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SYSTEM INPUT/OUTPUT CHANGES REQUIRED TO EXPORT THE FORCE REQUIREMENTS EXPERT SYSTEM (FRESH) TO THE COMMANDER IN CHIEF ATLANTIC FLEET

by

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System Input/Output Changes Required to Export the Force Requirements Expert System (FRESH) to the Commander in Chief Atlantic Fleet

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ABSTRACT

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I. INTRODUCTION

This research will look into what needs to be changed, in terms of the system inputs and outputs, in order to transport the expert system FRESH to the Commander in Chief Atlantic Fleet (CINCLANTFLT) Norfolk, VA.

A. FRESH OVERVIEW

FRESH is an expert system developed by Texas Instruments Corp. and BTG Inc. and is presently being prototyped at Commander in Chief Pacific Fleet (CINCPACFLT), Pearl Harbor, HI. According to the Pacific Fleet Headquarters, FRESH is an extremely useful expert system prototype that is used:

- to generate long range ship's employment schedules--a macro ship's schedule which covers all major events for a ship over a five year period.
- to monitor changes that impact Fleet readiness and provide viable replacements for units with major casualties
- to evaluate the impact of rescheduling ships
- to improve effectiveness of valuable personnel resources.

The specific capabilities of FRESH are presented in more detail in Chapter III of this research, however at this point, suffice it to say that FRESH is proving to be a very valuable decision aid.

B. EXPERT SYSTEMS

Expert Systems, like FRESH, have been flooding the marketplace over the last ten years. They are computer based systems incorporating human "expertise" to help decision makers in complex decision environments and are emerging as significant components of operational human-machine systems [LANE 1986:121-125]. To date, expert systems have been used extensively in Medical Diagnosis, Mineral Prospecting, Chemistry, Mathematics, Speech Recognition, High Value Target Analysis, and Oil Drilling [TETER 1986:2-26]. Likewise, the Department of Defense (DOD) is a strong believer in expert systems and their present/future applications to Command, Control, Communications, and Intelligence (C3I) systems. Many military applications have been implemented from an expert system to train jet fighter pilots to an expert system to help DOD make smarter purchasing decisions in today's high cost procurement world.

One of the major stumbling blocks in today's DOD computer systems is that they involve software which is "non-portable, inflexible and largely unresponsive, expensive to develop and maintain, with little or no interoperability and few standards...." [LASHER 1982:26] In short, expert systems are a part of DOD that although becoming well entrenched, require further attention to overcome the previously mentioned shortfalls.

C. OBJECTIVES/RESEARCH QUESTIONS

The overall research question driving this thesis is concerned with changes to FRESH to transport it to the Commander in Chief Atlantic Fleet (CINCLANTFLT)--specifically system input and output changes needed.

The answer to this question is not trivial. The Atlantic and Pacific Fleets are run somewhat differently. This research is intended to identify these differences in so far as required system inputs to FRESH and desired system outputs from FRESH are concerned. In other words, what changes, regarding system input and output requirements, must be made to FRESH such that it meets the requirements of the Atlantic Fleet? Many Pacific Fleet FRESH input documents may be different than their counterparts on the Atlantic side. Likewise, the Atlantic Fleet may see different uses for FRESH and require the output in some other form than is presently provided by the Pacific FRESH.

D. SCOPE

This thesis is concerned only with the external system inputs and outputs of FRESH. It is not a research project on the inner decision making processes found in FRESH, nor is it designed to prove FRESH's effectiveness.

E. ASSUMPTIONS AND LIMITATIONS

One intent of this research was to assess the cost of making the required changes. However, while conducting this research and talking with Texas Instrument personnel it became readily apparent that these "change costs" could not be quantified. The reason for this is that T.I. can not produce a cost estimate unless contracted to do so.

Another limitation was the under-funding of travel. Although funding was available for a single trip to CINCPACFLT headquarters, there was insufficient funding for the author to travel to CINCLANTFLT headquarters and Texas Instruments in Dallas, Texas. This inability to travel to CINCLANTFLT headquarters forced the author to base his Atlantic Fleet findings on written correspondence and telephone conversations with appropriate personnel. This should not seriously affect the results.

Interest in FRESH was assumed to be high at CINCLANTFLT headquarters. In most cases this assumption held to be true. However, soliciting and receiving information from CINCLANTFLT was difficult due in large part to the aforementioned travel funding constraint.

The author feels that this thesis research will prove to be very useful. FRESH represents a valid requirement at CINCLANTFLT and this cornerstone research into the transportability of FRESH will provide valuable background for those attempting the actual transportation of FRESH in the near future.

F. METHODOLOGY

This research was carried out through an investigative approach that involved theoretical analysis of expert systems, a practical evaluation of FRESH and an overview of the external hardcopy inputs and outputs required of both Fleets.

G. ORGANIZATION OF THESIS

Chapter II presents an overview of Expert System Theory including a review of literature relevant to expert systems history, development and terminology.

Chapter III depicts CINCPACFLT's external hardcopy input and output requirements for FRESH. Also this chapter contains a comprehensive overview of the uses of FRESH in CINCPACFLT.

Chapter IV presents an overview of the present CINCLANTFLT employment scheduling system concentrating on their required external, hardcopy inputs and outputs. Then the CINCLANTFLT external hardcopy inputs and outputs are contrasted with their CINCPACFLT counterparts and differences are highlighted.

Chapter V sets forth the conclusions and recommendations, regarding external hardcopy inputs and outputs, for the proposed transfer of FRESH from CINCPACFLT to CINCLANTFLT.

II. EXPERT SYSTEM THEORY

The design and implementation of FRESH, as in any military command and control expert system is more complicated than that of an expert system intended for commercial use. This increased difficulty arises because, unlike private companies, DOD has many government regulations that must be followed and likewise, the continual turnover of military personnel throughout a project's design and implementation can have a negative impact.

FRESH in essence is a centrally controlled, strategic scheduling system. It must be able to operate in both peace and time-constrained combat and produce up-to-date, realistic, usable information to the Fleet Commander in Chief. But even though FRESH is strategic in nature, lives may be at risk due to "wrong employment of forces."

In order to better understand FRESH, one must first understand expert systems in general. The goal of this chapter is to provide a basic introduction to expert systems. It includes an overview of decision theory, expert system history and development, applications of expert systems in the world today, and how knowledge is acquired for expert systems.

A. THE BASICS OF EXPERT SYSTEMS

As described by Stefik [STEFIK 1982:1], expert systems are problem solving programs designed to help the user solve substantial, unstructured problems generally conceded as being difficult and requiring expertise. Expert systems are referred to as "knowledged based" because their performance depends critically on the use of facts and heuristics representing the knowledge of human experts. Through interaction with the user and by exercising the internal decision making logic provided by a human expert in a particular field (in the case of FRESH, the CINCPACFLT staff), the expert system helps the decision maker arrive at a solution for the problem at hand. Hayes-Roth went further in his definition of expert systems and described them in terms of seven features that he considers fundamental to the goals we should strive for in an expert system. [HAYES-ROTH 1983:43-50] These features are:

1. Expertise

The expert system must act as its expert human counterpart would--as much as possible their 'thought processes' should be similar. In other words, FRESH must perform as well as the CINCPACFLT staff, both in timeliness and quality of product. Preliminary results have shown this to be true for FRESH. As witnessed by the author, in day to day realtime casualty updating and decision making, what previously required several hours to complete manually, now takes only minutes with FRESH.

2. Symbol Manipulation

According to [HAYES-ROTH 1983:45], expert systems can not effectively use conventional, algorithmic computer languages to represent knowledge. Instead, they must use a symbolic reasoning language, i.e., they utilize symbols and symbol structures to represent and manipulate knowledge.

A brief Navy example is provided using a common symbol manipulation language--Predicate Calculus. Consider a ship labeled (B) and a 16" gun labeled (A). To denote that the 16" gun (A) is resting on top of the ship (B), the correct symbolic syntax would be: (TOP-OF A B), where TOP-OF is the functional symbol. These functional symbols delineate relations between entities [STEFIK 1982:4] and by stringing these symbols together, knowledge is represented. Although this example is simple, it gives a flavor of symbolic manipulation languages. FRESH is written in the symbolic manipulation language LISP.

3. General Problem-Solving Ability in a Domain

The expert system should possess all the available knowledge about a particular domain--in the case of FRESH, its domain is employment scheduling. Likewise, the expert system should be able to apply that knowledge not only to anticipated problems (for FRESH--typical employment scheduling), but also unanticipated problems, those one of a kind, highly unstructured problems. For example, an urgent requirement for mine sweepers in the Persian Gulf.

4. Complexity and Difficulty

Certain problem domains do not qualify as potential areas for expert system implementation because they are not complex enough. In other words, the reasoning involved in these "simple" domains may not contain enough steps or enough alternatives at any branch decision point to warrant the use of an expert system. In order for the requirement of an expert system to exist, the problem domain in question must be sufficiently complex and difficult.

5. Reformulation

An expert system should be able to take a problem presented in 'lay' terms and reformulate it into terms that it can use in processing by expert rules. In other words, the system must be able to take human inputs and translate them into appropriate symbolic statements that can be used by the computer. FRESH uses Natural Language Menu (NL menu) to facilitate this translation. NL menu attempts to translate English-like commands entered by the user into appropriate expert system functions [TENANT 1984:630].

6. Abilities Requiring Reasoning About Self

This means that the expert system must be able to "explain" how it arrived at its solution to a problem. No senior Naval Officer is going to take the recommendation of a computer unless he/she can see how that computer's decision was derived--FRESH must be able to explain its logic.

7. Task

An expert system must be specific. It must deal with a specific problem domain rather than a number of different disjoint, unrelated tasks. FRESH, an expert system specifically designed for scheduling U.S. Navy ships would perform only that task, it would not be used for any other unrelated task e.g., medical diagnosis.

The above attributes of expert systems depict "the optimum system." To date no one system possesses all of the attributes. In fact, reformulation and general problem-solving in a domain are attributes that are still being strived for and are in their infancy [HAYES-ROTH 1983:47]. In conclusion, an expert system should aim for all of the above attributes and have flexibility built into it such that it can 'grow' as requirements change over time.

B. DECISION THEORY

Discussion of expert systems naturally includes the topic of decision theory--since expert systems often are used to support a user in making decisions. The context of management decision making is the single most important factor when considering the design and implementation of an expert system.

Simon proposed the idea that all decisions can be boiled down to three phases--Intelligence, Design, and Choice

[SIMON 1971:26]. The intelligence phase is summarized as problem finding, searching the environment for conditions requiring decisions. The design phase is characterized as "inventing, developing, and analyzing possible courses of action...to solve the problem" [DAVIS 1985:310]. Lastly, the choice phase involves selecting one of the alternatives identified in the design phase. Although somewhat simplistic, Simon's model of decision making is often cited in decision making literature. Mintzberg touches on more detail regarding the managerial decision maker, the most likely candidate to become an expert system user [MINTZBERG 1973:45]. Mintzberg says that, "managers seldom make decisions as part of a deliberate, coherent, and continuous decision making process. Instead, the manager's workday is characterized by brevity, variety, and fragmentation, with, on average, less that five minutes continuously spent in any single activity" [MINTZBERG 1973: 45]. Anyone who has witnessed the typical Flag officer's workday will agree with this.

Tying together the philosophies of Simon and Mintzberg, an expert system should support the design and choice phases of Simon's model, while simultaneously reflecting Mintzberg's theory on how a management expert makes decisions, i.e., how he makes use of his time.

C. EXPERT SYSTEM HISTORY AND DEVELOPMENT

Roughly 20 years ago, Artificial Intelligence experts set out to make use of the latest available computer hardware and software and devise computer systems that could solve problems, answer questions and make decisions better (or at least much faster) than a human could. These experts wrongly felt that a powerful computer, armed with a set of "laws of reasoning" could generate a "computer expert" that would show superhuman effort [HAYES-ROTH 1983:7]. What they overlooked in their initial research was the impact of human expert knowledge. They relied too heavily on the abilities of the computer and neglected input from the human expert. In short, the first attempts at expert systems involved mathematics and chemistry problems that fit a certain structured decision making model and followed specific, standard rules. When these rules were applied by the computer, math and chemistry problems could be solved. Two examples of this initial attempt at expert system technology are:

1. DENDRAL--Developed at Stanford in the mid 1960s to analyze mass spectrographic nuclear magnetic resonance and other chemical experiment data to infer the plausible structure of an unknown chemical compound. [HAYES-ROTH 1983:7]

2. MACSYMA--Developed at MIT as a follow on to SAINT, which was developed in 1961. It is used to perform simplification of differential and integral calculus expressions. [HAYES-ROTH 1983:9]

Researchers then wrongly concluded that this same sort of expert system could be expanded and applied to a wider spectrum of problems including more difficult, unstructured problems [BENNETT 1983:210]. As further expert systems development continued using this thinking, it soon became apparent that researchers were more concerned with fitting the problem to the rule-based model rather than fitting solutions to the nonrule-based unstructured type of problems. In other words, they were concentrating on problems that could be solved using explicit models, those that were rule-based. It soon became readily apparent that the scope of expert systems research was heading down the wrong track. In 1977, Edward Feigenbaum, in a paper prepared for the International Joint Conference on Artificial Intelligence, verbalized the conclusion, "The power of an expert system derives from the knowledge it possesses, not from the particular formalisms and inference schemes it employs." Thus the conclusion was reached that knowledge, i.e., human expert knowledge, is required in order to build a sufficiently effective expert system. Using the concept of "knowledge is power," several expert systems were developed which incorporated human expert knowledge and human expert interaction. [MICHE 1981:8-11] A sample of these include:

1. CASNET--Used for consultation in diagnosis and treatment of glaucoma.

2. CADUCEUS--Used for diagnosis and treatment of internal medical problems.

3. MYCIN--Used for diagnosis and treatment of infectious blood diseases.

4. PROSPECTOR--Used to aid geologists in evaluating mineral mining sites.

The above applications have proven to be extremely reliable. In fact when MYCIN's performance was compared against manual, human diagnosis and treatment, the expert system was shown to perform at least as good or superior to most human medical experts [HAYES-ROTH 1983:10].

Based on the above, it appears that there have been two somewhat distinct phases of expert system development:

- early rule based systems that did not use human expert knowledge.
- later systems that incorporated human decision making heuristics within.

FRESH is of this latter category.

D. KNOWLEDGE ACQUISITION

If human expert knowledge is to be placed within a skilled computer system, if must first be extracted from the human expert and then translated and organized in such a manner that it can be effectively implemented into an expert system; knowledge acquisition is the term used to describe this action.

There have been several methods of knowledge acquisition proposed. Examples of four of these techniques are [BUI 1987b]:

1. Make the Developer an Expert

This is a somewhat unrealistic, if not extremely difficult method as it involves requiring the developer to become an expert in the field of the system, i.e., the developer of a medical expert system would have to learn everything a medical doctor knows prior to system development.

2. Use the Human Expert

This is the opposite difficult method and involves having the field expert develop the expert system, i.e., the doctor developing a medical expert system would have to become adept in expert system development--in other words, the doctor would have to become a computer expert!

3. Knowledge Engineering

This technique is the most popular. It involves a single knowledge engineer (an expert system computer type) becoming somewhat familiar with the field of study in question and through interaction with a select few application experts, translating the expert knowledge into a computer expert system usable format. This information, provided by the knowledge engineer, is then utilized by the expert system developers to produce the system. This is in fact the way that FRESH was designed and implemented. The knowledge engineer is a Texas Instrument employee, as are the expert system developers, the application experts are CINCPACFLT Naval officers.

4. Text Understanding Mode

Recently there has been research into automated knowledge acquisition, which basically involves computers 'reading' books on a particular application in order to gain the knowledge required to build an appropriate expert system. Although this technology may become useful in the future, today, the knowledge engineering method appears to be the standard way of acquiring knowledge.

Because knowledge engineering is the most effective and widely used method of knowledge acquisition set forth to date, it warrants further discussion. There are several distinct phases of knowledge acquisition [HAYES-ROTH 1983: 140-148].

5. Identification Phase

The following are identified: the major human experts to be utilized, problems to be solved, resources available to solve the problems and the major goals to be met. The computer systems expert attempts to become conversant in the language of the application. This involves repeated interaction between the knowledge engineer and the field expert.

6. Conceptualization Phase

In this phase, the information collected in the identification phase is formalized and tied together. Conceptualization should involve setting down on paper in the form of diagrams, narrative descriptions etc., the major concepts and interactions noted between the above entities discovered in the identification phase. Hidden causal relations and problem solving processes are searched for and identified. This again involves repeated interaction between the knowledge engineer and the field expert.

7. Formalization Phase

This is a further refinement of delineating the key concepts, subproblems and information flow characteristics found during the conceptualization phase. At this time, the knowledge engineer takes a more active role and sets forth possible ways of setting up the specific expert system to solve the problems identified. Specifically, models to solve the problem are discussed, these models can be either mathematic or behavioral. The most likely expert system building language (for the particular application) will be decided upon. Likewise, methods and associated costs of reliable data acquisition are highlighted. The bottom line is, what are the problems that are solvable given dollar constraints?

8. Implementation Phase

This phase is involved with integrating the formalized expert human knowledge collected in the earlier phases into the representational frame of the computer system that will form the expert system. More clearly stated, this is when the knowledge engineer translates the expert knowledge into a computer expert system usable format. This newly evolved representation of the human expert knowledge is then used to develop a prototype expert system.

9. <u>Testing Phase</u>

Finally, the prototype is tested. Tests range from easy, everyday type queries to hard, unusual, unlikely queries. In order to fully test the system, as many possible scenarios as feasible should be presented to the system with the system's resulting conclusions compared against expected human expert generated results.

The above steps are iterative and earlier steps may need rework when flaws are discovered in later steps. Since FRESH is being developed through the prototyping technique, i.e., analyzing, designing, and coding a small set of subproblems (modules), and immediately implementing them into the prototype expert system, this see-saw effect of problem identification and problem solution is expected to occur.

E. CHAPTER SUMMARY

To better help the reader understand FRESH, this chapter has introduced expert systems including an overview of decision theory, expert system history and development, applications of expert systems in the world today, and how knowledge is acquired for expert systems.

III. FRESH AT CINCPACFLT

The intent of this chapter is to provide for the reader a basic understanding of the CINCPACFLT perspective on FRESH. This includes how FRESH was developed, how it is used, and its input/output requirements.

A. CINCPACFLT GOALS FOR FRESH

CINCPACFLT's goals for FRESH are to use it as an extremely powerful automated aid to CINCPACFLT personnel in order to:

- generate Pacific Fleet unit long range employment schedules.
- perform as a tool to monitor Fleet readiness.
- determine the impact of changes to the Fleet (e.g., major mission-degrading casualty to a ship).
- generate alternative responses to these changes and recommend appropriate action.

There are several specific goals (see Appendix A) for the FRESH prototype. However, the most important is to collapse response time for significant planning/decision making, and allow CINCPACFLT personnel to make faster decisions. This makes sense, since as noted in Chapter II, one of the major reasons for an expert system is to assist the manager in making decisions as quickly as possible.

B. FRESH DEVELOPMENT

FRESH, an expert system prototype used in CINCPACFLT to generate Pacific Fleet ships long range employment schedules and to monitor Fleet readiness, determine the impact of changes to the Fleet (e.g., major mission-degrading casualty to a ship), and generate alternative responses to these changes, is being developed using the prototyping, middle-out approach to development. This method of development as described by Peter Keen, starts with defining what the user would like to see at the terminal (CRT screen display), then selecting commands and verbs familiar to the user (e.g., START, READ, QUIT), and lastly implementing these commands into Version 0--the first prototype. The aim is to support first, extend later. In other words, the goal of the prototyping method is to try to give the users something right away that they will readily accept, and then to add the less familiar, more complex capabilities later. The term middle-out pertains to "beginning close to the level of the problem at hand, and it involves a cyclical process of generalization (bottom-up) and specifying (top-down) at each stage of the problem solving process" [HURST 1983:124]. This procedure involves continuous feedback between the knowledge engineer and the user expert during the design and implementation process.

The prototyping method should not be confused with the more conventional top-down systems analysis and design technique which involves months (or even years) of long, drawn out, analysis and design for each and every module of the program prior to implementation [HURST 1983:125]. On the other hand, the prototyping method involves analyzing, designing, and coding a small set of subproblems (modules), and immediately implementing them into the prototype expert system.

These so-called subproblems are merely pieces (modules) of the pie that make up the whole expert system program. The main problem, is that problem for which the system has been developed to solve.

In FRESH the main problem area is, "all employment scheduling related problems," whereas a subproblem (module) would be, "Can ship A replace ship B?" The prototype is quickly developed and because of this the user has a working product (though incomplete) in his hands much faster than he could ever expect using the thorough step by step, top-down systems analysis and design approach. In terms of FRESH, this means that a specific subset of employment scheduling problem modules were tackled first and implemented into the prototype. As development proceeds other modules are continually being added and this process will continue until FRESH is complete i.e., contains all modules encompassing the total employment scheduling problem. According to Bui and Sivasankaran [SIVASANKARAN 1987:737]:

> ...prototyping consists of an implementation methodology that focuses on the effort in building a quick and working

prototype or model that has the minimum features, and meets the basic information requirements.

Charles Rich refers to this process as "incremental automation" [WINSTON 1984:132]. Both the user and the developer are expected to make mistakes, but attempts to learn as much as possible from these mistakes is the key to making the prototyping method effective [SIVASANKARAN 1987: 737].

FRESH, since it is still in the prototype stage of its development, receives new software updates every 45-90 days. These software updates include both new modules and reworked existing modules (those that required changes/updates). Present real-time operational uses of the FRESH prototype are very limited, as would be expected, however the future holds much promise. Both present and future uses of FRESH are discussed below in terms of the major reports generated by FRESH and the major queries answered by FRESH.

C. FRESH USES AT CINCPACFLT

The FRESH uses listed below are highlighted for illustration purposes. They include the two major reports: Alert Summaries and Long Range Employment Schedules and some typical ad hoc queries.

1. Alert Summaries

FRESH's current primary operational duty is to produce daily Alert Summaries for CINCPACFLT staff meetings. These Alert Summaries provide a listing of operational units having a Combat Readiness Rating of C3 or C4 (marginally combat ready or not combat ready respectively) [NWP-10-1-11 1985:34]. An Alert Summary is generated when a unit fails to meet certain thresholds for Mission/Combat Readiness, the specifics of Alert Summary Generation are outlined in Figure 3-1.

- when a unit submits a deficiency report, this report contains a numerical value for the area of degradation --overall combat readiness, primary mission, equipment, personnel, training, support, and each applicable secondary mission.
- FRESH compares this numerical value (provided by the unit) to the threshold table value that was previously constructed from data provided by the user.
- when a unit's readiness value in one of the specified areas e.g., overall combat readiness, primary mission readiness (equipment, personnel, training, support) or applicable secondary mission, is equal to or less than the user provided threshold value, an alert is generated.

Figure 3-1 Causes of Alert Summary Generation

The threshold values mentioned above, are at present, expressly for the unit's primary mission area. They are set to generate an alert if a unit is above its threshold for either an input Casualty Report (CASREP) or an input Unit Status and Identity Report (UNITREP). In essence the given threshold can be thought of as the equipment, personnel, training, and support required to effectively fulfill the primary mission area. Degradations affecting equipment, personnel, training, and support required to effectively fulfill the primary mission area are reported by either UNITREP, CASREP or both.

FRESH has the capability for the user to set threshold values for secondary mission areas but this is not currently done as there appears to be little CINCPACFLT interest in monitoring secondary mission areas on a general basis. Once the ability of FRESH to correctly identify significant events is proven to the CINCPACFLT staff, an interest in monitoring secondary mission areas may be seen.

It should be noted that the threshold values may be changed dynamically, i.e., by the user at any time prior to a FRESH run. These threshold values are the basis for generating unit replacements when a unit must be replaced to meet an operational commitment. To illustrate this, if an anti-aircraft unit reported a Combat Readiness Rating of C4 (not combat ready) and consequently had to be replaced to meet an operational commitment, the FRESH user would put a high threshold number in the anti-aircraft primary mission area threshold table. Thus in order for a unit to be selected to replace the above C4 unit, it would have to have to meet the high anti-aircraft capability threshold specified by the FRESH user.

At first glance this Alert Summary sounds as if it would be quite valuable, but the Alert Summary lacks sufficient data to make it a useful document. The Alert

Summary does not state what is driving the high Combat Readiness Rating--the CINCPACFLT staff only knows that SOMETHING is wrong, they don't know WHAT is wrong. This lack of sufficient knowledge forces the CINCPACFLT staff to conduct further research, through FRESH, to determine the cause of the high Combat Readiness Rating (reasons can range from the ship having a major equipment failure to only lacking training in a particular area). This apparent breakdown of the knowledge engineering system can be attributed to either problems in the Formalization Phase (refinement of subproblems) or the Implementation Phase (integrating knowledge into the computer representational framework) [HAYES-ROTH 1983:144-146]. It is not the intent of this research to fix blame. CINCPACFLT personnel are working to change the Alert Summary Report to include the reason for the poor Combat rating.

2. Long Range Employment Schedules

Long Range Employment Schedule production is in its infancy. Manually produced Quarterly Employment Schedules are used as the primary input. Then FRESH focuses on the major ship in the battle group, for example the carrier in a Carrier Battle Group, and bases the Long Range Employment Schedule on this particular platform's long range maintenance schedule. The same procedure is followed for Amphibious Ready Groups, Battle Ship Battle Groups, Cruiser Battle Groups, etc. This long term scheduling system appears to be very weak in terms of making effective use of FRESH technology, too much up front manual work is required to prepare Quarterly Employment Schedule input to FRESH (it may take weeks or months to manually produce the Quarterly Employment Schedules). One flaw appears to be the large amount of manual labor required to produce this Long Range Employment Schedule. This flaw is serious because it is in direct conflict with the reason for having a computer system --to reduce the amount of human manual work that is required.

Another apparent flaw is that basic assumptions have been made are not always true, for example the assumption that all members of a battle group will always deploy centered around the same major combatant (e.g., carrier) is not a good long range planning assumption. Why? Because a Destroyer's maintenance requirements are not the same as the carrier that it deploys with. This lack of concern for the "small boys" seems to be the weakest link in the system. The only platform with a valid Long Range Employment Schedule would be the platform that the battle group is formed upon. The 'small boys' Long Range Employment Schedule might be in sync with the major combatant for the first year but little credibility can be given to the schedule for the out years unless of course CINCPACFLT makes it a hard and fast requirement that battle group composition remain constant--an unrealistic and hard task to manage.

3. <u>Ad Hoc Queries</u>

This is the area in which FRESH shines. The scheduling scenarios that can be set up, projected, changed, and tested appear almost limitless. Specific examples of FRESH ad hoc queries and respective outputs will be provided later in this chapter. It is obvious to any user that the FRESH prototype is not effective in producing employment schedules (see above), rather FRESH is an extremely powerful tool when tasked to manipulate employment schedules and answer 'What if' types of questions.

For example, if an Aegis Class Cruiser is unable to deploy with its battle group, what will be the impact on battle group readiness? Do we need to replace the missing ship? If there is not another available Aegis Class Cruiser can we get a comparable platform to replace it? What weapons and resources will be needed to offset the loss of the Cruiser? Queries presently may only involve a single unit (ship or submarine) however in the future FRESH will hopefully be able to evaluate the overall capacity of an entire battle group [DELEOT 1987:2]. Queries such as--"How long will it take to move a ship from point A to point B?" can also be answered. FRESH is very powerful in its ability to work out hypothetical situations without interfering with the real world, i.e., without interfering with the actual data in the FRESH database.

D. PROBLEMS WITH FRESH AT CINCPACFLT

1. Database

a. General Problems

The database is to some extent not qualitatively correct. Through discussions with CINCPACFLT, Texas Instruments and BTG representatives and likewise through the author's observations, it was noted that the database contains both duplicate and incorrect data. CINCPACFLT personnel further stated that there are empty fields within the relations in the database and that modification, insertion and deletion anomalies [KROENKE 1983:287] are present.

This leads one to believe that the data found in FRESH's relational database is not correctly normalized. Rather, the normalization rules which are designed to prevent update anomalies and data inconsistencies are not at a sufficient level to preclude serious problems with the FRESH database. In order for FRESH to become a viable, usable tool this database must be redesigned to meet at least fifth normal form (when a record's information content cannot be reconstructed from several smaller record types [KENT 1985:120]) and be filled with correct data.

b. Configuration Data Problems

FRESH contains configuration data within its database. This configuration data outlines, among other things, which equipment is installed on which unit. Through close observation, it is readily apparent that incorrect data is rampant in this portion of the database. The configuration data on file was provided by the Naval Ocean Systems Center (NOSC), San Diego and was based on the configuration of the lead ship in a class of ships e.g., all Spruance Class Destroyers have the same configuration data as that found on file for the U.S.S. Spruance. It is assumed that the lead ship's configuration data was obtained from the Weapons Systems File which is the master configuration file for all United States Ships and Submarines [NSCS 1983:I.6-2].

This generalization that all ships in a class have identical configuration is grossly incorrect and in fact the Navy Ships Parts Control Center in Mechanicsburg, PA (the maintainer of the Weapons Systems File) feels that after five years from the start of construction of a new class of ships, at most, 50% of the equipments found on the lead ship are common equipments on follow on ships of the class. CINCPACFLT personnel are aware of the problem and are seeking new avenues for the submission of configuration data, however it is the author's belief that FRESH should utilize Level A (unit to installed equipment on unit) of the

Weapons Systems File as the basis for this configuration data. Although it is commonly known that the Weapons Systems File is not 100% complete, it is the best configuration file available.

2. Testing

According to Texas Instruments and BTG representatives, it is extremely difficult, if not impossible, to fully test out a module of FRESH code. In large part this problem exists simply because the number of queries that can be made of an individual module of code is practically unlimited. In a problem related to the database issue, when problems are found it is difficult to pinpoint if the fault resides in FRESH or in the database. This results in almost doubling of the time required to find the solution to a surfaced problem.

3. Problem Summary

FRESH has problems, but once detected, these problems are being attacked with a vigor. The major drawback in the FRESH implementation is without a doubt the database issue noted above. Until the FRESH database is fixed, FRESH development will continually be hampered by problems caused by bad data.

E. CINCPACFLT FRESH EXTERNAL SYSTEM INPUTS

It is apparent that the most important input to FRESH is the present geographical position of a unit. This geographic position can be input to FRESH by Casualty

Report, Unit Status and Identity Report, Movement Report, Pacific Advanced Command Exchange (PACACE), and unit submitted weather report messages. The most recent geographical position data (regardless of input mode) will automatically update the FRESH database.

Unless otherwise stated in the narrative, the below inputs are standard all-Navy reports, i.e., they are used on both Atlantic and Pacific coasts and therefore would not require change in order to transport FRESH from CINCPACFLT to CINCLANTFLT. A summary of FRESH external system inputs is shown in Figure 3-2.

REAL-TIME LOAD--PACACE (Blue Positional Reports), FOSIC (Red Positional Reports)

WWMCCS LOAD--UNITREP (subset), Ship's Positional data (Departure Report, etc.)

TAPE LOAD (twice/week)--Weapons Loadout, Quarterly Employment Schedule

TAPE LOAD (Quarterly)--Configuration data from NOSC

MANUAL LOAD--CASREP data, MOVREP data

FUTURE INPUT--Port Information, Routing Information.

Figure 3-2 FRESH System Inputs

1. Real-time Computer Input

a. Pacific Advanced Command Exchange (PACACE)

This is a Pacific Fleet Integrated Tactical Decision Aid that assists the Battle Group Commander in rapidly assessing threat information. It is used as a FRESH input to provide geographic positions of U.S. Forces, otherwise known as Blue Positionals. When PACACE reports are received at CINCPACFLT, unit positional information is gleaned from them and is placed in the FRESH database. The Atlantic Fleet counterpart of this system is called the Joint Operational Tactical System (JOTS). According to CINCPACFLT, JOTS and PACACE are the same system they simply have different names on the different coasts.

b. Fleet Ocean Surveillance Information Center Reports

The Fleet Ocean Surveillance Information Center (FOSIC) provides CINCPACFLT with position information on Soviet, Chinese, Vietnamese, North Korean, and other unfriendly forces, otherwise known as Red Positionals. FOSIC reports ensure appropriate early warning to the Seventh Fleet Commander and to the Commander of the Middle East Force (COMSEVENTHFLT and COMMIDEASTFOR respectively) regarding high interest or threat activity for the assigned areas of responsibility [COMSEVENTH 1984]. These Red Positional reports are likewise fed into the FRESH database.

2. <u>Pseudo Real-time Computer Input (Update Every 6 Hours</u>)

a. Unit Status and Identity Report (UNITREP)

A subset of data from the Unit Status and Identity Report (UNITREP) is fed into the FRESH database via the World Wide Military Command and Control System (WWMCCS) every six hours. A UNITREP is submitted to inform the National Command Authority of changes to unit identification, location, general status, current unit activity and employment, weapons load out and combat readiness information [NWP-10-1-11 1985]. As far as FRESH is concerned, UNITREP presently only provides the geographical position of the unit and the combat readiness rating which FRESH compares against the threshold values loaded into the system by the FRESH user.

The subset of UNITREP data is automatically accepted by the FRESH database (the geographical position of the unit and the combat readiness rating). This UNITREP data oversight was an interface design omission and BTG Inc. is working to correct this deficiency--most data found on UNITREP is important to FRESH (especially the weapons load out) and should be included within the FRESH database. Further discussion below will identify how other UNITREP data (not included in the WWMCCS subset) is loaded into FRESH today 'manually.'

b. Ship's Position Reports

This standard Navy report simply depicts a unit's geographical position. A common example of a positional report is a Departure Report which a unit submits just as it leaves a port. There are also reports which must be submitted when entering a port. This data updates a unit's geographical position within the FRESH database.

3. <u>Magnetic Tape Load (Twice Per Week)</u>

a. Weapons Load Out

This is one of the data fields that should be automatically updated via the UNITREP, but due to the interface design mentioned above, it was left out and now must be manually gleaned from UNITREP, put on tape, and loaded to FRESH twice a week. This weapons load out depicts significant weapons that a unit presently holds. This information is important in both a strategic and tactical sense.

b. Unit Employment Schedule

This information is prepared at CINCPACFLT Headquarters and is based on what a unit is scheduled to do and is updated based on what the unit is actually doing. Dynamic changes due to real world requirements, often change the employment schedule already on file. This employment schedule data is used as a basis for update changes to a units future employment.

4. <u>Magnetic Tape Load (Every Three to Five Months)</u>

a. Unit Configuration Data

This data is provided by the Naval Ocean Systems Center (NOSC), San Diego and is used to update unit configuration (which units have which weapons systems) in the FRESH database. Problems with this data are outlined above. This data includes listings of the unit's installed equipment, specific characteristics of the equipment such as associated signals and effective ranges, and unit fuel usage statistics. In contrast to the Weapons Loadout, Unit Configuration Data may be thought of as a unit's installed equipments i.e., a specific radar or gun fire control system that is organic to the unit as opposed to a specific special weapon not always found on a unit e.g., Harpoon Missiles, which might be placed on a unit for a specific evolution; these would be noted in the Weapons Loadout.

5. <u>Manual Load (Keyboard)</u>

a. Casualty Report Data

A Casualty Report (CASREP) is used to: a) report an initial equipment casualty, b) update the chain of command on the status of the casualty and c) report that the casualty has been corrected. Through CASREP, the chain of command is advised of significant equipment malfunctions which may result in the degradation of a unit's readiness [NWP-7 1984:B-1]. FRESH uses the mission rating provided by CASREP to compare against the mission rating thresholds already established for the given unit. This data is manually loaded as soon as it is received from the fleet. CASREP data is scheduled to be loaded realtime, via the World Wide Military Command and Control System (WWMCCS) in the summer of 1988.

b. MOVREP Data

A Movement Report (MOVREP) in general is used to report: a) a departure from port, b) an arrival into port, and c) the intended courses and speeds a unit anticipates using while going between point A and point B [NWP-7 1984: 11-1]. Likewise, if there is a change to a unit's planned movement a MOVREP would be required. FRESH uses this data to update unit position. Like CASREP, this data is manually loaded as soon as it is received from the fleet and is scheduled to be loaded realtime, via the World Wide Military Command and Control System (WWMCCS) in the near future.

c. Personnel Tempo and Operational Tempo Data

The Chief of Naval Operations has established a policy regarding the maximum duration of time that a ship may spend away from homeport. In terms of personnel, this is referred to as PERSTEMPO and in terms of the operating unit this is called OPTEMPO. The OPTEMPO/PERSTEMPO policy was developed in response to sagging morale and lower retention that was thought to have been caused by arduous, extended deployments. Because of this policy, the FRESH database includes OPTEMPO/PERSTEMPO information, e.g., start date of a unit's deployment. This OPTEMPO/PERSTEMPO data is used to ensure that units do not exceed the six month deployment length maximum and that units in fact exhibit a two for one turnaround time between deployments (six months deployed, twelve months operating out of homeport). There are several other OPTEMPO/PERSTEMPO constraints included in the FRESH unit replacement algorithm however inclusion in this thesis is unnecessary. Suffice it to say that

OPTEMPO/PERSTEMPO restrictions play a significant role when FRESH performs analysis to determine replacement units.

d. Fuel Cost Information

Fuel costs, per barrel, are loaded into the FRESH database and are used in concert with the fuel usage data already in FRESH to calculate the fuel cost that will be incurred by unit replacement, e.g., if several unit replacement candidates are generated by FRESH, which one will cost the least (in terms of fuel) to transit to the required area?

6. Future FRESH Inputs

a. Port to Port Routing Data

This routing information will include the most efficient land avoidance routes between any two Pacific ports. Route efficiency will be determined based on fuel costs, weather, and avoidance of areas of hostility.

b. Western Pacific Port Data

Information on Western Pacific (WESTPAC) ports will include descriptions of fuel facilities, drydock facilities, repair facilities, etc. The value of this data should be obvious, if CINCPACFLT is required to divert a unit into port because of an equipment casualty, they must be able to readily assess the location of the nearest port that can effect the required repairs.

F. CINCPACFLT FRESH EXTERNAL SYSTEM OUTPUTS

1. Alert Summaries

As noted above, FRESH provides Alert Summaries as they occur. Alert Summaries provide a listing of operational units having a Combat Readiness Rating of C3 or C4 (marginally combat ready or not combat ready respectively) [NWP-10-1-11 1985], and are used in the daily flag-level brief to the CINCPACFLT staff.

2. Long Range Employment Schedules

Long Range Employment Schedules reflect the timeframes and sequencing of all major predeployment evolutions for a unit over a five year time period. According to the available FRESH documentation, Long Range Employment Schedules are supposed to be used as the basis for building the quarterly employment schedule. However, after questioning CINCPACFLT personnel, it was readily apparent that presently FRESH performs just the opposite, i.e., FRESH determines Long Range Employment Schedules based on the manually produced quarterly employment schedule. The author feels and CINCPACFLT personnel agree, that FRESH is a long way from reaching the point of producing automated quarterly employment schedules based on the Long Range Employment Schedule. Presently, FRESH updates Long Range Employment Schedules as changes occur and these new schedules are distributed to those requiring the information. Problems with the Long Range Employment

Schedule as generated by FRESH are discussed above in Section C.2.

3. Alternative Unit Replacement

When a unit experiences a degradation which precludes it from carrying out its mission, replacement units are generated by FRESH. These replacement units are ranked according to their ability to fulfill the required mission and FRESH will provide a rational explanation as to why replacement units were ranked as they were. The user can also query FRESH as to the impact of selecting a specific replacement unit, e.g., what missions will the replacement unit be unable to perform as a result of the redirection?

4. Geographic Displays

FRESH allows the user to view geographic displays of the Pacific using a mercator projection, a stereographic projection, a gnomonic projection or a true view projection. On these geographic displays, the user may view any or all units' current positions (based on latest geographical position submitted), future positions, past and future tracks, and land avoidance routes (yet to be implemented).

5. Contexts

The term contexts refers to FRESH's ability to answer queries based on an artificial situation, a "what if" situation. Examples include:

- what if ship A replaced ship B?

- what if ship A were equipped with equipment C?

- what if ship A had a C-4 CASREP (equipment inoperable)?

- what if the overall combat readiness of ship A was C4?

- what if the fleet wide OPTEMPO changed to ___?

- what if the fleet wide PERSTEMPO changed to ___?

6. <u>Calculations</u>

FRESH has the ability to calculate the fuel cost of moving a unit from position A to position B. It can likewise compute the OPTEMPO, turnaround time, or deployment time (duration) of a unit.

7. <u>Database Queries</u>

The user may query the FRESH database to find out information on specific units, type and number of weapon(s)/equipment(s) carried on a unit, and specific characteristics such as associated signals, effective ranges, etc. Many examples are included in appendices B and C. However, to give the reader a flavor, the following examples are provided:

- list the associated signals of radar A.

- list all CASREPs for a ship.

- list the Anti Air Warfare rating of all applicable ships in CTF-75.

- list positions of one or more units.

- list all ships equipped with the Harpoon missile system.

- list the readiness history of a ship.

8. Output Conclusions

The above mentioned FRESH outputs are by no means to be considered all encompassing. The intent of the queries cited is to give the reader a broad view of the power of FRESH. The knowledgeable user of FRESH will possess an almost limitless ability to query the expert system regarding any of the attributes mentioned above.

G. CHAPTER SUMMARY

This chapter built upon the expert system theory foundation provided in Chapter II by depicting an actual expert system--FRESH. Specific topics included--FRESH's prototype method of development, FRESH's use of the knowledge engineering method of knowledge acquisition, problems experienced with both prototyping and knowledge engineering, uses of FRESH at CINCPACFLT, and FRESH's required inputs/outputs.

This now leads us to Chapter IV where CINCLANTFLT's existing unit scheduling system will be discussed and contrasted with that provided by the expert system FRESH in CINCPACFLT. Specifically, CINCLANTFLT's unit scheduling system inputs and outputs will be contrasted with those of CINCPACFLT, which have already been listed.

IV. CINCLANTFLT PERSPECTIVE--CAN FRESH HELP?

The basic goal of this thesis is to identify differences between CINCPACFLT and CINCLANTFLT inputs and outputs associated with FRESH. Chapter III presented the CINCPACFLT story. Now CINCLANTFLT's perspective will be presented. This view will include the inputs CINCLANTFLT uses to manually produce Long Range Employment Schedules, how rescheduling of ships occurs when casualties arise, and outputs that CINCLANTFLT's manual system generates that would be considered essential to be produced by FRESH were it to be transported to CINCLANTFLT.

CINCLANTFLT is extremely interested in FRESH, in fact, since beginning this research, CINCPACFLT and CINCLANTFLT staffs have met regarding FRESH. The Atlantic personnel have been impressed with FRESH's performance and its possibilities. Because of this, there is little doubt that FRESH will eventually be transferred to CINCLANTFLT if Congress provides funding. (In light of present budget constraints this funding may not materialize.)

A. CINCLANTFLT EMPLOYMENT SCHEDULING SYSTEM OVERVIEW

Unlike CINCPACFLT's scheduling operation, with its automated support through FRESH, CINCLANTFLT's employment scheduling system is highly manual, requiring several full-time scheduling officers and additional personnel at various levels of management, with little computer assistance provided. Their approach to building unit employment schedules is similar to CINCPACFLT's in that it is a bottom up as well as a top down approach. Input is received from the unit's respective Type Commander (Commander Naval Surface Forces Atlantic, Commander Naval Air Forces Atlantic or Commander Naval Submarine Forces Atlantic), Group Commanders, Squadron Commanders and the individual Unit Commanders themselves and goes up through the chain of command to CINCLANTFLT. Likewise, requirement inputs are pushed down the chain of command to CINCLANTFLT from the Secretary of Defense (SECDEF) and Chief of Naval Operations (CNO). The collection of these inputs culminates in the quarterly scheduling conference (chaired by CINCLANTFLT) where the actual quarterly employment schedules are manually constructed. In the overall process, computers are only used to store and retrieve schedule data; they are not used in any way to assist in the decision making process [GOODMAN 1985:9]. CINCPACFLT's employment scheduling process is somewhat more geared toward the bottom up approach, i.e., requirements are initially submitted by the unit itself and additional requirements (including required maintenance) are added as the schedule works its way up through the chain of command. Then at the CINCPACFLT level, SECDEF and CNO requirements are added.

B. CINCLANTFLT NAVAL UNIT CONTROL

It appears that scheduling and control of the Naval units on the Atlantic coast is somewhat more decentralized than on the Pacific coast. Although the author at first thought that this policy might have been a result of the existence of FRESH at CINCPACFLT headquarters, this proved to be untrue. CINCPACFLT personnel state that this "centralization of control" is just PACFLT tradition. In any case, scheduling and control in the Atlantic is more decentralized than in CINCPACFLT.

C. CINCLANTFLT EMPLOYMENT SCHEDULE INPUTS[1]

1. Maintenance Schedules

These schedules include major maintenance/overhaul schedules, new construction vessels available, units that will undergo inactivation during the timeframe concerned, minor maintenance/post overhaul availablilities, selected restricted availabilities, and intermediate maintenance availabilities.

Maintenance schedules are maintained and promulgated by the unit's type commander in both the Atlantic and Pacific fleets.

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[1]CINCLANTFLT inputs to the employment scheduling process were solicited via correspondence and the response received was in terms of the Commander Submarine Forces Atlantic perspective (considered representative of CINCLANTFLT). All inputs are manually generated and submitted.

2. Unit Deployment Requirements

This category of input includes both mandatory deployments, i.e., those that have been dictated by higher command and must be undertaken, and discretionary deployments, i.e., things that they would like to have done --usually proposed via lower levels in the chain of command.

This process is conducted in the same fashion in both PACFLT and LANTFLT.

3. Personnel Tempo and Operational Tempo

In the process of determining the required deployments mentioned above, Personnel Tempo and Operational Tempo (PERSTEMPO/OPTEMPO) are also considered. As outlined earlier, the Chief of Naval Operations has established an all-Navy policy regarding the maximum duration of time that a ship and it's personnel may spend away from homeport. This is termed PERSTEMPO/OPTEMPO. This policy applies to both CINCLANTFLT and CINCPACFLT in exactly the same way and is further described in Chapter III.

4. Unique Material Conditions

In this category of deployment scheduling, CINCLANTFLT considers the class of the ship and, the combat systems configuration e.g., specific sonar, fire control system, and electronics surveillance system on specific units, the unit's weapons capability, the unit's speed capability, fuel limits etc. In addition to those material conditions which strictly deal with a units material configuration, CINCLANTFLT likewise considers the unit's Commanding Officer's deployment experience, and the crews overall deployment experience.

5. Major Unit Exercise Requirements

These exercise requirements include the minimum and maximum participation expected for NATO Exercises, Joint Exercises, Fleet Exercises and Type Commander Exercises.

6. Major Unit Inspections

This input is received by all commands that could possibly inspect a unit during the year. The type of inspection that is scheduled can range from supply inspections to nuclear material security inspections. Also included in this category would be live weapon firing for proficiency testing.

7. Desired Evolutions of Unit

This input defines the activities that the unit commander would like to perform during the scheduled time period; they include changes of command, dependent cruises, desired periods at sea, desired periods inport, desired port visits, etc.

8. Fleet Services Requested

These are services that are requested by the numbered Operational Fleet commanders, 2nd Fleet on the Atlantic coast and 6th Fleet in the Mediterranean (likewise in the Pacific by the 3rd and 7th Fleets). When unit assignments are made to fulfill these requirements, once again unit capabilities are considered, e.g., unit class, combat systems embarked on the unit, unit speed limits, and fuel limits, in the case of submarines--depth limits, under ice capabilities.

9. <u>Miscellaneous Considerations</u>

This category would include such things as Blue and Gold crew training periodicity for Ballistic Missile Submarine crews and all other out of the ordinary considerations.

D. DYNAMIC UNIT RESCHEDULING

As noted in the beginning of this chapter, the quarterly employment scheduling process performed by CINCLANTFLT is primarily a manual operation. This is likewise the case when it comes to dynamically rescheduling units based upon changing requirements. Discussions with CINCLANTFLT personnel highlight an extremely labor intensive effort required to replace ships with material casualties--in fact CINCLANTFLT personnel told this author they were so busy performing this manual labor that they would only be able to provide limited support for this research.

The primary cause of dynamic rescheduling is sudden degradation of a unit, e.g., material casualties precluding a unit from fulfilling its requirements. Due to a change in a disabled unit's M-rating or C-rating it is identified as requiring replacement by a comparable unit with similar capabilities, and thus dynamic rescheduling is required. As is found in the logic of FRESH, this activity is usually triggered by the receipt of a Casualty Report (CASREP) or Unit Status and Identity Report (UNITREP). Armed with the reported casualty, the CINCLANTFLT staff then commences the long drawn out manual process of determining a replacement unit.

When a unit reports a casualty and a subsequent inability to fulfill a requirement, the CINCLANTFLT staff checks its positional database (the only automated aid they have) to see which possible replacement units are in the vicinity of the unit requiring replacement. Then based on their personal experience with what capabilities the possible replacement units have, and after manually checking the employment schedules of possible replacements, they decide on a replacement unit. There is no database containing unit configuration available to CINCLANTFLT--unit capabilities are either based on personal experience with a specific unit or through manually looking up a unit's configuration. This manual process is likewise undertaken to determine which units have what special weapons aboard, e.g., harpoon.

Utilizing FRESH technology this dynamic rescheduling process would take only minutes, however operating in the manual mode, it may take CINCLANTFLT personnel a full work day or longer, involving several individuals; the benefit of FRESH is obvious.

E. CINCLANTFLT EQUIVALENT OF ALERT SUMMARY

As depicted in Chapter III, paragraph C.1, FRESH automatically provides the CINCPACFLT staff with a daily Alert Summary which provide a listing of operational units having a Combat Readiness Rating of C3 or C4 (marginally combat ready or not combat ready respectively) [NWP-10-1-11 1985]. FRESH generates an Alert Summary whenever a unit fails to meet certain thresholds for Mission/Combat Readiness. CINCLANTFLT's equivalent of the FRESH generated Alert Summary is merely a manually produced summary report of all CASREPs and UNITREPs received since the last staff briefing. One major problem with this procedure is that they don't know that something is wrong until they have the CASREP or UNITREP in hand. CASREPs and UNITREPs can be very long documents which are not in a very user-friendly, readable format; put simply, crises don't jump out at the reader as quickly as they do in the Alert Summary format provided by FRESH. Each CASREP and UNITREP must be read by the CINCLANTFLT staff, digested, and summarized into a format presentable to CINCLANTFLT at the morning briefings. This manual effort takes several manhours to complete and must be done daily to provide CINCLANTFLT with the most up to date information on the readiness of the Atlantic Fleet.

F. AD HOC QUESTIONS

Due to CINCLANTFLT's lack of automated assistance, they are unable to perform timely ad hoc, "what if?" type of questioning regarding the scheduling or employment of units without a significant amount of manual effort and time. In fact, discussions with CINCLANTFLT personnel indicate that the process of doing any sort of sensitivity analysis on scheduling is so time consuming that they rarely even attempt it. This puts them in much more of a reaction mode than is seen in CINCPACFLT.

In CINCPACFLT, if a unit reports a minor casualty that they feel could develop into a major casualty, sensitivity analysis (what if this unit becomes mission incapable?) can be done simply through FRESH. However CINCLANTFLT, due to the tremendous labor required to perform such an analysis, is more likely to wait until the unit is mission incapable before doing any schedule manipulation.

G. CINCLANTFLT SCHEDULING OUTPUTS

The intent of this section is to set forth what different outputs (or changes to existing outputs) CINCLANTFLT would desire if FRESH is transferred.

1. Employment Schedules

CINCLANTFLT was impressed with FRESH's ability to readily update employment schedules as changes in requirements dictate, however they desire an 'automatic update' capability down through the chain of command. In other words, they would like FRESH to automatically generate and forward the new approved/updated employment schedule down through the chain of command to the unit. In this way, everyone would be readily assessed of the changes and could make required adjustments.

2. Port to Port Routing

As noted in Chapter III, Section E.6.a, FRESH will soon have the capability to generate land avoidance routes from port to port. CINCLANTFLT is pleased with this idea however, they feel that the FRESH output screen format may be of insufficient granularity (not clear or precise enough) to provide a quality picture for the shorter routes typically taken by units operating in the Mediterranean. Likewise, the smaller bodies of water (e.g., Mediterranean Sea, Black Sea, Ionian Sea) usually traveled by deployed Atlantic fleet units must be expanded in the FRESH knowledge base to show greater detail.

Discussions with CINCPACFLT personnel indicate that this 'granularity upgrade' is presently not possible due to hardware constraints (not enough memory), but will be available if a proposed hardware upgrade to expand the existing memory is approved and implemented.

3. NATO Requirements

CINCLANTFLT is a double hatted position. In addition to being in command of the U.S. Atlantic Fleet, CINCLANTFLT is also the commander of the Supreme Allied

Command Atlantic. Therefore CINCLANTFLT commands both U.S. and NATO forces and feels that in addition to Atlantic U.S. Naval entities, FRESH should also include NATO forces.

a. Knowledge Base and Database Enhancements

CINCLANTFLT desires to add NATO naval units, with their respective characteristics (weapons/sensors), to the FRESH database. In addition they would like to have Warsaw Pact units included in the knowledge base for tracking purposes.

b. NATO Mobilization

In the event if a crisis situation that would trigger a NATO response, CINCLANTFLT would want the capability to 'switch' on NATO forces such that they would be equally considered with U.S. forces as replacement units in so far as FRESH is concerned. Ideally they would prefer that these 'switches' be country based in addition to a NATO collective switch. This country based switching would allow CINCLANTFLT to only consider units from those NATO countries that were actually called into action.

H. CAN FRESH HELP?

Several CINCLANTFLT schedulers indicate that they looked forward to the installation of FRESH. Their scheduling process, as it exists today, is so labor intensive that any assistance would be instantly accepted. In terms of the Nolan Stage Model of information systems, it is felt that CINCLANTFLT would almost instantly jump from the initiation stage (limited use by small number of users) to the contagion stage (proliferation of use, many users) [DAVIS 1985:451]. In other words, it is felt that FRESH would almost instantaneously be identified by CINCLANTFLT as an invaluable tool in terms of scheduling, alert summary generation and ad hoc query ability.

I. CHAPTER SUMMARY

In this chapter, the CINCLANTFLT perspective toward scheduling was set forth. Discussion centered on their Long Range Employment Scheduling system, unit replacement scheme and their lack of an effective mechanism with which to perform ad hoc/sensitivity analysis for unit replacement. The labor intensive nature of the CINCLANTFLT system has been contrasted with the automated capabilities of FRESH where appropriate.

Through discussion with CINCLANTFLT personnel, the strong impression is that offering FRESH to them would be equal to offering a tractor to a farmer that has for years been plowing with a horse. Use of the FRESH prototype in CINCPACFLT sets them light years ahead of their manually functioning Atlantic Fleet counterparts.

FRESH input and output requirements for CINCLANTFLT were discussed. It was noted that little if any changes need to take place on the input side to transfer FRESH to the Atlantic. Concerning FRESH outputs, certain CINCLANTFLT specific requirements have been addressed and no doubt once CINCLANTFLT becomes more familiar with FRESH their desire to tailor FRESH more specifically to their needs will require further changes to FRESH outputs.

V. CONCLUSIONS AND RECOMMENDATIONS

The United States Navy, with its construction of the prototype expert system FRESH, is pushing forward the frontier of technology. Although problems with FRESH do exist and have been highlighted in Chapter III, it is nonetheless an exceptional system which warrants continued attention and funding.

A. CONCLUSIONS

The overall goal of this research was to identify changes in FRESH system inputs and system outputs in order to meet the requirements of the Atlantic Fleet and effectively transport FRESH to the Commander in Chief Atlantic Fleet. It is felt that this objective was attained and that this research will be a useful document when FRESH transference to the Atlantic Fleet actually takes place. The overall conclusion of this thesis is that, in terms of system inputs and outputs, FRESH can (with limited modification) be transferred to CINCLANTFLT. Specific system input and output changes are outlined below.

1. FRESH Required System Input Changes

The present system inputs utilized by FRESH were well thought out, consequently all FRESH inputs are all-Navy documents, i.e., documents that are identical throughout the Navy. Therefore, if FRESH were to be transported to

CINCLANTFLT there appear to be no problems or additional costs associated with changes in system inputs. The all-Navy FRESH system inputs are shown in Figure 5-1 (repeated from Chapter III).

<u>REAL-TIME LOAD</u>--PACACE (Blue Positional Reports), FOSIC (Red Positional Reports).

<u>WWMCCS LOAD</u>--UNITREP (subset), Ship's Positional data (Departure Report, etc.).

<u>TAPE LOAD</u>--Weapons Loadout, Quarterly Employment Schedule.

<u>TAPE LOAD</u> (Quarterly)--Configuration data from NOSC.
<u>MANUAL LOAD</u>--CASREP data, MOVREP data.

<u>FUTURE INPUT</u>--Port Information, Routing Information
FRESH System Inputs.

Figure 5-1 FRESH System Inputs

2. <u>FRESH Required System Output Changes</u>

Several FRESH system output changes required by CINCLANTFLT have been identified. However, it is felt that once CINCLANTFLT acquires hands-on experience with FRESH, additional changes will be forthcoming.

CINCLANTFLT's desired changes to the present FRESH output are summarized below. (Estimates of man-months of effort are based on the authors knowledge of systems analysis and design techniques.)

- Automatic generation and forwarding of approved, updated quarterly employment schedules down the chain of command to the unit involved. (Currently FRESH does not possess this capability. Estimate six man-months of effort to complete.)

- Enhancement of the Port to Port routing CRT screen presentation to more clearly represent the European operating areas. (If the proposed FRESH memory expansion is approved and installed, enhancement of the CRT screens will be possible. Estimate three man-months of effort to complete.)

- Reflect NATO units and their respective capabilities within the database such that they may be output as possible replacement units in time of crisis, i.e., when collective NATO action is required. (Currently FRESH depicts only U.S. Navy units when considering possible replacement units. Estimate nine to twelve man-months of effort to complete.)

- Provide an ability to switch on/off NATO units (by country) in the event that not all NATO countries equally respond to a given crisis. (Currently FRESH does not possess this capability. Estimate six man-months effort after NATO units are loaded into the database.)

B. RECOMMENDATIONS

It is recommended that FRESH be transported to CINCLANTFLT. No change in FRESH system inputs appear to be required and the few output changes identified in this thesis should be readily accomplished. But it is important that CINCLANTFLT's proposed output changes be implemented prior to transportation of the system. By having the Atlantic FRESH 'ready to go' prior to its installation at CINCLANTFLT, their personnel will be spared the turmoil of learning a new automated system and simultaneously going through the analysis and design stages for their output changes.

It is felt that the unique CINCLANTFLT output requirements will not be extremely difficult to attain. The author estimates a development period of at least nine months (requiring at least 27 man-months of effort) to design and implement the new output requirements.

This research has presented the power of FRESH; power that will be invaluable to CINCLANTFLT. In today's atmosphere of decreasing operational forces coupled with increasing operational commitments, it is essential that this automated tool, FRESH, be used to upgrade the east coast manual mode for Fleet scheduling.

APPENDIX A

CINCPACFLT GOALS FOR THE FRESH PROTOTYPE

Description: This appendix provides a complete listing of the CINCPACFLT goals for the expert system prototype FRESH as set forth in [DELEOT 1987:CDDEC2/C].

CINCPACFLT GOALS FOR THE FRESH PROTOTYPE

1) to assist in planning/decision making process employing experience and knowledge of user.

2) to support consistency in logical planning/decision making (reduce role of emotion).

3) to collapse response time for significant planning/decision making, and allow CINCPACFLT personnel to make faster decisions.

4) to identify the implications of combinations of events and decisions.

5) to support development of early offensive postures.

6) to provide an explicit framework for inclusion of counter argument "What if's?"

7) to identify sensitivities in key decisions--what will be the effect of moving ship A to position B?

8) to facilitate knowing long term implications of a course of action vs. near term snapshot.

APPENDIX B

SAMPLE FRESH VIGNETTES AND CORRESPONDING OUTPUTS

Description: These vignettes were developed by the Naval Oceanographic System Command in San Diego, California to test users in their ability to utilize FRESH's Natural Language Menu. The inclusion of this material in this research is to provide the reader a flavor of the queries one might expect to ask FRESH.

The numbered statements are the vignettes that were presented to the "test" users. Subsequent output requested by these users is depicted as POSSIBLE OUTPUT.

SAMPLE FRESH VIGNETTES AND CORRESPONDING OUTPUTS

1. Someone has asked you for information about the ships in Task Group 30.3 and Task Group 30.5.
   POSSIBLE OUTPUT:
   List of ships in Task Group 30.3 and 30.5.
   Location of ships in these groups.
   Weapons Loadout for the individual ships.

2. You want to know which ships in Task Group 30.5 have Harpoon Capability.
   POSSIBLE OUTPUT:
   List of all ships in Task Group 30.5 that are Harpoon Capable.

3. You want the number of Harpoons in Task Group 30.5.
   POSSIBLE OUTPUT:
   List of ships having Harpoon and the quantity of missiles on each ship.

4. You want to know the length and beam of the SPRUANCE class ships in Task Group 30.0.
   POSSIBLE OUTPUT:
   The measurements of the length and beam of the SPRUANCE class destroyers in Task Group 30.0.

5. You want to see a chart showing the last five positions of the USS Carl Vinson.
   POSSIBLE OUTPUT:
   A graphical display of the USS Carl Vinson's last five reported positions.

6. You want to know what CASREPs have been reported by USS Ranger with an initial report date of after 18 July 87.
   POSSIBLE OUTPUT:
   A listing of all USS Ranger CASREPs that have an initial date of 18 July 87 or later.

7. You want to know the ASW ratings for all ships in Task Group 30.3.
   POSSIBLE OUTPUT:
   A listing of all ships in Task Group 30.3 with their corresponding ASW ratings.

8. You want to know the OPTEMPO of the USS Blue Ridge through the second quarter of FY87.
POSSIBLE OUTPUT:
A listing of all USS Blue Ridge operations that are scheduled for second quarter FY87.

9. You want to locate and identify a USS Los Angeles class submarine in order to support an emergent operational requirement at 30N 140W.
POSSIBLE OUTPUT:
A listing of all USS Los Angeles class submarines in the area--their respective present locations and anticipated times to transit to 30N 140W.

10. You want to see a true view projection centered at 30N 140W.
POSSIBLE OUTPUT:
A true view projection centered at 30N 140W.

11. You want to see the positions of all USS Los Angeles class submarines on the chart described in question (10).
POSSIBLE OUTPUT:
A true view projection centered at 30N 140W with positional markings indicating the actual locations of all USS Los Angeles class submarines in that particular area.

12. You want to know the amount of fuel consumed by the USS New Jersey in transit from 15N 165W to 40N 150E.
POSSIBLE OUTPUT:
An estimated amount of fuel for the transit based on fuel usage statistics for the USS New Jersey.

13. You are using FRESH to monitor alerts occurring to the USS Kitty Hawk.
POSSIBLE OUTPUT:
Alerts as they occur for USS Kitty Hawk.

14. You want to see the alerts that occurred to the USS Kitty Hawk during the last week.
POSSIBLE OUTPUT:
A listing of alerts for the USS Kitty Hawk for the desired time frame.

15. You add a tickler alert to FRESH so that you are notified when the USS Kitty Hawk arrives in the Sea of Japan.
POSSIBLE OUTPUT:
A hardcopy alert is generated when the USS Kitty Hawk is enters the Sea of Japan--this may be calculated/ projected by FRESH or may result from an actual

position report being submitted by the USS Kitty Hawk via CASREP, UNITREP, etc.

16. You want to see the route that the USS Jouett will take to transit from its current position to 15S 120E.
    POSSIBLE OUTPUT:
    A land avoidance route (courses to take) for USS Jouett to take in order for her to get from her present position to 15S 120E.

17. You want to see the quarterly employment schedule for Task Group 70.
    POSSIBLE OUTPUT:
    A list of all ships in Task Group 70 with their corresponding quarterly employment schedules.

18. FRESH has informed you of an alert based on a UNITREP for the USS Jarrett. You want FRESH to provide you with information about the options available for responding to the casualty.
    POSSIBLE OUTPUT:
    An ordered list of possible replacement units for USS Jarrett. An explanation of why replacement ships were ranked the way they were.

19. You want to know why FRESH identified the casualty in vignette (18) as being significant.
    POSSIBLE OUTPUT:
    FRESH reasoning/logical explanation of why this casualty was considered significant.

20. You want to know the two best options (possible replacement units) including the USS Curtz and the USS Tisdale that are available to respond to the casualty in USS Jarrett.
    POSSIBLE OUTPUT:
    A ranked list of replacement units including USS Curtz and USS Tisdale.

21. You want to know the impact associated with the first option in vignette (20).
    POSSIBLE OUTPUT:
    A list of operations that the first option (unit) will miss by being diverted to meet the requirements of the USS Jarrett.
    A cost figure in terms of time and fuel required to transit to desired location.

22. Why did FRESH rank option 1 as better than option 2?
    POSSIBLE OUTPUT:
    An explanation of why replacement ships were ranked the way they were.

APPENDIX C

FRESH ANSWERABLE SCENARIOS

Description: The following scenarios were provided by the Naval Ocean System's Command in San Diego, California. Scenarios are presented, along with possible FRESH queries that would enable the user to decide what course of action would be required to correct the problem identified.

Each scenario begins with a date time grouped message. In scenario q the departure report 150700Z MAR 87 indicates that the message was sent on the 15th of March 1987 at 0700 Greenwich mean time.

FRESH ANSWERABLE SCENARIOS

Scenario #1

150700Z MAR 87 DEPARTURE REPORT

CG-18 (USS WORDEN) will depart Pearl Harbor at 150830Z MAR 87 to participate in a Sea of Japan transit in three days. The Sea of Japan transit requires the following capabilities:

SPS-10 Surface Search Radar
SPS-48 3D Air Search Radar
SQS-23 Sonar

CG-18 (WORDEN) Primary Mission Areas:

AAW, ASW, ASU, MOB, CCC, ELW

UNITREP 001 as of 161440Z MAR 87

CG-18 (WORDEN) reports that it's SPS-48 Air Search Radar is inoperative:
> C-3 CASREP reported on SPS-48
> M-3 reported on AAW (anti aircraft warfare) mission area

Possible FRESH Queries to Determine Required Action

a) What is the WORDEN's estimated time of repair for the SPS-48?

b) What other cruisers are available in Pearl Harbor with an SPS-48?

c) Display the location of all cruisers.

d) What is the employment schedule for USS HALSEY and USS FOX?

e) What is the status of USS HALSEY's SPS-48 radar?

f) What is the percentage of fuel remaining for USS HALSEY?

Scenario #2

221630Z MAY 87 DEPARTURE REPORT

CG-29 (JOUETT) and DDG-996 (CHANDLER) have been selected to transit the Sea of Okhotsk to demonstrate the right of free passage in international waters contiguous to the Soviet Union. Because of the sensitivity of the mission, the following capabilities are required:

CG-29 (JOUETT)	DDG-996 (CHANDLER)
SQS-26 Sonar	SQS-53 Sonar
SLQ-32 V(3)	LAMPS Helos
SM-2 (ER)	SLQ-32 V(2)
SPS-48 3D Radar	SM-2 (MR)
SPS-10 Surface Radar	TACTAS (Towed Array Sonar)
	SPS-48 3D Radar
	SPS-10 Surface Radar

222100Z MAY 87 CASREP

DDG-996 (CHANDLER) has developed a propulsion problem which is estimated to take two weeks to repair:
> M-3 reported on MOB (mobility)

Possible FRESH Queries to Determine Required Action

a) What is the position of DDG-996 (CHANDLER)?

b) What is the position of CG-29 (JOUETT)?

c) What other ships are within 500 miles of DDG-996 (CHANDLER)?

d) What is the position of USS CALLAGHAN (a ship of the same class)?

e) What are the primary mission area M-ratings for USS CALLAGHAN?

f) Display USS CALLAGHAN's CASREP status.

g) Display USS CALLAGHAN's capabilities.

h) Display USS CALLAGHAN's employment schedule.

Scenario #3

051440Z JUL 87 DEPARTURE REPORT

FFG-41 MCCLUSKY has been assigned tattletale surveillance of the MINSK Task Group during its operations in the South China Sea. The task group is expected to depart the area 120800Z JUL 87. The primary objective of the surveillance is intelligence collection on the MINSK use of electronic sensors and communications during task group operations. Required capabilities are: SPS-55 surface search radar and LAMPS MK III helicopter.

UNITREP 003 as of 061020Z JUL 87

FFG-41 MCCLUSKY reports surface search radar unreliable.
>CREQP: C-3
>M-3 reported on ELW

Possible FRESH Queries to Determine Required Action

a) What is the estimated time of repair for MCCLUSKY's SPS-55 surface search radar?

b) Display locations of all FFG-07 and DD-963 class ships in the South China Sea area.

c) Does DD-976 have a LAMPS III helicopter?

d) What is the CASREP status of DD-976?

e) How far is DD-976 from the MINSK task group?

f) What is DD-976's percentage of fuel remaining?

g) What is DD-976's overall combat readiness rating?

h) What is DD-976's overall primary mission area rating?

i) What is DD-976's present employment schedule?

j) What is DD-976's present OPTEMPO?

k) When is DD-976 supposed to complete their WESTPAC deployment?

Scenario #4

121000Z AUG 87 MOVEMENT REPORT

Due to a civil disturbance, CG-24 REEVES and DD-976 MERRILL have been selected to participate in a show of force off the coast of Port Moresby, New Guinea in four days. Because of a highly volatile situation, the following capabilities are critical should the evacuation of American civilians require shore bombardment:

Phalanx CIWS Mk 16
5-inch 54-cal DP MK-45 Gun
3-inch 50-cal AA MK-33 Gun

CG-24, DD-976 Primary Mission Areas:
AAW, ASW, ASU, MOB, CCC, ELW

UNITREP 001 as of 141440Z AUG 87

> DD-976 reports C-3 CASREP on Phalanx gun control system
> Primary Mission areas affected: ASU, AAW, AMW

Possible FRESH Queries to Determine Required Action

a) What is the estimated time of repair for the MERRILL's C3 CASREP on Phalanx close in weapon system?

b) What is REEVES' overall M-rating?

c) What is REEVES' current CASREP status?

d) What other DD-963 class ships are within 1500 miles of Port Moresby, New Guinea?

e) What is O'BRIEN's current employment?

f) What is O'BRIEN's current speed; maximum speed?

g) What is O'BRIEN's CASREP status?

h) What weapons does O'BRIEN have aboard?

i) What is O'BRIEN's percentage of fuel remaining?

Scenario #5

281205Z NOV 86 DEPARTURE REPORT

CV-64 CONSTELLATION with FF-1086 BREWTON will participate in a space craft recovery mission. The space craft will splash down at 32N 144W at 041500Z DEC 87 in the central Pacific. The following capabilities will be required:

LAMPS helicopter
SPS-10 Surface Search Radar
SPS-40 Air Search Radar

291100Z NOV 87 CASREP REPORT

FF-1086 BREWTON reports LAMPS helicopter mainrotor damaged
>C-3 reported on EQP

Possible FRESH Queries to Determine Required Action

a) What is the estimated time of repair on the LAMPS?

b) What is the position of the CONSTELLATION?

c) What is the position of the BREWTON?

d) What ships are within 1500 miles of BREWTON?

e) What are the capabilities of CALLAGHAN?

f) What are the primary mission area ratings of the CALLAGHAN?

g) What are the resource area C-ratings on CALLAGHAN?

h) What are CASREP dates and descriptions and estimated times of repair for CALLAGHAN?

i) What is the position of CALLAGHAN?

j) What is the distance from CALLAGHAN to BREWTON?

k) What other ships are within 2000 miles of 32N 144W?

l) What is the CALLAGHAN's employment schedule?

Scenario #6

021115Z JAN 87 MOVEMENT REPORT

DDG-9 TOWERS is conducting three a week good will visit to Malaysia. Malaysia has been attempting to close its ports to DD and CG surface combatants. Therefore, the port visit has high political ramifications. Following the visit, DDG-9 TOWERS will have a ten (10) day R & R port call in Hong Kong.

UNITREP 004 as of 121440Z JAN 87

DDG-9 TOWERS struck an underwater object at 245S 102E in the Indian Ocean enroute to Singapore damaging number 1 main shaft and propeller.

>loss of full power capability on number 1 main engine. Speed restricted to 10 knots.
> M-3 reported for MOB.

Possible FRESH Queries to Determine Required Action

a) How far is TOWERS from Singapore?

b) What other DD and CG surface combatants are within 2000 miles of Malaysia?

c) What is the employment of THATCH?

d) How far is TOWERS from Subic Bay, Philippines?

e) What is the estimated time of repair for number 1 main shaft and propeller?

f) How far is TOWERS from Hong Kong?

g) What is the CASREP status of THATCH?

h) What is the percentage of fuel remaining for THATCH?

i) What is THATCH's maximum speed available?

j) What is THATCH's present employment?

k) What is STERRET's present employment schedule?

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