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AN EXPERT SYSTEM FOR INVENTORY MANAGERS AT RETAIL STOCK POINTS

by

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An Expert System for Inventory Managers at Retail Stock Points

by

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ABSTRACT

The responsiveness of the Navy supply system depends upon the effectiveness of its inventory managers. It is difficult to achieve and maintain the high skill levels required of inventory managers to perform their jobs. Improvement in the effectiveness and productivity of existing personnel is possible through the application of "expert systems" technology. This thesis presents the design and development of expert system prototypes for two tasks performed by Navy stock point inventory managers: Delinquent Dues and Variable Ranking Lists processing. A review is provided of the acquired knowledge factors and the steps taken in the construction of the systems. The prototypes were evaluated by inventory managers and found to be extremely functional. The inventory managers were enthusiastic about the effectiveness and future use of these systems.

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I. INTRODUCTION

A. BACKGROUND

The Naval Supply Systems Command (NAVSUP) operates over twenty Navy Stock Points (SPs) that service the "retail" supply customer. These stock points are responsible for managing local material inventories, maintaining financial controls, and ordering replenishment materials. SPs utilize an automated data processing system known as the Uniform Automated Data Processing System for Stock Points (UADPS-SP). UADPS-SP is operated on a medium size computer, the Burroughs 3500, that has been continuously upgraded to keep pace with the increasing requirements at each stock point. However, in spite of these upgrades access to on-line information by retail inventory managers is very limited and has had an adverse effect on their responsiveness and productivity.

Retail inventory management at Navy Stock points is a highly labor intensive process. Inventory managers must make complex decisions that require specialized skills and access to information obtained from a variety of different sources. Considerable amounts of time, resources and training are required to ensure that dependable decisions are reached. Given the size and varied skill levels of the

retail inventory management staff, providing adequate training is labor intensive, time consuming, and expensive.

The responsiveness of the Navy Supply System depends upon the effectiveness of inventory managers. The inefficiencies of the current system can be traced to the difficulty in achieving and maintaining the high skill levels required of inventory managers and the inefficient manner in which information is currently accessed at the retail level. In these times of budget constraints and personnel cutbacks, the Navy Supply System is confronted with the problem of how to improve the capacity and information access of the retail inventory manager without significantly increasing expenditures. Initiatives having the potential to improve the effectiveness and productivity of existing assets need to be closely examined.

The development of commercial artificial intelligence software that can simulate the decision making processes of experts, offers the potential for overcoming some of NAVSUP's problems at the retail level [Ref. 1:p. 8]. Developing an "expert system" for processing complex retail inventory problems can potentially shorten the overall processing cycle and reduce the present training requirements. It is with this in mind that NAVSUP is looking at developing an "expert system" for the inventory manager and analyzing its effects on the responsiveness,

efficiency and productivity of the retail inventory management function.

B. THESIS OBJECTIVE

In August, 1986 NAVSUP requested that NPS develop a preliminary expert system for inventory manager's at stock points. The project has been divided into three major areas of research. The first was to determine item managers' tasks that would have provided the greatest potential for benefit from expert system technology. The second was the actual development of a basic prototype expert system. And the third was to determine the potential costs/benefits of developing a full-scale expert system for inventory managers.

The first area of research has been completed [Ref. 1] and most of the basic decision rules were developed for two inventory manager job tasks. With these decision rules as a foundation, it was the objective of this thesis to refine these rules and to design and develop expert system prototypes for processing Delinquent Dues Listings and Variable Ranking Lists. Subsequent theses are expected to further develop these prototypes and analyze their costs and future benefits for Navy wide, full-scale development.

C. PREVIEW

A brief discussion of artificial intelligence is provided in Chapter II. It is followed by an overview of

Expert Systems. This overview includes the definition, a summary of the structure, and a discussion of the steps used to develop an expert system. Chapter III presents the actual development of two expert system prototypes, "DELDUE" and "VRANK". A review is provided of the acquired knowledge factors, the construction of the system files, and the explanation facility used in the prototypes. The last section of Chapter III presents an analysis of the performance of the prototypes. Chapter IV provides a brief summary, conclusions and some recommendations for further research.

II. BUILDING AN EXPERT SYSTEM

A. ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) is concerned with developing computer programs that make computers smarter. The most commonly accepted definition of AI is [Ref. 2:p. 9]:

> **artificial intelligence is the branch of computer science devoted to programming computers to carry out tasks that if carried out by human beings would require intelligence.**

A slightly more in-depth definition is [Ref. 3:p. 2]:

> **Artificial Intelligence (AI) is the subfield of computer science concerned with the use of computers in tasks that are normally considered to require knowledge, perception, reasoning, learning, understanding and similar cognitive abilities. Thus, the goal of AI is a qualitative expansion of computer capabilities.**

The field of artificial intelligence offers distinctive approaches to dealing with real-world types of problem solving and decision making. This form of problem solving greatly differs from conventional computer programs that are primarily numeric in nature and for which solutions are known that produce satisfactory answers. AI is concerned with complex, uncertain and ambiguous problems, that are non-numeric and for which no known algorithmic solutions exist. Instead of simply performing calculations, artificial intelligence programs utilize a knowledge base

and heuristics (rules of thumb) to guide its solution process.

B. EXPERT SYSTEMS: AN OVERVIEW

Expert systems (ES) is a branch of artificial intelligence. It is a class of computer programs that address problems normally thought to require human expertise for their solution. According to Hayes-Roth, [Ref. 4:p. 51], an expert system is defined as:

> **a knowledge-intensive program that solves problems that normally require human expertise. It performs many secondary functions as an expert does, such as asking relevant questions and explaining its reasoning.**

The goals of ES include substituting for an unavailable human expert, integrating and duplicating the knowledge of multiple human experts and providing valuable training for new experts. If an ES is developed properly it will have the basic knowledge of the subject, as well as the decision rules used by an expert or experts, and provide technically correct solutions to particular problems. Understanding and reproducing the knowledge of human experts is the main task in constructing expert systems. [Ref. 5:p. 4]

Expert systems differ from both conventional data processing systems and systems developed in other branches of artificial intelligence. First, they emphasize domain-specific problem solving strategies. Secondly, they employ self-knowledge to reason about their own inference processes and provide explanations or justifications for

the conclusions reached. Thirdly, they solve problems that generally fall into one of the following categories: interpretation, prediction, diagnosis, debugging, design, planning, monitoring, repair, instructions, or control. As a result, expert systems represent an area of AI research that involves paradigms, tools and system development strategies [Ref. 5:p. 52].

C. STRUCTURE

As shown in Figure 2.1, there are three major components in an expert system structure. These components are: a task-specific

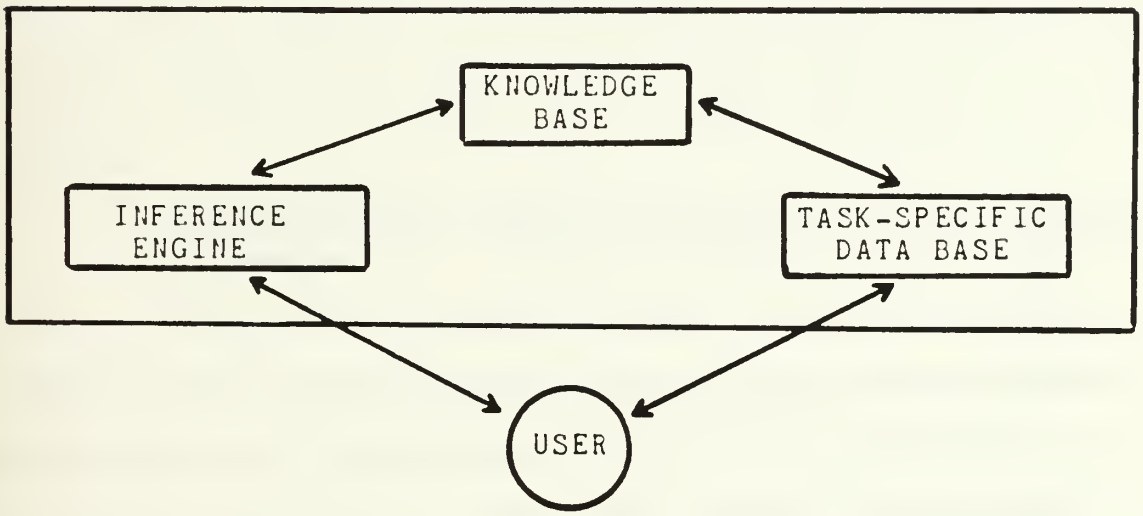

Figure 2.1 An "Essential Components" ES Structure.

data base (taxonomy), the knowledge base (rule base), and the inference engine (front-end). [Ref. 6] The task-specific data base contains a body of facts about a particular subject. These facts usually represent the properties or characteristics of the subject and how these concepts are related to each other. The knowledge base contains rules about the behavior of elements of a particular subject. These rules are heuristic and are based on the developed expertise of human experts. The rules are formatted in such a manner that it is executable by the expert system. Usually expert systems use a format of "if....then...." statements. The inference engine is a knowledge-based computer program. It accesses and manipulates the information that is provided by the knowledge base, the data base and the user to arrive at a conclusion. The inference engine interprets the rules in the base in conjunction with the control options in order to infer solutions to consultations. Its basic function is to control the problem-solving process and, in doing so, simulate the deductive reasoning processes of an expert.

There are two main ways in which inference engines control the use of knowledge in solving problems, either forward chaining or backward chaining. In the forward chaining or data-driven method the inference engine examines the data that is available and applies the rules to reason forward from the data to the conclusions. In a

backward chaining or goal-driven approach the conclusions that it needs to establish its goals are identified, and then the rules are examined to see which ones contribute to these goals. If the facts and rules are comprehensive and contain the required information to logically make a decision, then all the inference engine has to do is make sure all the relevant facts and rules are retrieved. If the facts and rules are not sufficiently comprehensive the inference engine will be unable to make appropriate conclusions.

D. STEPS TO DEVELOP AN ES

The development and implementation of an expert system requires careful planning and a thorough understanding of the decision making process that is being duplicated. The following steps are involved in constructing an expert system:

1. Determine if a task is suited to expert system technology

The task to be performed should be analyzed to ensure that the expert system approach is the best and most practical way to address the problem. Characteristics commonly associated with the use of expert system technology are:

- Problems which human experts typically perform
- Tasks which involve knowledge that can be expressed as "rules of thumb"

- Tasks which do not rely heavily on "common sense"
- Tasks which involve knowledge that is rapidly changing
- Tasks which can be represented as a set of independent actions or conditions
- Tasks which involve inexact reasoning

Other factors that should be considered include the amount of time needed to create the expert system and the costs associated with its development. In other words, the time and financial resources committed to the development of the expert system should be justified.

2. **Acquire knowledge and refine it**

This step involves gathering and formalizing the required information needed to develop an expert system. This includes the identification of the characteristics, resources and goals associated with the tasks under consideration. During this phase the key elements and major components of the reasoning process that should be included in the expert system are determined. Precise identification of these can greatly reduce development time.

Refinement of the acquired knowledge and organization of key elements must be accomplished prior to any further system development. Analysis of the interrelationships of the knowledge elements and reasoning

paths should be noted and identified. This analysis of the knowledge should be done to a level where it can be organized into a formalized framework or representation of information. It is this framework that will be used to develop the prototype system.

3. **Develop an initial system design**

Initial system design involves organizing the information acquired during knowledge acquisition into a usable form. It is important that the purpose of the system be kept in mind while designing the system. The design should reflect the most efficient manner in which to represent the acquired knowledge. It should also provide users who may not fully understand expert systems an appropriate way for users to interface with the system.

4. **Build a prototype system**

The development of the prototype system is an extremely important step in the construction of an expert system. Building a prototype system involves the: 1) construction of the initial taxonomy and rule files (these files will be explained in Chapter 3), 2) production of an interpreter that incorporates the elements of the taxonomy, and 3) validation of the taxonomy and the rule base through the use of expert system predicates.

Development of a prototype system should be done in steps. Small versions of the rule base file and taxonomy file should be coded and tested. Once these initial files

have been sucessfully tested then further construction of these files can be accomplished. The finished prototype should be a complete working system. From this finished prototype the expert should be able to determine if the system is functioning correctly.

5. **Analysis, redesign and fine tune the system**

The prototype should be thoroughly tested by the experts who provided the knowledge during the acquisition phase and by the users of the system. The experts can determine if the conclusions generated by the system are valid. They can provide information previously overlooked and recommend changes and improvements to the system. The intended users can provide valuable information concerning the ease of use and understandability of the system.

During this phase, extensive analysis should be done to determine weaknesses of the system, knowledge base, and inference engine. Through this analysis and redesign phase, areas may be discovered where further explanation needs to be given for the actions taken by the system in reaching a conclusion. Once this analysis is complete, redesign of the system can be accomplished, thereby improving the overall system. After the recommended changes have been made to the initial design, the system should be ready for final testing and evaluation.

6. **Conduct periodic system maintenance**

Expert systems are often used in tasks in which information is regularly being added or updated. Whenever this occurs, the system must be updated with the new information. When this new information is added the system must be analyzed and redesigned to ensure the conclusions generated by the system are still valid. System upkeep and maintenance is required on a continuous basis to ensure the system stays functional and the generated conclusions remain valid.

The construction of an expert system roughly follows the above defined steps. Development of a full-scale system requires extensive analysis, redesign and testing of system concepts, elements, and reasoning processes. Numerous reworkings may be required before an acceptable level of system performance is achieved.

III. DEVELOPMENT OF DELDUE AND VRANK

A. OVERVIEW

The goal of this thesis was to develop an expert system prototype for Inventory Managers at Naval Supply System Command (NAVSUP) retail stock points. The methodology used to accomplish the research paralleled the first five steps for building an expert system outlined in Chapter II. During the initial problem analysis two common tasks of stock point inventory managers were chosen as candidates for the application of expert system technology. These tasks were the processing of Delinquent Dues and Variable Ranking Lists. During the knowledge acquisition phase the knowledge factors and decision rules used by retail inventory managers in processing the delinquent dues and variable ranking lists were accumulated and recorded. From these rules and knowledge factors concepts were developed to represent the pertinent information. An expert system development package was then used to organize these concepts into the working prototypes. These prototypes were then analyzed by the expert inventory managers at NSC San Diego. During this analysis inconsistencies within the systems were identified and additional reasoning processes were discussed. Changes were then made to the prototypes to correct these inconsistencies and to improve the system.

B. TASK DETERMINATION AND KNOWLEDGE ACQUISITION

The job of inventory managers (IMs) at Navy retail stock points is highly labor intensive. Stock point IMs are tasked with managing a large number of National Stock Numbers (NSNs) at the intermediate level of the Navy's supply system to meet customer demand from a specific geographic area. An inventory manager is responsible for particular cognizance symbols, or "cogs," not all of which are managed by Navy Inventory Control Points (ICPs). A cog is the supply system's indicator of the particular NSN's ICP and material type. In order to properly manage these cogs, IMs may be required to liaison with numerous defense supply agencies and hence to know the unique procedures required by each agency.

Equally important to their daily performance is the mastery of the data files, procedures and manual aids associated with the Navy wide computer system for stock point management. This system is known as the Uniform Automated Data Processing System-Stock Point (UADPS-SP). The accumulation of sufficient knowledge to perform adequately requires years of training and supervision. [Ref. 1:pp. 7-8]

The tasks performed by retail inventory managers meet the characteristics associated with expert system technology. IM tasks are repetitive in nature, require a considerable amount of human expertise, and involve

knowledge that can be represented as independent actions resulting from inexact reasoning that varies from case to case.

Two particular IM tasks were selected for the application of expert systems technology. They were "Delinquent Dues Processing" (UADPS-SP Program Number B-UA52) and the "Variable Ranking Program" (UADPS-SP Program Numbers H-UA64 and H-UA65). These tasks were selected because they are time consuming, and require considerable expertise to accomplish.

The Delinquent Dues Listing is manually reviewed by inventory managers on a monthly basis. The report is segregated by the number of days the receipt of a due-in requisition is past its estimated delivery date (EDD). The age group categories are as follows:

Code	No. of Days Overdue
1	1 - 30
2	31 - 60
3	61 - 90
4	91 - 120
5	121 - 180
6	180 or more

Inventory managers pay most attention to the oldest categories and, in practice, do not normally review categories 1 and 2.

The process of working the Delinquent Dues Listing varies from inventory manager to inventory manager. However, the fundamental rule followed is to classify the requisition as invalid when the age and/or unsatisfactory supply status indicates that further action to track the document is futile. Following this rule is an effective method of managing delinquent dues. Cancelling invalid dues helps to ensure better customer support and releases scarce stock fund dollars that are needlessly tied up in outstanding dues. [Ref. 1:pp. 13-16]

The Variable Ranking Lists are quarterly outputs that provide a mechanized screening and highlighting of situations requiring inventory managers' review. The Variable Ranking Lists are segregated into seven groups. The group defines one of the following problem areas:

Group	Definition
1	Excess on Order
2	Backorder with Material On Hand
3	Backorder with Zero On Hand, Zero Due
4	Invalid on Order
5	Zero Assets
6	Insufficient Stock
7	Excess On Hand

Because adequate coverage is provided by other programs and reviews, only Groups 1,3, and 5 are worked by IMs. Therefore, a prototype has been built for processing only

these three groups. Group 1, Excess on Order, represents items that have excess quantities on order. These items are potentially in long supply. Cancelling these items would free up funds that can be used to purchase other items that are experiencing shortages. [Ref. 1:pp. 43, 50] Group 3, Backorder with Zero On Hand, Zero Due, highlights those NSNs having one or more requisitions backordered out which have neither stock on hand nor stock due in. [Ref. 1:p. 56] Group 5, Zero Assets, lists those NSNs that have zero on hand and zero due in. This situation may occur if: 1) demand for an NSN is being satisfied by a substitute item, and the decision has been made to procure only the substitute, or 2) the NSN may be a relatively new item being managed by the stock point for which there is no buy recorded in file as of yet. [Ref 1:p. 61]

After the selection of Delinquent Dues processing and Variable Ranking Lists processing was made, the next step was to gather the information necessary to construct the prototypes. To acquire this information, indepth group interviews were held with expert inventory managers from the Naval Supply Center (NSC), San Diego. These interviews were conducted to gain an understanding of the steps followed in processing the Delinquent Dues and Variable Ranking Listings. It was through these interviews that the major components of the reasoning process and the key

elements to be included in the expert system were determined.

Once the necessary knowledge was acquired, it had to be organized into a structure that could be utilized in the construction of the expert systems. This was accomplished through the development of narratives, flowcharts, and decision rules. (For the indepth narratives and flowcharts, see G. W. Westfall's thesis; reference 1). The decision rules would be used as the primary vehicle for building the expert systems prototypes. These decision rules are listed in Appendix A.

C. DELDUE AND VRANK PROTOTYPES

With an understanding of the knowledge factors and decision rules discussed in the previous section, prototype expert systems were developed to simulate the processing of the Delinquent Dues Listing and the Variable Ranking Lists by an inventory manager. Hereafter, these systems will be designated DELDUE and VRANK.

DELDUE and VRANK were developed using the Arity/Expert Development Package. This package is a collection of development tools which provide the basic framework for building expert systems. The Arity/Expert package was chosen for its useful format and its capability for future system expansion.

These prototype systems were built on the premise that each potential problem requisition would be individually resolved by the inventory manager. The input data required to arrive at each solution would be provided by the user via responses to system generated questions. These responses would then be fed back to the system for processing and solution recommendations.

1. Knowledge Representation

DELDUE and VRANK use a box structure similar to that of an organizational chart to represent the information and knowledge expertise used by the system. Each box represents a concept and has slots that describe the individual elements for that concept. The concepts are defined in terms of properties and roles. The slots within the frames represent the values of these properties and roles.

Figures 3.1 and 3.2 show a portion of the DELDUE and VRANK knowledge bases and the use of box structures to represent the different concepts within these systems.

Relationships of a concept with other concepts are represented using the idea of a role. For example, in Figure 3.1 the fact that the concept DELDUE is related to concepts supply_status, ss_age, priority_req is represented through the roles supply_status info, ss_age_info, and priority_req_info. These roles indicate that the concept DELDUE carries information concerning a delinquent due's

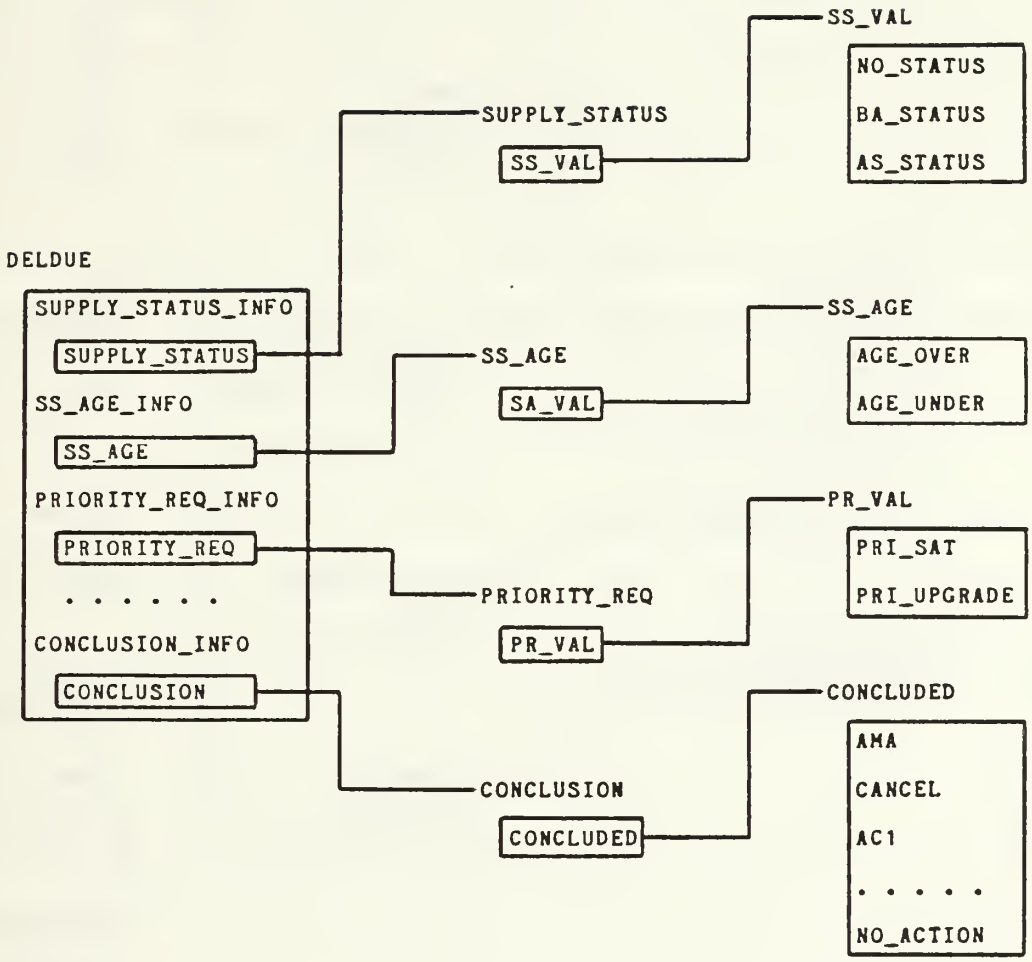

Figure 3.1 Knowledge Representation in DELDUE.

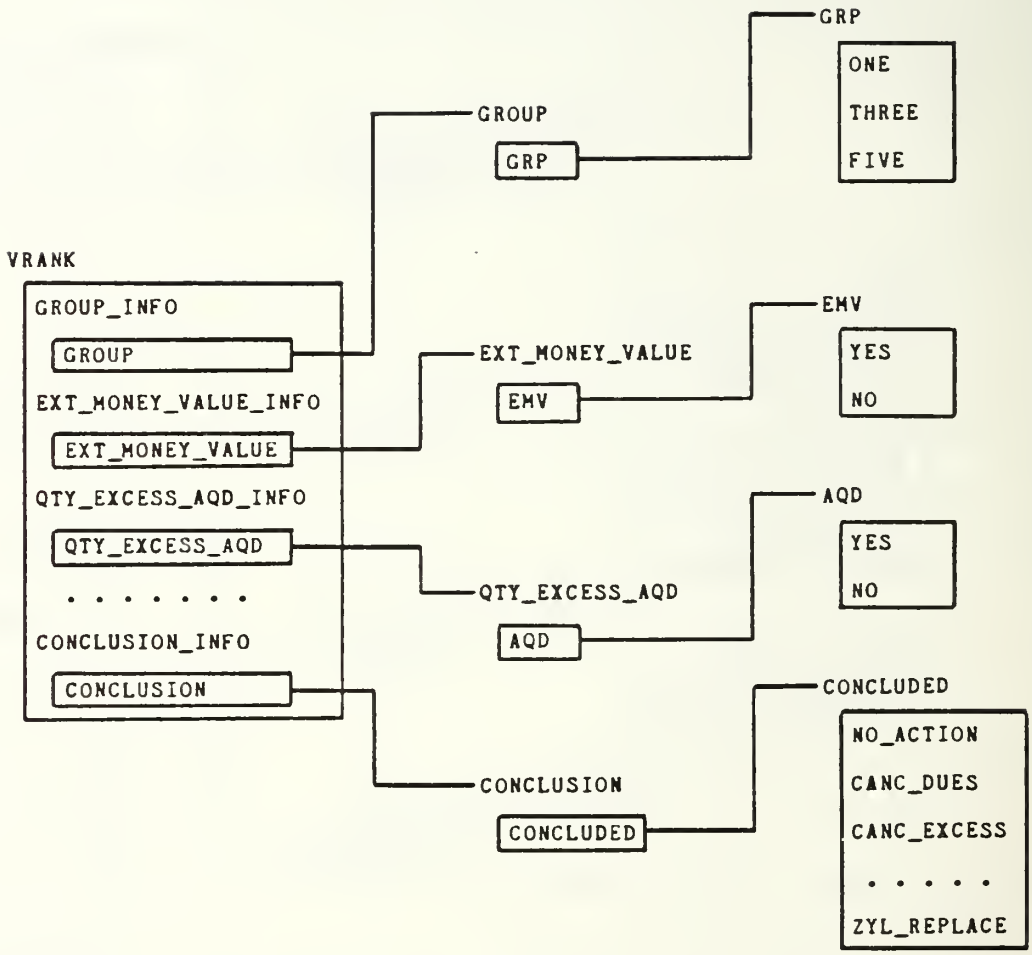

Figure 3.2 Knowledge Representation in VRANK

supply status, the age of the supply status and the priority of the requisition.

2. Files

The initial development of DELDUE and VRANK required that the identified concepts and rules be configured into various software files that conformed to a structured Arity format. The files that form the structure of the prototypes are shown in Figure 3.3. The following discussion reviews the content of these files. The actual file listings are found in Appendices B and C. A software dictionary that defines terms used in DELDUE and VRANK is provided in Appendix D.

a. Front-End File

The front-end file contains the code for executing the expert system. It holds the knowledge of when to access the information found in the Taxonomy file and Rule Base file. The contents of the DELDUE and VRANK front-end files, (Appendices B.1 and C.1) were written in Prolog and specify the procedure for the execution of the prototypes and the format of the user's terminal screen display.

b. Taxonomy File

The Taxonomy file provides the general description of the concepts that will be used in the expert system. This file must include every element that is involved in the decision making process.

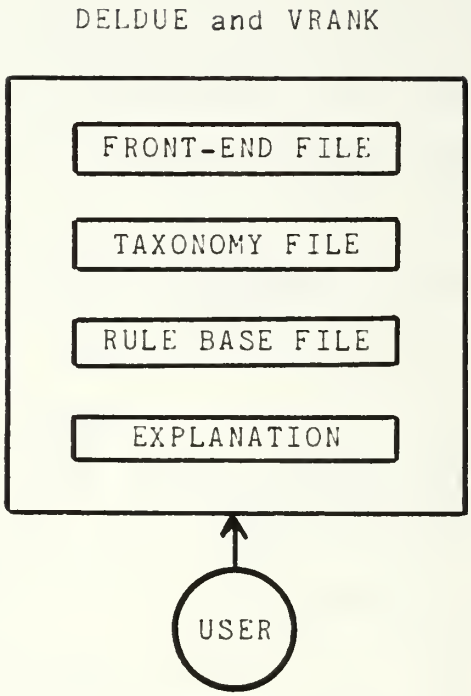

FIGURE 3.3 Structure of DELDUE and VRANK.

The purpose of the taxonomy language is for defining these elements in a way that can be interpreted by the computer.

The Taxonomy file is made up of two distinct sets of information: type declarations and concept definitions. Type declarations are declarations of the roles and properties used in the taxonomy. Concept definitions identify concepts and any roles or properties

they may have. Declarations and definitions are based on a simple taxonomy language.

There are two kinds of type declarations: role type declarations and property type declarations. When the quality of a concept is described in terms of another concept, that quality is known as a role. A second way of describing the qualities of a concept is through the use of properties. A property describes a very specific quality of a concept. Examples of type declarations from the DELDUE taxonomy file are shown below:

```
type supply_status_info = role.
type ss_age_info = role.
type ss_val = multivalue [no_status,ba_status,as_status,
other_status].
type sa_val = [age_over,age_under].
```

In the above examples "supply_status_info" and "ss_age_info" are roles because they are qualities of the concept DELDUE and are describing the concepts "supply_status" and "ss_age". The examples "ss_val" and "sa_val" are property declarations. They describe specific qualities for particular concepts. For instance, "type ss_val" shows that the concept "supply_status" can have any one of the qualities or values; no status, BA status, AS status, or other status. A BA status indicates that the material is being processed for release and shipment, and AS status indicates that the material has been shipped.

"Type sa_val" indicates that the concept ss_age can either have the value of over 30 days old or under 30 days old.

Whether the quality of a concept is a role or property, its underlying purpose as a type declaration is to describe a quality of a particular concept. Type declarations can be placed in any order, but they must be placed ahead of concept definitions.

The following examples depict portions of concept definition from the DELDUE and VRANK taxonomy files:

```
DELDUE:
  define primitive deldue with
      supply_status_info = supply_status and
      ss_age_info = ss_age and
      priority_req_info = priority_req and
      physical_qty_info = physical_qty and
      etc.

VRANK:
  define primitive vrank with
      group_info = group and
      ext_money_value_info = ext_money_value and
      qty_excess_aqd_info = qty_excess_aqd and
      current_status_info = current_status and
      etc.
```

These examples show a partial description of the concepts "deldue" and "vrank" using taxonomy language. The roles of the concepts are listed along with their associated values.

The first example defines the concept deldue. The roles, supply_status_info, ss_age_info, priority_req_info, and physical_qty_info, each describe qualities of the concept deldue. Everything that the system needs to know about deldue, such as deldue includes supply_status_info and this supply status information equals a supply status, is contained in the deldue concept definition.

Likewise in the second example, the concept vrank (variable ranking) is described by the roles; group_info, ext_money_value_info, qty_excess_aqd_info, and current_status_info. Everything the system needs to know about vrank is included in the vrank definition. For instance, vrank includes group_info and this group information equates to a particular variable ranking group. A complete listing of the DELDUE and VRANK taxonomy files are provided in Appendices B.2 and C.2 .

c. Rule Base File

The objective of the Rule Base file is to identify the interaction of the concepts listed in the taxonomy file. The Rule Base file is made up of control options and rules. Rules apply distinct characteristics to the concepts, properties and values defined in the taxonomy

file. It is through the evaluation of these rules and the manipulation of concepts that the expert system arrives at conclusions. A rule is made up a consequent and an antecedent. A consequent (or conclusion) of the rule consists of only one goal and is always listed before the antecedent. The antecedent of the rule can have one or more goals. A goal indicates that there is a particular value associated with the property of a concept and this value can be proved either true or not true. The consequent of a rule can be determined to be true only if all the goals of the antecedent are determined to be true. If any one of the antecedent goals are not true the expert system regards the consequent as not true and it is not regarded as a possible solution. Therefore, if the four conditions of rule in the following example are true, then the conclusion is also true.

```
the concluded of conclusion_info is store_to_zero
  if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is mit and
the dr_val of dollar_value_info is dollar_under and
the cl_val of class_pil_cont_info is no_classified.
```

In the example, the antecedent and the consequent are separated by the keyword "if" and the goals of the antecedent are separated by the keyword "and". The consequent of the rule is the conclusion to store the delinquent due to zero. The antecedent consists of the following goals: (1) the delinquent due must have an AS

status, (2) the funds associated with the delinquent due must be in the MIT (material in transit) account, (3) the dollar value of the material due in is under $100.00, and (4) the material due in is not classified, pilferable, or controlled material.

A complete listing of the DELDUE and VRANK Rule Base files are listed in Appendices B.3 and C.3 .

d. Explanation Facility

An explanation facility is also available to provide details of how a certain conclusion was derived. This capability of the system helps to verify that valid deductions were made to reach conclusions. Any time a conclusion is reached or a question is asked, the system can be queried to get an explanation for the conclusion or question.

The following is a sample interaction of the explanation facility using the DELDUE system:

```
EXPLAIN
    [How was concluded of conclusion-1 judged to be cancel
(1.000)?]
Since [1] the ss_val of supply_status-1
              is AS status (1.0)
  and [2] the fi_val of financial-1
              is Funds are in MIT (1.0)
  and [3] the pq_val of physical_qty-1
              is Disbursed qty IS NOT EQUAL TO MIT qty
```

```
                and the qty in MIT PLUS the disbursed
                qty IS NOT GREATER than the original qty
                (1.0)
  and [4] the dd_val of est_del_date-1
                is Yes (60 or more days) (1.0)
  and [5] the ps_val of part_ship-1
                is Yes (1.0)
  and [6] the st_val of substitute-1
                is Yes (1.0)
then the concluded of conclusion-1 is cancel (1.0)

EXPLAIN (number of value)? 1

    [How was ss_val of supply_status-1 judged to be AS
status (1.000)?]

. This value was determined by your response to a question.

EXPLAIN (number of value)? 2

    [How was fi_val of financial-1 judged to be Funds are
in MIT (1.000)?]

. This value was determined by your response to a question.

EXPLAIN (number of value)? 3

    [How was pq_val of physical_qty-1 judged to be
    Disbursed qty IS NOT EQUAL to MIT qty and qty
    in MIT PLUS the disbursed qty IS NOT GREATER than the
    original qty (1.0)

. This value was determined by your response to a question.
```

EXPLAIN (number of value)? 4

[How was dd_val of est_del_date-1 judged to be Yes (60 or more days) (1.0)

. This value was determined by your response to a question.

EXPLAIN (number of value)? 5

[How was ps_val of part_ship-1 judged to be Yes (1.0)

. This value was determined by your response to a question.

EXPLAIN (number of value)? 6

[How was st_val of substitute-1 judged to be Yes (1.0)

. This value was determined by your response to a question.

3. The Final Prototypes

Once the system files were constructed, they were compiled or condensed to create stand-alone systems. (Stand-alone systems operate independent of the Arity/Expert Development Packages). Compiling the files greatly reduced the execution times of the prototypes and allows the systems to be stored on single floppy disks.

The prototypes may be executed utilizing a standard personal computer with 610K of memory. When executing DELDUE or VRANK the user answers questions posed by the system. These questions are displayed one at a time on the video screen followed by a menu of possible answers. The user responds to the questions by choosing the appropriate answer. Once all the questions required by the system have been answered, a conclusion to the problem is displayed.

At this point the user chooses either to use the explanation facility to review his decision, to continue to the next problem or to stop the program.

D. VALIDATION AND EVALUATION

The next step in the development of the prototypes was to analyze the first draft of the systems. To accomplish this, the prototypes were used by the experts at NSC San Diego who provided the initial knowledge for the system. A list of NSC San Diego contacts is provided in Appendix E. These inventory managers ran the systems against actual delinquent dues and variable ranking information. The expert system conclusions were compared to conclusions derived manually. Reasoning processes were reviewed and analyzed to ensure reasoning by the ES was sound and that accurate conclusions were being derived.

Overall, the DELDUE and VRANK prototypes were found to be functional. In most cases the systems provided conclusions that agreed with those manually derived by the experts. The rules used in VRANK were reviewed by expert IMs and no major problems or revisions were found. However, a more thorough review and evaluation of the VRANK prototype is still needed to ensure the system is operating at an "expert" level of performance.

In reviewing the DELDUE prototype however, several conclusions were found to be in error. These cases were

reviewed by the IMs to locate the causes of the problems. Several cases showed that the system rules were correct except that the recommended conclusion was not appropriate. For example in Rule 32 of Appendix A.1, the conclusion was to "cancel the due." This conclusion was incorrect and was changed within the system from: "the concluded of conclusion_info is cancel" to "the concluded of conclusion_info is store_to_zero."

Another cause of problems was that several rules in the deldue system did not ask sufficient questions to arrive at optimal conclusions. An example of such a case is rule number 4. Decision rule number 4 arrives at the conclusion to cancel the due when the supply status is other than BA or AS and there is no record of funds in the stock point financial ledgers. However, two additional questions are required to ensure that a cancellation is appropriate. These questions are: 1) Is there a requisition for the material in the Defense Logistic Agency (DLA) files? And if so, 2) Is the material needed? To add these questions to the rule base, required Rule 4 to be changed and an additional two rules needed to be created. Rule 4 was changed to read:

```
the concluded of conclusion_info is cancel
  if
the ss_val of supply_status_info is other_status and
the fi_val of financial_info is no_info and
the dl_val of dla_info is no_file.
```

The additional rules that were created read as follows:

```
  the concluded of conclusion_info is afl
    if
  the ss_val of supply_status_info is other_status and
  the fi_val of financial_info is no_info and
  the dl_val of dla_info is yes_file and
  the mn_val of matl_needed_info is matl-needed.
```

and

```
  the concluded of conclusion_info is cancel
    if
  the ss_val of supply_status_info is other_status and
  the fi_val of financial_info is no_info and
  the dl_val of dla_info is yes_file and
  the mn_val of matl_needed_info is matl_needed.
```

In evaluating the system, it was also found that the systems' displayed language was not easy to understand and therfore not very "user friendly." This problem can be corrected by more extensive use of system control options. Through the use of these control options, the system can be customized. Limited use of the question option and the synonym option can be seen in Appendix B and C. The question option and synonym option basically function the same way. When a system generates questions and explanations to describe the reasoning for reaching goals, it does so by using terms described in the taxonomy. If these terms are cryptic or vague, the explanations may be difficult for a user to understand. Alternative questions or synonyms for these terms can be provided using the question and synonym options. When generating explanations or questions, the system first checks whether an

alternative question or synonym exists for a term. If one is available it is used by the system.

As a last evaluation test, several novice inventory managers were asked to use the systems and, with the exception of the language problem, found them to be helpful in leading them through the delinquent dues and variable ranking processes.

IV. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

The primary goal of this thesis was to design and develop preliminary expert system prototypes for use by Navy retail inventory managers. Such efforts to automate inventory manager tasks have the potential to improve IM operating efficiency and increase their productivity.

Chapter III presented the steps taken to construct two such systems, one for Delinquent Dues and one for Variable Ranking Lists. The first phase of the systems development led to the establishment of a set of rules based upon knowledge factors and reasoning processes used by expert inventory managers. The second phase used the Arity Development Package to construct the corresponding expert system prototypes DELDUE and VRANK. These were then tested by the expert inventory managers and their responses were recorded.

In most cases DELDUE and VRANK were found to produce accurate expert system conclusions based upon the rules used by these managers. A portion of the rules in DELDUE did not provide the most accurate conclusions possible. The inefficient rules and the knowledge factors associated with them were then identified to include the additional information relevant to arriving at optimal conclusions.

It was also found that the systems were not sufficiently "user friendly." This can be improved through more extensive use of control options within the systems.

B. CONCLUSIONS

Even in their preliminary forms the DELDUE and VRANK prototypes provided workable systems and can serve as the basis for further research and development in the application of expert system technology in the inventory management area. Further development of DELDUE and VRANK, and expansion of expert systems technology into other areas could lead to measurable improvements in retail inventory management and enhance the effectiveness of Navy-wide supply support.

C. AREAS FOR FUTURE RESEARCH

Now that basic prototypes have been constructed, the next step in this research project is to extensively test and evaluate the prototypes to determine if the conclusions generated by the expert systems are indeed valid in all cases and to improve the "user friendliness" of the systems. Further changes should then be incorporated into the design of the systems.

Once final systems are achieved for these management areas, research attention can turn to three distinct areas: (1) training and tutoring of inexperienced inventory management personnel in processing delinquent dues and

variable ranking lists, (2) incorporation of external data sources with the expert system prototypes, and (3) expanding expert system technology to other areas of inventory management,

1. Training and Tutoring

With a minor amount of further research and development, the expert system prototypes which have been developed could be used as instructional/tutoring aids. The details and feedback nature of the prototypes would help develop a novice manager's skills in recognizing, interpreting and analyzing information associated with processing the delinquent dues and variable ranking listings. He or she should develop fundamental skills more rapidly than they do now. In addition, the number of hours that senior IMs and supervisors presently spend providing training to inexperienced IMs could be substantially reduced.

2. Incorporation of External Data Sources

An important area for research would be to examine the feasibility of interfacing the expert system prototypes with the Navy stock points' data processing system UADPS-SP. At present, to answer the majority of the questions asked by the prototypes, inventory managers are required to extract information from the UADPS-SP data base. If the developed expert system prototypes were interfaced with this mainframe system this information could be retrieved

automatically, thereby reducing the manual efforts of inventory managers. Successful research in this area would increase the credibility of utilizing expert systems in inventory management functions.

3. **Expansion to other areas of inventory management**

The tasks considered so far in the development of the stock point expert system prototypes have been limited to the processing of delinquent dues and variable ranking listings. Follow-on research should expand the use of expert system technology to other inventory manager tasks. Stock replenishment processing or Subsafe/Level One Material processing are two examples of inventory manager tasks where expert systems technology would be helpful. Eventually, when expert systems are developed for most IM tasks an aggregate expert system for inventory managers should be developed.

APPENDIX A

DECISION RULES

[Ref. 6]

1. DELINQUENT DUES LISTING

Rule 1

If:
1. No supply status has been received, and
2. The priority of the requisition should be upgraded,

Then:
Submit an AMA modifier which will follow up or reestablish the document and raise the priority.

Rule 2

If:
1. No supply status has been received, and
2. The current priority is satisfactory,

Then:
Submit an ATA follow up.

Rule 3

If:
1. The status is other than BA or AS, and
2. The funds are in Accounts Payable,

Then:
The due should be cancelled.

Rule 4

If:
1. The status is other than BA or AS, and
2. There is no Z67 record,

Then:
Cancel the due.

Rule 5

If:
1. The status is BA, and
2. The status is greater than 30 days old, and

3. Neither AS status nor a revised EDD has been received in response to a follow up, and
4. The item is not classified, pilferable, or controlled, and
5. The EDD in not greater than 60 days old,

Then:
No action is required as of yet.

Rule 6

If:
1. The status is BA, and
2. The status is greater than 30 days old, and
3. Neither AS status nor a revised EDD has been received in response to a followup, and
4. The item is classified, pilferable, or controlled,

Then:
Cancel the due and forward the appropriate ROD information.

Rule 7

If:
1. The status is BA, and
2. The status is greater than 30 days old, and
3. An extended EDD is received in response to a followup,

Then:
Update the EDD in file. The document is no longer delinquent.

Rule 8

If:
1. The status is BA, and
2. The status is greater than 30 days old, and
3. A follow up was previously submitted, and
4. The dollar value is less than $100, and
5. The item is not classified, pilferable, or controlled,

Then:
Store to zero.

Rule 9

If:
1. The status is BA, and
2. The status is greater than 30 days old, and
3. A follow up was previously submitted, and
4. The dollar value is less than $100, or the item is classified, pilferable, or controlled,

Then:
Cancel the due and forward the appropriate ROD information.

Rule 10

If:
1. The status is BA, and
2. The status is greater than 30 days old, and
3. No follow up has been submitted,

Then:
Confirmation of supply status is needed. Submit an AF1 follow up.

Rule 11

If:
1. BA supply status is received, and
2. The status is greater than 30 days old,

Then:
Evidence indicates good supply status. No further action is called for.

Rule 12

If:
1. The status is other than BA or AS, and
2. The funds are in MIT, and
3. The dollar value is less than $100, and
4. The item is not classified, pilferable, or controlled,

Then:
Store to zero.

Rule 13

If:
1. The status is other than BA or AS, and
2. The funds are in MIT, and

3. The dollar value is less than $100 or the item is classified, pilferable, or controlled,

Then:
Cancel the due and forward the appropriate ROD information.

Rule 14

If:
1. The status is other than BA or AS, and
2. The funds are in Obligations, and
3. The material is no longer needed, and
4. A cancellation request has not been submitted,

Then:
Send a AC1 cancellation request.

Rule 15

If:
1. The status is other than BA or AS, and
2. The funds are in Obligations, and
3. The material is no longer needed, and
4. A cancellation request has not been acknowledged,

Then:
Submit another cancellation request.

Rule 16

If:
1. The status is other than BA or AS, and
2. The funds are in Obligations, and
3. The material is no longer needed, and
4. A cancellation request has been acknowledged,

Then:
No further action is required.

Rule 17

If:
1. The status is other than BA or AS, and
2. The funds are in Obligations, and
3. The material is no longer needed, and
4. The priority of the requisition should be upgraded,

Then:
Send an AMA modifier to raise the priority.

Rule 18

If:
1. The status is other than BA or AS, and
2. The funds are in Obligations, and
3. The material is still needed, and
4. The current priority is satisfactory,

Then:
No action is required.

Rule 19

If:
1. AS status is received, and
2. The EDD is not greater than 60 days old,

Then:
No further action is required as of yet.

Rule 20

If:
1. AS status is received, and
2. The EDD is not greater than 60 days old, and
3. The funds are in MIT, and
4. The disbursed physical quantity is not equal to the MIT physical quantity, and
5. There is a partial shipment, and
6. The quantity in MIT plus the disbursed quantity is not greater than the original quantity ordered, and
7. A substitute was not provided, and
8. The dollar value is less than $100, and
9. The item is not classified, pilferable, or controlled,

Then:
Store to zero.

Rule 21

If:
1. AS status is received, and
2. The EDD is greater than 60 days old, and
3. The funds are in MIT, and
4. The disbursed physical quantity is not equal to the MIT physical quantity, and
5. There is a partial shipment, and
6. The quantity in MIT plus the disbursed quantity is not greater than the original quantity ordered, and
7. A substitute was not provided, and

8. The dollar value is greater than $100 or the item is classified, pilferable, or controlled,

Then:
Cancel the due and forward the appropriate ROD information.

Rule 22

If:
1. AS status is received, and
2. The EDD is greater than 60 days old, and
3. The funds are in MIT, and
4. The disbursed physical quantity is not equal to the MIT physical quantity, and
5. There is a partial shipment, and
6. The quantity in MIT plus the disbursed quantity is not greater than the original quantity ordered, and
7. A substitute was provided,

Then:
Cancel the due.

Rule 23

If:
1. AS status is received, and
2. The EDD is greater than 60 days old, and
3. The funds are in MIT, and
4. The disbursed physical quantity is not equal to the MIT physical quantity, and
5. There is a partial shipment, and
6. The quantity in MIT plus the disbursed quantity is greater than the original quantity ordered,

Then:
Cancel the outstanding due. Probable explanation is duplicate documents for some of the outstanding shipments.

Rule 24

If:
1. AS status is received, and
2. The EDD is greater than 60 days old, and
3. The funds are in MIT, and
4. The disbursed physical quantity is not equal to the MIT physical quantity, and
5. There is no partial shipment, and
6. No substitute is provided, and
7. The dollar value is less than $100, and

8. The item is not classified, pilferable, or controlled,

Then:
Store to zero.

Rule 25

If:
1. AS status is received, and
2. The EDD is greater than 60 days old, and
3. The funds are in MIT, and
4. The disbursed physical quantity is not equal to the MIT physical quantity, and
5. There is no partial shipment, and
6. No substitute is provided, and
7. The dollar value is less than $100 or the item is classified, pilferable, or controlled,

Then:
Cancel the due and forward the appropriate ROD information.

Rule 26

If:
1. AS status is received, and
2. The EDD is greater than 60 days old, and
3. The funds are in MIT, and
4. The disbursed physical quantity is equal to the MIT physical quantity, and
5. The dollar value is less than $100, and
6. The item is classified, pilferable, or controlled,

Then:
Store to zero.

Rule 27

If:
1. AS status is received, and
2. The EDD is greater than 60 days old, and
3. The funds are in MIT, and
4. The disbursed physical quantity is not equal to the MIT physical quantity, and
5. There is no partial shipment, and
6. There is a substitute provided,

Then:
Cancel the due.

Rule 28

If:
1. AS status is received, and
2. The EDD is greater than 60 days old, and
3. The funds are in MIT, and
4. The disbursed physical quantity is equal to the MIT physical quantity, and
5. The dollar value is greater than $100 or the item is classified, pilferable, or controlled,

Then:
Cancel the due and forward the appropriate Rod information.

Rule 29

If:
1. AS status is received, and
2. The EDD is greater than 60 days old, and
3. There is a Z67 record, and
4. The funds are in neither MIT nor Obligations,

Then:
Cancel the due.

Rule 30

If:
1. AS status is received, and
2. The EDD is greater than 60 days old, and
3. The funds are in Obligations,

Then:
Cancel the due. Take no action to cancel the outstanding obligation.

Rule 31

If:
1. AS status is received, and
2. The EDD is greater than 60 days old, and
3. There is no Z67 record, and
4. The document is a Fund Code 26 item, and
5. The NSN due is a 9 cog item,

Then:
Do not cancel the due. The 9 cog item is probably being shipped as a substitute for a Fund Code 26 item.

Rule 32

If:
1. AS status is received, and
2. The EDD is greater than 60 days old, and
3. There is no Z67 record, and
4. The document is a Fund Code 26 item, and
5. The NSN due is not a 9 cog item,

Then:
Cancel the due.

Rule 33

If:
1. AS status is received, and
2. The EDD is greater than 60 days old, and
3. There is no Z67 record, and
4. The document is not a Fund Code 26 item,

Then:
Cancel the due.

2. VARIABLE RANKING LISTS

Rule 1 - Grp 1

If:
1. The excess on order EMV is not greater than $500,

Then:
No action is required.

Rule 2 - Grp 1

If:
1. The excess on order EMV is greater than $500, and
2. The quantity in excess is not greater than AQD, and
3. The document has BB or BD status with a future EDD,

Then:
No action is required.

Rule 3 - Grp 1

If:
1. The excess on order EMV is greater than $500, and
2. The quantity in excess is greater than AQD, and
3. Current status for the due is in file, and
4. There is no substitute NSN, and

5. There are multiple dues, and
6. At least one of the dues has a status other than BA, BV, AS,

Then:
Cancel any or all dues with other than BA, BV, or AS status, starting with those having the most distant EDDs, until the excess is eliminated, or there are no more dues.

Rule 4 - Grp 1

If:
1. The excess on order EMV is greater than $500, and
2. The quantity in excess is greater than AQD, and
3. Current status for the due is in file, and
4. There is no substitute NSN, and
5. There are multiple dues, and
6. All dues have a status of either BA, BV, or AS,

Then:
None of the dues can be cancelled. No action is recommended.

Rule 5 - Grp 1

If:
1. The excess on order EMV is greater than $500, and
2. The quantity in excess is greater than AQD, and
3. Current status for the due is in file, and
4. There is no substitute NSN, and
5. There are no multiple dues, and
6. The status is other than BA, BV, or AS,

Then:
The excess quantity should be cancelled.

Rule 6 - Grp 1

If:
1. The excess on order EMV is greater than $500, and
2. The quantity in excess is greater than AQD, and
3. Current status for the due is in file, and
4. There is no substitute NSN, and
5. There are no multiple dues, and
6. The status on the due is BA, BV, or AS,

Then:
The due cannot be cancelled. No action is recommended.

Rule 7 - Grp 1

If:
1. The excess on order EMV is greater than $500, and
2. The quantity in excess is greater than AQD, and
3. Current status for the due is in file, and
4. There is a substitute NSN, and
5. The combined demand for the original and substitute NSNs does not account for the excess, and
6. There are multiple dues, and
7. At least one of the dues has a status other than BA, BV, or AS,

Then:
Cancel any or all dues with other than BA, BV, or AS status, starting with those having the most distant EDDs, until the excess is eliminated or there are no more dues.

Rule 8 - Grp 1

If:
1. The excess on order EMV is greater than $500, and
2. The quantity in excess is greater than AQD, and
3. Current status for the due is in file, and
4. There is a substitute NSN, and
5. The combined demand for the original and substitute NSNs does not account for the excess, and
6. There are no multiple dues, and
7. The status is other than BA, BV, or AS,

Then:
The excess quantity should be cancelled.

Rule 9 - Grp 1

If:
1. The excess on order EMV is greater than $500, and
2. The quantity in excess is greater than AQD, and
3. Current status for the due is in file, and
4. There is a substitute NSN, and
5. The combined demand for the original and substitute NSNs does not account for the excess, and
6. There are multiple dues, and
7. All dues have a status of either BA, BV, or AS,

Then:
None of the dues can be cancelled. No action is recommended.

Rule 10 - Grp 1

If:
1. The excess on order EMV is greater than $500, and
2. The quantity in excess is greater than AQD, and
3. Current status for the due is in file, and
4. There is a substitute NSN, and
5. The combined demand for the original and substitute NSNs does not account for the excess, and
6. There are no multiple dues, and
7. The status on the due is BA, BV, or AS,

Then:
The due cannot be cancelled. No action is recommended.

Rule 11 - Grp 1

If:
1. The excess on order EMV is greater than $500, and
2. The quantity in excess is greater than AQD, and
3. Current status for the due is in file, and
4. There is a substitute NSN, and
5. The combined demand for the original and substitute NSNs accounts for the excess,

Then :
The due should be retained in file. No action is recommended.

Rule 12 - Grp 1

If:
1. The excess on order EMV is greater than $500, and
2. The quantity in excess is greater than AQD, and
3. Current status for the due is not in file,

Then:
Cancel the due and forward the appropriate ROD information.

Rule 13 - Grp 1

If:
1. The excess on order EMV is greater than $500, and
2. The quantity in excess is not greater than AQD, and
3. Neither BB nor BD status with a future EDD is available, and
4. The funds are in MIT,

Then:
Cancel the due and forward the appropriate ROD information.

Rule 14 - Grp 1

If:
1. The excess on order EMV is greater than $500, and
2. The quantity in excess is not greater than AQD, and
3. Neither BB nor BD status with a future EDD is available, and
4. The funds are in not MIT,

Then:
Cancel the due and obligation.

Rule 1 - Grp 3

If:
1. There are no backorders on the NSN,

Then:
No action is recommended.

Rule 2 - Grp 3

If:
1. There are backorders on the NSN, and
2. There is no replenishment indicator,

Then:
Process a ZYL using a 7 bypass code.

Rule 3 - Grp 3

If:
1. There are backorders on the NSN, and
2. There is a replenishment indicator, and
3. A due is being established,

Then:
No action is recommended.

Rule 4 - Grp 3

If:
1. There are backorders on the NSN, and
2. There is a replenishment indicator, and
3. No due is being established,

Then:
Process a ZYL using a 7 bypass code or start an offline buy if the procurement must be initiated immediately.

Rule 1 - Grp 5

If:
1. There is a replenishment indicator, and
2. A due is being established,

Then:
No action is recommended.

Rule 2 - Grp 5

If:
1. There is a replenishment indicator, and
2. No due is being established,

Then:
Process a ZYL using a 7 bypass code.

Rule 3 - Grp 5

If:
1. There is no replenishment indicator, and
2. There is no index code,

Then:
Process a ZYL using a 7 bypass code.

Rule 4 - Grp 5

If:
1. There is no replenishment indicator, and
2. There is an index code of P or S, and
3. The on hand stock for both NSNs is sufficient to cover the demand for each,

Then:
No action is recommended.

Rule 5 - Grp 5

If:
1. There is no replenishment indicator, and
2. There is an index code of P or S, and
3. The on hand stock for both NSNs is deficient,

Then:
Process a ZYL using a 7 bypass code.

Rule 6 - Grp 5

If:
1. There is no replenishment indicator, and
2. There is an index code other than Y, P, or S,

Then:
Refer to Standard Data Reference or request supervisory assistance.

Rule 7 - Grp 5

If:
1. There is no replenishment indicator, and
2. There is an index code Y,

Then:
Process a ZYL against the replacement NSN.

APPENDIX B

DELDUE FILE LISTINGS

1. THE FRONT-END FILE

```
start
  :-  nl, repeat,
  ['ua52.db'],
  [! run_once !], write($Would you like another
consultation ?$),     read(X), gc(full),
  nl,  X \= yes , X \=  y.
run_once
      :-   root_instance(deldue,I,N),
  eval(concluded,conclusion_info,I,Val,true,CF),
  fail.
run_once   :-  nl.
```

2. THE TAXONOMY FILE

```
/* ---------------------------
       Type declarations
--------------------------- */

type supply_status_info = role.
type ss_age_info = role.
type priority_req_info = role.
type financial_info = role.
type physical_qty_info =role.
type follow_up_info = role.
type class_pil_cont_info = role.
type dollar_value_info = role.
type matl_needed_info = role.
type canc_request_info = role.
type est_del_date_info = role.
type fund_code_info = role.
type nine_cog_info = role.
type revised_edd_info = role.
type part_ship_info = role.
type substitute_info = role.
type dla_info = role.
type conclusion_info = role.

type ss_val = multivalue
 [no_status,ba_status,as_status,other_status].
type sa_val = [age_over,age_under].
type pr_val = [pri_sat,pri_upgrade].
```

```
type fi_val = multivalue [no_info,obligations,acc_pay,mit].
type pq_val = multivalue [dnem,dem,dnem_ngo,dnem_go].
type fu_val = [folup_sub,folup_nosub].
type cl_val = [classified,no_classified].
type dr_val = [dollar_over,dollar_under].
type mn_val = [matl_needed,matl_noneed].
type cr_val = multivalue
 [not_submitted,submitted_no_acknow,submitted_acknow].
type dd_val = [edd_over,edd_under].
type fc_val = [fund_code,no_fund_code].
type nc_val = [nine_cog,no_nine_cog].
type re_val = [revised_edd,no_revised_edd].
type ps_val = [partial_ship,no_partial_ship].
type st_val = [sub,no_sub].
type dl_val = [yes_file,no_file].
type  concluded =
 [ama,ata,cancel,store_to_zero,cancel_and_submit_rod,ac1,
 submit_another_cancellation_request,no_action,
 cancel_due_no_cancel_obligation,af1,do_not_cancel].


/* ---------------------------
     Concept definitions
--------------------------- */

define primitive deldue with
 supply_status_info = supply_status and
 ss_age_info = ss_age and
 priority_req_info = priority_req and
 financial_info = financial and
 physical_qty_info = physical_qty and
 follow_up_info = follow_up and
 class_pil_cont_info = class_pil_cont and
 dollar_value_info = dollar_value and
 matl_needed_info = matl_needed and
 canc_request_info = canc_request and
 est_del_date_info = est_del_date and
 fund_code_info = fund_code and
 nine_cog_info = nine_cog and
 revised_edd_info = revised_edd and
 part_ship_info = part_ship and
 substitute_info = substitute and
 dla_info = dla and
 conclusion_info = conclusion.
define primitive supply_status with
 any ss_val.
define primitive ss_age with
 any sa_val.
define primitive priority_req with
 any pr_val.
```

```
define primitive financial with
 any fi_val.
define primitive physical_qty with
 any pq_val.
define primitive follow_up with
 any fu_val.
define primitive class_pil_cont with
 any cl_val.
define primitive dollar_value with
 any dr_val.
define primitive matl_needed with
 any mn_val.
define primitive canc_request with
 any cr_val.
define primitive est_del_date with
 any dd_val.
define primitive fund_code with
 any fc_val.
define primitive nine_cog with
 any nc_val.
define primitive revised_edd with
 any re_val.
define primitive part_ship with
 any ps_val.
define primitive substitute with
 any st_val.
define primitive dla with
 any dl_val.
define primitive conclusion with
 concluded =
[ama,ata,cancel,store_to_zero,cancel_and_submit_rod,ac1,
submit_another_cancellation_request,no_action,
cancel_due_no_cancel_obligation,af1,do_not_cancel].
```

3. THE RULE BASE FILE

```
/*----------------------------
     Control Options
---------------------------- */

report(concluded of conclusion) = $The action is:$.
order(concluded of conclusion) = [r,q].
set(supply_status_info of deldue) = supply_status_info.
set(ss_age_info of deldue) = ss_age_info.
set(priority_req_info of deldue) = priority_req_info.
set(financial_info of deldue) = financial_info.
set(physical_qty_info of deldue) = physical_qty_info.
set(follow_up_info of deldue) = follow_up_info.
set(class_pil_cont_info of deldue) = class_pil_cont_info.
```

```
set(dollar_value_info of deldue) = dollar_value_info.
set(matl_needed_info of deldue) = matl_needed_info.
set(canc_request_info of deldue) = canc_request_info.
set(est_del_date_info of deldue) = est_del_date_info.
set(fund_code_info of deldue) = fund_code_info.
set(nine_cog_info of deldue) = nine_cog_info.
set(revised_edd_info of deldue) = revised_edd_info.
set(part_ship_info of deldue) = part_ship_info.
set(substitute_info of deldue) = substitute_info.
set(conclusion_info of deldue) =  conclusion_info.
set(dla_info of deldue) = dla_info.

name(supply_status_info of deldue) =ignore.
name(ss_age_info of deldue) = ignore.
name(priority_req_info of deldue) = ignore.
name(financial_info of deldue) = ignore.
name(physical_qty_info of deldue) = ignore.
name(follow_up_info of deldue) = ignore.
name(class_pil_cont_info of deldue) = ignore.
name(dollar_value_info of deldue) = ignore.
name(matl_needed_info of deldue) = ignore.
name(canc_request_info of deldue) = ignore.
name(est_del_date_info of deldue) = ignore.
name(fund_code_info of deldue) = ignore.
name(nine_cog_info of deldue) = ignore.
name(revised_edd_info of deldue) = ignore.
name(part_ship_info of deldue) = ignore.
name(substitute_info of deldue) = ignore.
name(dla_info of deldue) = ignore.
name(conclusion_info of deldue) = ignore.

question(ss_val of supply_status) =
$What is the supply status?$.
 synonym(no_status) = $No supply status received$.
 synonym(ba_status) = $BA status$.
 synonym(as_status) = $AS status$.
 synonym(other_status) = $Other than BA or AS status$.

question(sa_val of ss_age) =
$What is the age of the supply status?$.
 synonym(age_over) = $Status age is 30 days or more$.
 synonym(age_under) = $Status age is less than 30 days$.

question(pr_val of priority_req) =
$Is the priority satisfactory?$.
$Should the priority be upgraded?$
 synonym(pri_upgrade) = $Yes$.
 synonym(pri_sat) = $No$.
question(fi_val of financial) =
$What is the financial information?$.
 synonym(no_info) = $There is no Z67 record$.
```

```
 synonym(obligations) = $Funds are in Obligations$.
 synonym(acc_pay) = $Funds are in Accounts Payable$.
 synonym(mit) = $Funds are in MIT$.

question(pq_val of physical_qty) =
$What is the status of physical quantities?$.
 synonym(dnem) = $Disbursed qty IS NOT EQUAL to MIT qty$.
 synonym(dem) = $Disbursed qty IS EQUAL to MIT qty$.
 synonym(dnem_ngo) = $Disbursed qty IS NOT EQUAL to MIT qty
    and the qty in MIT PLUS the disbursed qty IS NOT
    GREATER than the original qty$.
 synonym(dnem_go) =  $Disbursed qty IS NOT EQUAL to MIT qty
    and the qty in MIT PLUS the Disbursed qty IS
GREATER than the original qty$.

question(fu_val of follow_up) =
$Has a follow up been previously submitted?$.
 synonym(folup_sub) = $Yes$.
 synonym(folup_nosub) = $No$.

question(cl_val of class_pil_cont) =
$Is the matl classified,pilferable,or controlled?$.
 synonym(classified) = $Yes$.
 synonym(no_classified) = $No$.

question(dr_val of dollar_value) =
$Is the dollar value of the matl more than 100 dollars?$.
 synonym(dollar_over) = $Yes (100 or more)$.
 synonym(dollar_under) = $No$.

question(mn_val of matl_needed) =
$Is the matl still needed?$.
 synonym(matl_needed) = $Yes$.
 synonym(matl_noneed) = $No$.

question(cr_val of canc_request) =
$Has a cancellation request been submitted and
acknowledged?$.
 synonym(not_submitted) = $A cancellation has not been
    submitted$.
 synonym(submitted_no_acknow) = $A cancellation has been
    submitted but not acknowledged$.
 synonym(submitted_acknow) = $A cancellation has been
    submitted and been acknowledged$.

question(dd_val of est_del_date) =
$Is the EDD more than 60 days old?$.
 synonym(edd_over) = $Yes (60 or more days)$.
 synonym(edd_under) = $No$.
```

```
question(fc_val of fund_code) =
$Is the document a Fund Code 26 item?$.
 synonym(fund_code) = $Yes$.
 synonym(no_fund_code) = $No$.

question(nc_val of nine_cog) =
$Is the item a 9 cog item?$.
 synonym(nine_cog) = $Yes$.
 synonym(no_nine_cog) = $No$.

question(re_val of revised_edd) =
$Has a revised/extended EDD been received?$.
 synonym(revised_edd) = $Yes$.
 synonym(no_revised_edd) = $No$.

question(ps_val of part_ship) =
$Is there a partial shipment?$.
 synonym(partial_ship) = $Yes$.
 synonym(no_partial_ship) = $No$.

question(st_val of substitute) =
$Is there a substitute item?$.
 synonym(sub) = $Yes$.
 synonym(no_sub) = $No$.

question(dl_val of dla) =
$Is the requisition held in the DLA files?$
 synonym(yes_file) = $Yes$.
 synonym(no_file) = $No$.

synonym(cancel) = $Cancel the due$.
synonym(cancel_and_submit_rod) = $Cancel the due and
 submit a ROD$.
synonym(no_action) + $No action is required $.
synonym(cancel_due_no_cancel_obligation $.
synonym(do_not_cancel) = $Do not cancel the due $.

/* ---------------------------
            Rules
--------------------------- */

the concluded of conclusion_info is ama
 if
the ss_val of supply_status_info is no_status and
the pr_val of priority_req_info is pri_upgrade.

the concluded of conclusion_info is ata
 if
the ss_val of supply_status_info is no_status and
the pr_val of priority_req_info is pri_sat.
```

```
the concluded of conclusion_info is no_action
 if
the ss_val of supply_status_info is ba_status and
the sa_val of ss_age_info is age_under.

the concluded of conclusion_info is af1
 if
the ss_val of supply_status_info is ba_status and
the sa_val of ss_age_info is age_over and
the fu_val of follow_up_info is folup_nosub.

the concluded of conclusion_info is no_action
 if
the ss_val of supply_status_info is ba_status and
the sa_val of ss_age_info is age_over and
the re_val of revised_edd_info is revised_edd.

the concluded of conclusion_info is cancel_and_submit_rod
 if
the ss_val of supply_status_info is ba_status and
the sa_val of ss_age_info is age_over and
the re_val of revised_edd_info is no_revised_edd and
the cl_val of class_pil_cont_info is classified.

the concluded of conclusion_info is cancel_and_submit_rod
 if
the ss_val of supply_status_info is ba_status and
the sa_val of ss_age_info is age_over and
the fu_val of follow_up_info is folup_sub and
the cl_val of class_pil_cont_info is classified.

the concluded of conclusion_info is no_action
 if
the ss_val of supply_status_info is ba_status and
the sa_val of ss_age_info is age_over and
the re_val of revised_edd_info is no_revised_edd and
the cl_val of class_pil_cont_info is no_classified and
the dd_val of est_del_date_info is edd_under.

the concluded of conclusion_info is store_to_zero
 if
the ss_val of supply_status_info is ba_status and
the sa_val of ss_age_info is age_over and
the fu_val of follow_up_info is folup_sub and
the cl_val of class_pil_cont_info is no_classified and
the dr_val of dollar_value_info is dollar_under.

the concluded of conclusion_info is cancel_and_submit_rod
 if
the ss_val of supply_status_info is ba_status and
the sa_val of ss_age_info is age_over and
```

```
the fu_val of follow_up_info is folup_sub and
the dr_val of dollar_value_info is dollar_over.

the concluded of conclusion_info is cancel
 if
the ss_val of supply_status_info is other_status and
the fi_val of financial_info is no_info and
the dl_val of dla_info is no_file.

the concluded of conclusion_info is alf
 if
the ss_val of supply_status_info is other_status and
the fi_val of financial_info is no_info and
the dl_val of dla_info is yes_file and
the mn_val of matl_needed_info is matl needed.

the concluded of conclusion_info is cancel
 if
the ss_val of supply_status_info is other_status and
the fi_val of financial_info is no_info and
the dl_val of dla_info is yes_file and
the mn_val of matl_needed_info is matl_noneed.

the concluded of conclusion_info is cancel
 if
the ss_val of supply_status_info is other_status and
the fi_val of financial_info is acc_pay.

the concluded of conclusion_info is cancel_and_submit_rod
 if
the ss_val of supply_status_info is other_status and
the fi_val of financial_info is mit and
the dr_val of dollar_value_info is dollar_over.

the concluded of conclusion_info is store_to_zero
 if
the ss_val of supply_status_info is other_status and
the fi_val of financial_info is mit and
the dr_val of dollar_value_info is dollar_under and
the cl_val of class_pil_cont_info is no_classified.

the concluded of conclusion_info is cancel_and_submit_rod
 if
the ss_val of supply_status_info is other_status and
the fi_val of financial_info is mit and
the dr_val of dollar_value_info is dollar_under and
the cl_val of class_pil_cont_info is classified.

the concluded of conclusion_info is ac1
 if
the ss_val of supply_status_info is other_status and
```

```
the fi_val of financial_info is obligations and
the mn_val of matl_needed_info is matl_noneed and
the cr_val of canc_request_info is not_submitted.

the concluded of conclusion_info is
submit_another_cancellation_request
 if
the ss_val of supply_status_info is other_status and
the fi_val of financial_info is obligations and
the mn_val of matl_needed_info is matl_noneed and
the cr_val of canc_request_info is submitted_no_acknow.

the concluded of conclusion_info is no_action
 if
the ss_val of supply_status_info is other_status and
the fi_val of financial_info is obligations and
the mn_val of matl_needed_info is matl_noneed and
the cr_val of canc_request_info is submitted_acknow.

the concluded of conclusion_info is ama
 if
the ss_val of supply_status_info is other_status and
the fi_val of financial_info is obligations and
the mn_val of matl_needed_info is matl_needed and
the pr_val of priority_req_info is pri_upgrade.

the concluded of conclusion_info is no_action
 if
the ss_val of supply_status_info is other_status and
the fi_val of financial_info is obligations and
the mn_val of matl_needed_info is matl_needed and
the pr_val of priority_req_info is pri_sat.

the concluded of conclusion_info is cancel
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is mit and
the pq_val of physical_qty_info is dnem_ngo and
the dd_val of est_del_date_info is edd_over and
the ps_val of part_ship_info is partial_ship and
the st_val of substitute_info is sub.

the concluded of conclusion_info is cancel_and_submit_rod
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is mit and
the pq_val of physical_qty_info is dnem_ngo and
the dd_val of est_del_date_info is edd_over and
the ps_val of part_ship_info is partial_ship and
the st_val of substitute_info is no_sub and
```

```
the dr_val of dollar_value_info is dollar_under and
the cl_val of class_pil_cont_info is classified.

the concluded of conclusion_info is store_to_zero
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is mit and
the pq_val of physical_qty_info is dnem_ngo and
the dd_val of est_del_date_info is edd_over and
the ps_val of part_ship_info is partial_ship and
the st_val of substitute_info is no_sub and
the dr_val of dollar_value_info is dollar_under and
the cl_val of class_pil_cont_info is no_classified.

the concluded of conclusion_info is cancel_and_submit_rod
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is mit and
the pq_val of physical_qty_info is dnem_ngo and
the dd_val of est_del_date_info is edd_over and
the ps_val of part_ship_info is partial_ship and
the st_val of substitute_info is no_sub and
the dr_val of dollar_value_info is dollar_over.

the concluded of conclusion_info is cancel
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is mit and
the pq_val of physical_qty_info is dnem_go and
the dd_val of est_del_date_info is edd_over and
the ps_val of part_ship_info is partial_ship.

the concluded of conclusion_info is cancel
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is mit and
the pq_val of physical_qty_info is dnem and
the dd_val of est_del_date_info is edd_over and
the ps_val of part_ship_info is no_partial_ship and
the st_val of substitute_info is sub.

the concluded of conclusion_info is store_to_zero
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is mit and
the pq_val of physical_qty_info is dnem and
the dd_val of est_del_date_info is edd_over and
the ps_val of part_ship_info is no_partial_ship and
the st_val of substitute_info is no_sub and
the dr_val of dollar_value_info is dollar_under and
the cl_val of class_pil_cont_info is no_classified.
```

```
the concluded of conclusion_info is cancel_and_submit_rod
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is mit and
the pq_val of physical_qty_info is dnem and
the dd_val of est_del_date_info is edd_over and
the ps_val of part_ship_info is no_partial_ship and
the st_val of substitute_info is no_sub and
the dr_val of dollar_value_info is dollar_over.

the concluded of conclusion_info is store_to_zero
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is mit and
the pq_val of physical_qty_info is dem and
the dd_val of est_del_date_info is edd_over and
the dr_val of dollar_value_info is dollar_under and
the cl_val of class_pil_cont_info is no_classified.

the concluded of conclusion_info is cancel_and_submit_rod
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is mit and
the pq_val of physical_qty_info is dem and
the dd_val of est_del_date_info is edd_over and
the dr_val of dollar_value_info is dollar_under and
the cl_val of class_pil_cont_info is classified.

the concluded of conclusion_info is cancel_and_submit_rod
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is mit and
the pq_val of physical_qty_info is dem and
the dd_val of est_del_date_info is edd_over and
the dr_val of dollar_value_info is dollar_over.

the concluded of conclusion_info is cancel
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is acc_pay and
the dd_val of est_del_date_info is edd_over.

the concluded of conclusion_info is
cancel_due_no_cancel_obligation
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is obligations and
the dd_val of est_del_date_info is edd_over.
```

```
the concluded of conclusion_info is do_not_cancel
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is no_info and
the dd_val of est_del_date_info is edd_over and
the fc_val of fund_code_info is fund_code and
the nc_val of nine_cog_info is nine_cog.

the concluded of conclusion_info is cancel
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is no_info and
the dd_val of est_del_date_info is edd_over and
the fc_val of fund_code_info is fund_code and
the nc_val of nine_cog_info is no_nine_cog.

the concluded of conclusion_info is store_to_zero
 if
the ss_val of supply_status_info is as_status and
the fi_val of financial_info is no_info and
the dd_val of est_del_date_info is edd_over and
the fc_val of fund_code_info is no_fund_code.

the concluded of conclusion_info is no_action
 if
the ss_val of supply_status_info is as_status and
the dd_val of est_del_info is edd_under.
```

APPENDIX C

VRANK FILE LISTING

1. THE FRONT-END FILE

```
start
  :-  nl, repeat,
  [ !  run_once  !], write($Would you like another
consultation ?$),
  read(X), gc(full),
  nl,  X \= yes , X \=  y.

run_once
      :-   root_instance(vrank,I,N),
  eval(concluded,conclusion_info,I,Val,true,CF),
  fail.
run_once   :-  nl.
```

2. THE TAXONOMY FILE

```
/* ---------------------------
      Type declarations
--------------------------- */

type group_info = role.
type ext_money_value_info = role.
type qty_excess_aqd_info = role.
type current_status_info = role.
type substitute_info = role.
type multiple_dues_info = role.
type dues_status_info = role.
type combined_demand_info = role.
type financial_info = role.
type backorders_info = role.
type replen_indicator_info = role.
type dues_established_info = role.
type index_code_info = role.
type onhand_stock_info = role.
type conclusion_info = role.

type grp = multivalue [one,three,five].
type emv = [greater,not_greater].
type aqd = [greater,not_greater].
type cs_val = [infile,not_infile].
type subst = [sub,no_sub].
```

```
type md_val = [mult_dues,no_mult_dues].
type dues_stat = multivalue [a,b,c,d,e,f].
type comb_dem = [acct,no_acct].
type fin = [mit,no_mit].
type backord = [back,no_back].
type repl_ind = [rep_indic,no_rep_indic].
type dues_est = [dues_estab,no_dues_estab].
type xcode = multivalue [no_index,pors,not_ypors,a_y].
type oh_stock = [sufficient,deficient].
type concluded = [no_action,canc_dues,no_canc,canc_excess,
 ret_due,canc_rod,canc_obl,zyl_by,zyl_by_off,
 refer,zyl_replace].

/* ---------------------------
     Concept definitions
--------------------------- */

define primitive vrank with
 group_info = group and
 ext_money_value_info = ext_money_value and
 qty_excess_aqd_info = qty_excess_aqd and
 current_status_info = current_status and
 substitute_info = substitute and
 multiple_dues_info = multiple_dues and
 dues_status_info = dues_status and
 combined_demand_info = combined_demand and
 financial_info = financial and
 backorders_info = backorders and
 replen_indicator_info = replen_indicator and
 dues_established_info = dues_established and
 index_code_info = index_code and
 onhand_stock_info = onhand_stock and
 conclusion_info =conclusion.

define primitive group with
 any grp.
define primitive ext_money_value with
 any emv.
define primitive qty_excess_aqd with
 any aqd.
define primitive current_status with
 any cs_val.
define primitive substitute with
 any subst.
define primitive multiple_dues with
 any md_val.
define primitive dues_status with
 any dues_stat.
define primitive combined_demand with
 any comb_dem.
```

```
define primitive financial with
 any fin.
define primitive backorders with
 any backord.
define primitive replen_indicator with
 any repl_ind.
define primitive dues_established with
 any dues_est.
define primitive index_code with
 any xcode.
define primitive onhand_stock with
 any oh_stock.
define primitive conclusion with
 concluded = [no_action,canc_dues,no_canc,canc_excess,
 ret_due,canc_rod,canc_obl,zyl_by,zyl_by_off,refer,
 zyl_replace].
```

3. THE RULE BASE FILE

```
/* ---------------------------
        Control options
--------------------------- */

report(concluded of conclusion) = $The action is:$.
order(concluded of conclusion) = [r,q].

set(group_info of vrank) = group_info.
set(ext_money_value_info of vrank) = ext_money_value_info.

set(qty_excess_aqd_info of vrank) = qty_excess_aqd_info.
set(current_status_info of vrank) = current_status_info.
set(substitute_info of vrank) = substitute_info.
set(multiple_dues_info of vrank) =multiple_dues_info.
set(dues_status_info of vrank) =dues_status_info.
set(combined_demand_info of vrank) =combined_demand_info.
set(financial_info of vrank) = financial_info.
set(backorders_info of vrank) = backorders_info.
set(replen_indicator_info of vrank) =
replen_indicator_info.
set(dues_established_info of vrank) =
dues_established_info.
set(index_code_info of vrank) = index_code_info.
set(onhand_stock_info of vrank) = onhand_stock_info.
set(conclusion_info of vrank) = conclusion_info.

name(group_info of vrank) = ignore.
name(ext_money_value_info of vrank) = ignore.
name(qty_excess_aqd_info of vrank) = ignore.
name(current_status_info of vrank) = ignore.
name(substitute_info of vrank) = ignore.
```

```
name(multiple_dues_info of vrank) = ignore.
name(dues_status_info of vrank) = ignore.
name(combined_demand_info of vrank) = ignore.
name(financial_info of vrank) = ignore.
name(backorders_info of vrank) = ignore.
name(replen_indicator_info of vrank) = ignore.
name(dues_established_info of vrank) = ignore.
name(index_code_info of vrank) = ignore.
name(onhand_stock_info of vrank) = ignore.
name(conclusion_info of vrank) = ignore.

question(grp of group) =
$What Variable Ranking Group is the item ?$.
 synonym(one) = $Group One$.
 synonym(three) = $Group Three$.
 synonym(five) = $Group Five$.

question(emv of ext_money_value) =
$Is the extended money value (EMV) of the excess on order
greater than 500 dollars ?$.
 synonym(greater) = $Yes$.
 synonym(not_greater) = $No$.

question(aqd of qty_excess_aqd) =
$Is the qty in excess greater than the average quarterly
demand (AQD) ?$.
 synonym(greater) = $Yes$.
 synonym(not_greater) = $No$.

question(cs_val of current_status) =
$Is the current status for the due on file ?$.
 synonym(infile) = $Yes$.
 synonym(not_infile) = $No$.

question(subst of substitute) =
$Is there a substitute NSN ?$.
 synonym(sub) = $Yes$.
 synonym(no_sub) = $No$.

question(md_val of multiple_dues) =
$Are there multiple dues ?$.
 synonym(mult_dues) = $Yes$.
 synonym(no_mult_dues) = $No$.

question(dues_stat of dues_status) =
$What is the supply status of the due (or dues) ?$.
 synonym(a) = $The DUE has BB or BD status with a future
 EDD$.
 synonym(b) = $At least one of the DUES has a status other
 than BA, BV, or AS$.
```

```
 synonym(c) = $All DUES have a status of either BA, BV, or
 AS$.
 synonym(d) = $The status is other than BA, BV, or AS$.
 synonym(e) = $The status on the due is BA, BV, or AS$.
 synonym(f) = $Neither BB nor BD status with a future EDD
 is available$.

question(comb_dem of combined_demand) =
$Does the combined demand for the original and substitute
NSNs account for the excess ?$.
 synonym(acct) = $Yes$.
 synonym(no_acct) = $No$.

question(fin of financial) =
$Are the funds in MIT ?$.
 synonym(mit) = $Yes$.
 synonym(no_mit) = $No$.

question(backord of backorders) =
$Are there backorders on the NSN ?$.
 synonym(back) = $Yes$.
 synonym(no_back) = $No$.

question(repl_ind of replen_indicator) =
$Is there a replenishment indicator ?$.
 synonym(rep_indic) = $Yes$.
 synonym(no_rep_indic) = $No$.

question(dues_est of dues_established) =
$Is a due being established ?$.
 synonym(dues_estab) = $Yes$.
 synonym(no_dues_estab) = $No$.

question(xcode of index_code) =
$Is there an index code ?$.
 synonym(no_index) = $No$.
 synonym(pors) = $Yes, there is an index code of P or S$.
 synonym(not_ypors) = $Yes, there is an index code of other
 than Y, P, or S$.
 synonym(a_y) = $Yes, there is an index code of Y$.

question(oh_stock of onhand_stock) =
$Is the on hand stock for both NSNs sufficient to cover the
demand for each NSN ?$.
 synonym(sufficient) = $Yes$.
synonym(deficient) = $No$.
synonym(no_action) = $No action is required.$.
synonym(canc_dues) = $Cancel any or all dues with other
 than BA, BV, or AS status, starting with those having the
 most distant EDDs, until the excess is eliminated, or
 there are no more dues.$.
```

```
synonym(no_canc) = $None of the dues can be cancelled. No
 action is recommended.$.
synonym(canc_excess) = $The excess qty should be
 cancelled.$.
synonym(ret_due) = $The due should be retained in file. No
 action is recommended.$.
synonym(canc_rod) = $Cancel the due and forward the
 appropriate ROD information.$.
synonym(canc_obl) = $Cancel the due and the obligation.$.
synonym(zyl_by) = $Process a ZYL using a 7 bypass code.$.
synonym(zyl_by_off) = $Process a ZYL using a 7 bypass code
 or start an offline buy if the procurement must be
 initiated immediately.$.
synonym(refer) = $Refer to Standard Data Reference or
 request supervisory assistance.$.
synonym(zyl_replace) = $Process a ZYL against the
 replacement NSN.$.

/* ---------------------------
          Rules
--------------------------- */

the concluded of conclusion_info is no_action
 if
the grp of group_info is one and
the emv of ext_money_value_info is not_greater.

the concluded of conclusion_info is no_action
 if
the grp of group_info is one and
the emv of ext_money_value_info is greater and
the aqd of qty_excess_aqd_info is not_greater and
the dues_stat of dues_status_info is a.

the concluded of conclusion_info is canc_dues
 if
the grp of group_info is one and
the emv of ext_money_value_info is greater and
the aqd of qty_excess_aqd_info is greater and
the cs_val of current_status_info is infile and
the subst of substitute_info is no_sub and
the md_val of multiple_dues_info is mult_dues and
the dues_stat of dues_status_info is b.

the concluded of conclusion_info is no_canc
 if
the grp of group_info is one and
the emv of ext_money_value_info is greater and
the aqd of qty_excess_aqd_info is greater and
the cs_val of current_status_info is infile and
the subst of substitute_info is no_sub and
```

```
the md_val of multiple_dues_info is mult_dues and
the dues_stat of dues_status_info is c.

the concluded of conclusion_info is canc_excess
 if
the grp of group_info is one and
the emv of ext_money_value_info is greater and
the aqd of qty_excess_aqd_info is greater and
the cs_val of current_status_info is infile and
the subst of substitute_info is no_sub and
the md_val of multiple_dues_info is no_mult_dues and
the dues_stat of dues_status_info is d.

the concluded of conclusion_info is no_canc
 if
the grp of group_info is one and
the emv of ext_money_value_info is greater and
the aqd of qty_excess_aqd_info is greater and
the cs_val of current_status_info is infile and
the subst of substitute_info is no_sub and
the md_val of multiple_dues_info is no_mult_dues and
the dues_stat of dues_status_info is e.

the concluded of conclusion_info is canc_dues
 if
the grp of group_info is one and
the emv of ext_money_value_info is greater and
the aqd of qty_excess_aqd_info is greater and
the cs_val of current_status_info is infile and
the subst of substitute_info is sub and
the comb_dem of combined_demand_info is no_acct and
the md_val of multiple_dues_info is mult_dues and
the dues_stat of dues_status_info is b.

the concluded of conclusion_info is no_canc
 if
the grp of group_info is one and
the emv of ext_money_value_info is greater and
the aqd of qty_excess_aqd_info is greater and
the cs_val of current_status_info is infile and
the subst of substitute_info is sub and
the comb_dem of combined_demand_info is no_acct and
the md_val of multiple_dues_info is mult_dues and
the dues_stat of dues_status_info is c.

the concluded of conclusion_info is canc_excess
 if
the grp of group_info is one and
the emv of ext_money_value_info is greater and
the aqd of qty_excess_aqd_info is greater and
the cs_val of current_status_info is infile and
```

```
the subst of substitute_info is sub and
the comb_dem of combined_demand_info is no_acct and
the md_val of multiple_dues_info is no_mult_dues and
the dues_stat of dues_status_info is d.

the concluded of conclusion_info is no_canc
 if
the grp of group_info is one and
the emv of ext_money_value_info is greater and
the aqd of qty_excess_aqd_info is greater and
the cs_val of current_status_info is infile and
the subst of substitute_info is sub and
the comb_dem of combined_demand_info is no_acct and
the md_val of multiple_dues_info is no_mult_dues and
the dues_stat of dues_status_info is e.

the concluded of conclusion_info is ret_due
 if
the grp of group_info is one and
the emv of ext_money_value_info is greater and
the aqd of qty_excess_aqd_info is greater and
the cs_val of current_status_info is infile and
the subst of substitute_info is sub and
the comb_dem of combined_demand_info is acct.

the concluded of conclusion_info is canc_rod
 if
the grp of group_info is one and
the emv of ext_money_value_info is greater and
the aqd of qty_excess_aqd_info is greater and
the cs_val of current_status_info is not_infile.

the concluded of conclusion_info is canc_rod
 if
the grp of group_info is one and
the emv of ext_money_value_info is greater and
the aqd of qty_excess_aqd_info is not_greater and
the dues_stat of dues_status_info is f and
the fin of financial_info is mit.

the concluded of conclusion_info is canc_obl
 if
the grp of group_info is one and
the emv of ext_money_value_info is greater and
the aqd of qty_excess_aqd_info is not_greater and
the dues_stat of dues_status_info is f and
the fin of financial_info is no_mit.
```

```
the concluded of conclusion_info is no_action
 if
the grp of group_info is three and
the backord of backorders_info is no_back.

the concluded of conclusion_info is zyl_by
 if
the grp of group_info is three and
the backord of backorders_info is back and
the repl_ind of replen_indicator_info is no_rep_indic.

the concluded of conclusion_info is no_action
 if
the grp of group_info is three and
the backord of backorders_info is back and
the repl_ind of replen_indicator_info is rep_indic and
the dues_est of dues_established_info is dues_estab.

the concluded of conclusion_info is zyl_by_off
 if
the grp of group_info is three and
the backord of backorders_info is back and
the repl_ind of replen_indicator_info is rep_indic and
the dues_est of dues_established_info is no_dues_estab.

the concluded of conclusion_info is no_action
 if
the grp of group_info is five and
the repl_ind of replen_indicator_info is rep_indic and
the dues_est of dues_established_info is dues_estab.

the concluded of conclusion_info is zyl_by
 if
the grp of group_info is five and
the repl_ind of replen_indicator_info is rep_indic and
the dues_est of dues_established_info is no_dues_estab.

the concluded of conclusion_info is zyl_by
 if
the grp of group_info is five and
the repl_ind of replen_indicator_info is no_rep_indic and
the xcode of index_code_info is no_index.

the concluded of conclusion_info is no_action
 if
the grp of group_info is five and
the repl_ind of replen_indicator_info is no_rep_indic and
the xcode of index_code_info is pors and
the oh_stock of onhand_stock_info is sufficient.
```

```
the concluded of conclusion_info is zyl_by
 if
the grp of group_info is five and
the repl_ind of replen_indicator_info is no_rep_indic and
the xcode of index_code_info is pors and
the oh_stock of onhand_stock_info is deficient.

the concluded of conclusion_info is refer
 if
the grp of group_info is five and
the repl_ind of replen_indicator_info is no_rep_indic and
the xcode of index_code_info is not_ypors.

the concluded of conclusion_info is zyl_replace
 if
the grp of group_info is five and
the repl_ind of replen_indicator_info is no_rep_indic and
the xcode of index_code_info is a_y.
```

APPENDIX D

DELDUE AND VRANK DICTIONARY

1. DELDUE DICTIONARY

acc_pay
funds are in accounts payable

ac1
cancellation request document

af1
follow up document

ama
document modifier, process as requisition if original document not received

age_over
supply status age is 30 days old or more

age_under
supply status age is less than 30 days old

as_status
item shipped

ata
follow up, process as requisition if original requisition not received

ba_status
item being processed for release and shipment

canc_request_info
cancellation request information

cancel
cancel the due

cancel_and_submit_rod
cancel the due and submit a ROD

cancel_due_no_cancel_obligation
cancel the due, but do not cancel the obligation

cl_val
classified, pilferable and controlled values

class_pil_cont_info
classified, pilferable and controlled information

classified
the material is classified, pilferable or controlled

conclusion_info
conclusion information

cr_val
cancellation request values

dd_val
estimated delivery date values

deldue
delinquent due

dem
the disbursed quantity is equal to the quantity in MIT

dl_val
defense logistics agency values

dla
requisition held in defense logistics agency files

dla_info
defense logistics agency information

dnem
the disbursed quantity is not equal to the quantity in MIT

dnem_go
the disbursed quantity is not equal to the quantity in MIT and the quantity in MIT plus the disbursed quantity is greater than the original quantity ordered

dnem_ngo
the disbursed quantity is not equal to the quantity in MIT and the quantity in MIT plus the disbursed quantity is not greater than the original quantity ordered

dollar_over
the dollar value of the material is $100 or more

dollar_under
the dollar value of the material is less than $100

dollar_value_info
dollar value information

do_not_cancel
do not cancel the due

dr_val
the values of dollar value

edd_over
the estimated delivery date is 60 days old or more

edd_under
the estimated delivery date is less than 60 days old

est_del_date_info
estimated delivery date information

fc_val
fund code values

fi_val
financial values

financial_info
financial information

follow_up_info
follow up information

folup_nosub
a follow up has not been previously submitted

folup_sub
a follow up has been previously submitted

fu_val
follow up submitted values

fund_code
item is a Fund Code 26 item

fund_code_info
Fund Code 26 information

matl_needed
material is still needed

matl_needed_info
material needed information

matl_noneed
material is not needed

mit
funds are in MIT (material in transit)

mn_val
material needed values

nine_cog
item is nine cog material

nine_cog_info
nine cog information

no_action
no action is recommended

no_classified
material is not classified, pilferable or controlled

no_fund_code
item is not a Fund Code 26 item

no_info
there is no financial information available

no_nine_cog
item is not nine cog material

no_partial_ship
there is no partial shipment

no_revised_edd
no revised estimated delivery date has been received

no_status
there is no supply status available

no_sub
there is no substitute item

not_submitted
a cancellation request has not been submitted

obligations
funds are in obligations

other_status
supply status is other than BA or AS

part_ship_info
partial shipment information

partial_ship
there is a partial shipment

physical_qty_info
physical quantity information

pq_val
physical quantity values

pri_sat
the requisition priority should not be upgraded

pri_upgrade
the requisition priority should be upgraded

priority_req_info
priority requisition information

pr_val
priority requisition values

ps_val
partial shipment values

revised_edd
a revised estimated delivery date has been received

revised_edd_info
revised estimated delivery date information

sa_val
supply status age values

ss_age_info
supply status age information

ss_val
supply status values

st_val
substitute values

store_to_zero
store to zero

sub
there is a substitute item

submit_another_cancellation_request
submit another cancellation request

submitted_acknow
a cancellation request has been submitted and has been acknowledged with a B8/B9

submitted_no_acknow
a cancellation request has been submitted but has not been acknowledged

substitute_info
substitution information

supply_status_info
supply status information

update_edd
update the estimated delivery date

2. VRANK DICTIONARY

a_y
there is an index code of Y

back
there are backorders on the NSN

backord
backorder values

backorders_info
backorders information

canc_excess
the excess quantity should be cancelled

canc_dues
cancel any or all dues with other than BA, BV, or AS status, starting with those having the most distant estimated delivery dates until the excess is eliminiated, or there are no more dues

canc_obl
cancel the due and the obligation

canc_rod
cancel the due and forward the appropriate ROD information

comb_dem
combined demand for the original and substitute NSNs

combined_demand_info
combined demand information

conclusion_info
conclusion information

cs_val
current status values

current_status_info
current status information

deficient
the on hand stock for both NSNs is sufficient to cover the demand for each NSN

dues_est
dues established

dues_established_info
dues established information

dues_stat
dues supply status

dues_status_info
dues supply status information

emv
extended money value

ext_money_value_info
extended money value information

fin
financial values

financial_info
financial information

greater
the extended money value of the excess on order is $500 or greater or the quantity in excess is greater than the average quarterly demand

group_info
group information

grp
variable ranking group

index_code_info
index code information

infile
the current status for the due is on file

md_val
multiple dues values

mit
funds are in MIT (material in transit)

mult_dues
multiple dues

multiple_dues_info
multiple dues information

no_back
there are no backorders

no_canc
none of the dues can be cancelled, no action is recommended

no_dues_estab
no due is being established

no_index
there is no index code

not_greater
the extended money value of the excess on order is not greater than $500 or the quantity in excess is not greater than the average quarterly demand

no_action
no action is required

no_mit
funds are not in MIT (material in transit)

no_mult_dues
there are no multiple dues

no_rep_indic
there is no replenishment indicator

no_sub
there is no substitute

not_infile
the current status is not on file

not_ypors
there is an index code of other than Y, P or S

oh_stock
on hand stock

onhand_stock_info
on hand stock information

pors
there is an index code of P or S

qty_excess_aqd_info
quantity in excess of average quarterly demand information

refer
refer to the Standard Data Reference or request supervisor assistance

repl_ind
replenishment indicator

rep_indic
there is a replenishment indicator

replen_indicator_info
replenishment indicator information

ret_due
the due should be retained in file, no action is recommended

sub
there is a substitute NSN

subst
substitute

substitute_info
substitute information

sufficient
the on hand stock is sufficient to cover the demand for each NSN

vrank
variable ranking

xcode
index code values

zyl_by
process a ZYL using a 7 bypass code

zyl_by_off
process a ZYL using a 7 bypass code or start an offline buy if the procurement must be initiated immediately

zyl_replace
process a ZYL against the replacement NSN

APPENDIX E

NSC SAN DIEGO POINTS OF CONTACT

LCDR Bruce Feerer (Code 101)	Autovon:	958-3131
Mary J. Fesnock (Code 101A)		958-3131
Betty Courtney		958-3751/3775
Pat McClaughlin		958-3806
Roger Longnecker		958-3751/3581
Armando Conde		958-3751/3624

LIST OF REFERENCES

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Thesis
S33655 Schill
c.1 An expert system for inventory managers at retail stock points.