by an experienced Corps field engineer and was revised and simplified to fit the Corps office environment. The questions used in Kruppenbacher's system include many legal terms that could confuse the field engineers, therefore, questions for CGS-DSC were changed to be easily understandable by the Corps field office personnel. Using the revised logic diagram and questions, rules were developed to create the test version of CGS-DSC.

A steering committee was formed to review the and to evaluate it for validity test version and The committee consisted of six experts: two completeness. experienced legal counsels from the Corps headquarters and four engineers with many years of experience in the construction contract management within the Corps. The committee suggested many enhancements and necessary corrections to the logic diagram. The revised logic diagram is shown in Figure 1.

In revising rules for the second test version, fictitious cases were generated for the committee members to review. They evaluated these fictitious cases and rated the contractor's chance of entitlement based on the following scale: (1) No Chance, (2) Very Poor Chance, (3) Poor Chance, (4) Fair Chance, (5) Good Chance, and (6) Excellent Chance. For each case, a case summary describes the relevant facts as shown on a sample consultation session. After committee members considered one case, they were given about 25 to 30 what-if questions describing minor variations in the case and were asked to provide their opinions on the effect, if any. They performed these ratings for every case. Responses were collected to enable the CGS-DSC to handle as many cases as possible.

The Differing Site Conditions Clause (FAR 52.236-2) used in U.S. Government contracts covers many important aspects. To facilitate the development of logic and questions, the important issues in differing site

833

conditions claims were divided conceptually into the following subareas:

- (1) payment
- (2) notice to government
- (3) government action
- (4) prejudice to government
- (5) nature of problem
- (6) contract provision
- (7) assumptions
- (8) superior knowledge
- (9) site inspection.

several questions were generated to For each subarea cover the important aspects of the claim, some examples of questions are listed in the sample consultation these session. Depending on the answers to a particular the next question generated question, is different following the logic of claim evaluation.

2.5 Validating and Enhancing the System

Responses from the steering committee members will be incorporated in the field test version of CGS-DSC, which will be used for 6 months at three actual field offices. During the field testing, feedback from users, including their reactions to the use of the system (negative and positive) will be collected to validate the system and make more enhancements if needed. Although the field test version will be based on the expert knowledge from the committee members, most field test users will be inexperienced personnel; these users may feel differently from the committee members about using the system and may provide very useful information for enhancing the system to be more user-friendly and easy-to use. After about 6 months of field testing, the final system will be generated incorporating suggestions users. It will then be by distributed to a number of field offices to be used in actual real-time environment.

3. SAMPLE CONSULTATION SESSION

For a sample consultation session, a fictitious case is presented. The case is summarized as follows:

(1) Payment:

Payment has not been offered to the contractor.

(2) Notice to Government:

Contractor informed the RCO/COR of the differing site condition in written form before starting work on problem.

- (3) Government Action: RCO/COR investigated the site condition after receiving the information promptly.
- (4) Prejudice to Government: Government was not prejudiced because the Contractor gave appropriate notice.
- (5) Nature of Problem:

The condition is related to physical and static conditions at the site. Physical condition existed before the contract award and is substantially different from indicated condition. The condition caused increase in the contractor's cost and duration. Contractor made reasonable bid based on indicated condition.

(6) Contract Provision:

The condition is specifically addressed in contract documents, but these references are incorrect and inconsistent. There is a exculpatory clause limiting government's liability, which is specific to the condition encountered.

- (7) Assumptions: The condition would be normally anticipated by a prudent contractor.
- (8) Superior Knowledge: The contractor did not know about the situation prior to bid. The government did not have knowledge of the situation prior to bid.
- (9) Site Inspection: A reasonable site inspection would have provided information to detect the condition. The contractor performed a site inspection.

When the user types "Consult CGS" on the CGS keyboard, the title screen, "Current Objectives" will be displayed. For title and objective screens, any graphic image or text can be used. We used PC Story Board by IBM to create graphic images for these screens then captured and imported them into the Personal Consultant Plus.

During the consultation, four different types of prompts can be encountered with the CGS: (1) multiple choice, (2) explanation/name of something, (3) yes/no (with 100% certainty), (4) yes/no (with five different level of certainty).

For the multiple choice prompt, the user is supposed to select the answer from a given list of possible options. The user employs up/down arrow keys to move the cursor to the desired option. For the explanation/name prompt, the user must answer a question in one or more words that cannot be anticipated by the system. Typically, this situation occurs when further explanation to a previous answer is requested, or when the system is prompting for a name.

The first question the system asks is the contractor's name as shown below:

Q:

Please enter the name of the contractor Smith Construction Corp

- 1. Type your response.
- 2. Press RETURN/ENTER for another line.

3. Press RETURN/ENTER on a blank line to continue.

After entering the contractor's name, questions concerning final payment will be displayed, as listed

below. For all questions displayed below, the answers are shown in the parentheses (). However, in actual consultation, the user will move the cursor to the selection.

Q: Has the contractor signed the final payment release without condition ? . . (NO)

Q: Was the contractor offered the final payment ? (NO)

For both of the above questions, the user is to answer yes/no with 100% certainty. If the user answered NO to both questions above, the next step is to find out if the contractor had complied fully with notice requirements. In order to check if appropriate notice was given, the following questions will be asked:

- Q: How did the contractor inform the Corps of the problem? (written)
- Q: Please enter the name of the person that received the information first...

JOHN SMITH

Q: Please enter the date the information was received...

JULY 25, 1985

At any point before answering a question, the user can

invoke why option requesting to explain why the system is prompting for this information. Why screen for the previous question is shown below as an example:

WHY

Who was the first person to receive the notice is needed to determine if contractor did comply fully with requirements for form-ofnotice.

RULE 012 In order to check if the contractor complied fully with the requirements for the notice the following information is necessary regarding: (1) if responsible personnel received the notice, (2) if the form of notice was adequate (written)

(3) if the notice was prompt.

** End - RETURN/ENTER to continue

From the answers shown above, a conclusion can be made that the contractor has complied fully with notice requirements by informing the responsible personnel, in a written notice and before starting work on problem. Now the system will need to check whether the government's action was adequate with the following questions:

Q: Did the RCO/COR investigate the site condition after receiving the information about the problem from the contractor ?....(YES) 0:

Did the RCO/COR investigate promptly ?.

DEFINITELY YES PROBABLY YES NOT SURE PROBABLY NO DEFINITELY NO

The above question is an example of another type of prompts in the CGS expecting yes/no answer with five different degrees of certainty. The degree of certainty is assigned as follows:

100%	DEFINITELY YES
50%	PROBABLY YES
0%	NOT SURE
-50%	PROBABLY NO
-100%	DEFINITELY NO

In Personal Consultant Plus, to determine the certainty factor (CF) for an IF clause that includes more than one question, the minimum CF is used when questions in the IF clause are combined by AND function: the maximum CF is used when they are combined by OR function. The CF of the IF clause is multiplied by the CF of the THEN clause to produce the level of CF after firing a particular rule. For example, for the following rule the combined CF for the IF clause is 50% (minimum) and the resulting CF for entitlement will be 15%.

IF RCO/COR investigated the site...100%(YES) AND investigated promptly.....50% (PROBABLY YES)

 When the next rule is fired and the CF for entitlement is to be changed, the formula for combining the CF from different rules is similar to the method used by EMYCIN (Hayes-Roth, Waterman and Lenat 1983).

The next step in the CGS is to check the nature of the problem to see if this situation falls under the DSC claims, i.e., if there was a material difference in physical condition from indication or anticipation.

- Q: Is the claimed condition directly related to the physical conditions at the site ?. .(YES)
- Q: Is the claimed condition a part of the existing static work site ?... (YES)

any time during the consultation before At answering a question, the user can invoke the "Help" screen displayed for explanation of the question, to be as additional clarification. In order to display the Help screen, however, an explanation for each question has to be generated and included during the development. If a simple and there is question is no need for more explanation, a message will appear indicating that there is no help for this question. The help screen for the above question is shown below:

Help

A static part of the condition refers to a condition that existed prior to bid. For example, if the claim condition is the ground water level caused by heavy rain and an impermeable clay bed, the impermeable clay bed is a static part, but water level is not.

- Q: Does the physical condition substantially differ from the indicated/anticipated condition ?..... (PROBABLY YES)
- Q: Did the claimed condition increase the duration ?.... (PROBABLY YES)
- Q: Did the contractor make a reasonable bid based on the conditions indicated or to be expected ?....(PROBABLY YES)
- Q: Are there contract provisions or notes on drawings that pertain to this situation ?... (YES)
- Q: Please provide the location of these references....

PARA 5.a

- Q: Are these references incorrect ?. . . . (YES)
- Q: Are these references inconsistent ?. . (YES)

After this question is answered an intermediate conclusion is displayed with a case citation as follows:

It seems that the contract document indicated the condition specifically encountered but with erroneous information, therefore, a TYPE I condition is the most probable.

contract document example case of An deficiency is Veteran Administration Contract Appeals Board case No. 1095, dated May 1975. The bidding documents contained the language by which a reasonable prudent contractor would have been led to believe that it was possible pass duct-work through the ceilings to containing radiant heating pipes by avoiding the heating elements, and it was not possible for the contractor to discover at the time of pre-bid site inspection that the situation was otherwise. The contractor was entitled to an equitable adjustment for miscalculation in his bid due to the deficiency of the contract document....

- Q: Please provide enough information to identify the clause.

PARA 7.3B HAS SPECIFIC INFO

- Q: Should the contractor have known about the situation prior to bidding ?. . (PROBABLY YES)

- Q: Did the government have knowledge of the situation prior to bid ?.... (NO)
- Q: Would a reasonable site inspection have provided information to detect the condition ?....(PROBABLY YES)

This is the end of question and answer for this case. After the last question is answered, the conclusion screen is displayed as follows:

CONCLUSION

The contractor is probably entitled to his claim (63%)

Weights of important factors on reaching the above conclusion are as follows:

fully complied with notice requirement: 80 condition is materially different: 30 contract provision with erroneous information: 10 specific exculpatory clause: -30 reasonable pre-bid inspection would detect: -20

**END - RETURN to continue

Personal Consultant Plus also provides additional useful capabilities, such as HOW, REVIEW, PRINT CONCLUSIONS, SAVE PLAYBACK, AND GET PLAYBACK.

HOW option explains how the system reached its conclusions. This option is useful during consultation if you need to understand the progress of the analysis in the system. HOW can be requested for intermediate conclusions as well as for the final conclusion. For each conclusion you select, a screen will appear that contains an internal rule number and an explanation on how it was concluded. An example of the HOW screen follows:

HOW complied fully with notice contractor the requirement Determined to be: YES (100%)by using RULE022 contractor <u>did</u> comply fully because (1)contractor <u>did</u> notify the government promptly contractor did notify in written form (2)contractor did notify the responsible (3) receiver ** End - RETURN/ENTER to continue

For each selected parameter, all rules used to determine the value of that parameter will be displayed.

Review option allows you--at any time--to review the questions and answers you have given during a consultation. You can just observe the answers given or you can <u>modify</u> them. This option allows the user to perform what-if analyses with minor variations of a potential claim under consideration.

Print Conclusions option gives you a summary of the consultation session with questions and answers, and the conclusions reached. This printout is an important document for future reference in dealing with potential claims.

Save Playback File option allows you to save a consultation session. All the answers you have given will be saved on a disk. With Get Playback File option, you can load the contents of a playback file and rerun to a previous consultation session. It allows you to modify any of the answers provided in the loaded playback file.

4. FUTURE RESEARCH AREAS

Even though USA-CERL attempted to avoid legal terminology in writing questions for users (mainly engineers) the CGS still requires some legal judgment as input. For example, the user has to make a legal judgment characterize the difference "material" to as or "substantial" to answer the question, "Does the physical condition substantially differ from the indicated condition 211 It would be desirable to include more expert knowledge of lawyers on how to make a legal judgment on "materiality" and other topics. It seems that work on this area may be available in the near future if we look into the research and development of some law firms.

Many law firms are actively exploring expert system technology, as evidenced at the first International Conference on Artificial Intelligence and Law held during May 27-29, 1987. Some are even creating expert systems groups to perform in-house research and development. For example, Watt, Tiedler, Killian and Hoffar, a law firm, is developing the Microcomputer Expert System for Claim Identification and Evaluation described in a conference paper presented by Lester (1986).

Another approach was presented in Victor's (1984) article, "How Much is a Case Worth" which demonstrated how a collection of decision trees, subjective probability assessments and arithmetics can be used in evaluating claims; this application helps trial counsel to assess monetary worth of alternative courses of action.

Waterman, Paul and Peterson (1986) reviewed existing expert systems for legal decision-making potential and indicated that they expect more applications in the

following areas: organizing case information, estimating case value and strategies for negotiation, monitoring legal data bases to find changes in the law, interpreting the law in the context of a problem, and producing legal documents. it seems that a great amount of research Thus, and development is expected in the near future. We may take advantage of this interest in the legal field and include more legal expertise in improving the CGS to include other construction contract claims. of types For example, including construction delay claims would involve integration of scheduling and network analysis with legal Design deficiency claims would evaluation of claims. involve integration of CADD systems and claims evaluation to examine drawings for its deficiencies. These areas are challenging and hold potential benefit for the construction community.

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847

(Figure I) LOGIC DIAGRAM FOR CGS - DSC



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