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THESIS

A PRELIMINARY SOFTWARE DESIGN
FOR A PERSONAL COMPUTER-BASED
ANTISUBMARINE WARFARE TACTICAL
FLIGHT SIMULATOR

by

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September 1985

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A Preliminary Software Design for a Personal Computer-Based Antisubmarine Warfare Tactical Flight Simulator

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I. INTRODUCTION

A. PROBLEM STATEMENT

Maintaining tactical proficiency is of paramount concern for achieving optimum combat readiness in today's Naval forces. Real-time tactical simulators provide a complementary and supplementary means of accomplishing this major training and readiness objective. Stand-alone simulators offer the advantage of tactical training without requiring the use of the actual equipment or weapon system being simulated. This thesis provides a preliminary software design for a stand-alone Antisubmarine Warfare (ASW) tactical simulator for helicopters using the AN/ASN-123 Tactical Navigation Set (TACNAV) display formats, symbology, and functions.

Current research in the area of embedding tactical simulation software in the TACNAV system is aimed at fully utilizing onboard computer systems for tactical training while in flight. There is still a need to provide an opportunity for tactical training when the aircraft or computer equipment is not available for use.

As ASW helicopter squadrons and detachments deploy with microcomputers or deploy aboard ships that use microcomputers there is an opportunity and need to develop tactical training application software. This thesis focuses primarily on a simulation of the ASW scenario, but this simulation is only one of a variety of simulation possibilities.

B. PROJECT DESIGN OBJECTIVES

The primary objective of this simulator design was flexibility, to provide for easy change. The constant changes in technology, command and control, and tactics require that a software simulation in such a climate be readily adaptable.

This objective should not be confused with generality. As distinguished by Parnas, generality is a characteristic of software that can be used, without change, in a variety of situations. Flexibility, on the other hand, describes software that can be easily changed for use in a variety of applications. [Ref. 1: p. 234]

Other design objectives included utility and understandability. Utility refers to how easy the software is to use. It is critical to consider the interaction of man and machine in the analysis phase, and continue using this perspective to validate decisions made in the design process. The TACNAV display formats, symbology, and functions were specifically chosen to provide a familiar visual means of interaction.

Understandability refers to how easily the design documentation, structure, modules, and code can be understood by the users, programmers, and maintainers. Understandability has a major impact on software maintenance; the correcting, adapting, and enhancing of the software after it has been delivered and placed into use. It is not uncommon for fifty to ninety-five percent of the total software life cycle budget to be applied to maintenance, and almost half the maintenance effort to be consumed in understanding [Ref. 3: p. 311]. Consequently, preliminary design must emphasize clarity and simplicity. Modularization, structured programming, straightforward algorithms, and good documentation serve to improve understandability and maintainability.

II. BACKGROUND

The software design proposed in this thesis is based on a tactical scenario simulating a single ASW helicopter using the AN/ASN-123 TACNAV system to localize, track, and attack a single, fully-evasive, target submarine. The TACNAV system is a versatile, computer-based airborne navigation system intended for use in any fixed or rotary wing ASW aircraft , and is particulary capable of enhancing operational effectiveness in surface surveillance, over-the-horizon targeting, and electronic support missions, as well as antisubmarine warfare.

Controlled and directed by a Tactical Coordinator, the TACNAV system maintains and displays an accurate horizontal geographic plot of both navigational and tactical symbols, and provides other navigational and graphic functions to assist in a contact prosecution mission. The tactical use of these selectable navigational and graphic functions assists in sonobuoy deployment in a predetermined pattern, on-top position fixing, contact acknowledgement, target localization, and attack strategy formulation. All TACNAV functions are implemented in software, allowing the system to be enhanced as new technology or tactics are implemented. It is critical that a simulation based on the TACNAV be equally adaptable. [Ref. 2: p. 1-1]

A. AN/ASN-123 TACNAV SYSTEM PHYSICAL DESCRIPTION

The physical configuration of the TACNAV system includes a Processor Unit, a Display Unit, a Tactical Coordinator Control Unit, and a Sensor Operator Control Unit.

The Processor Unit is a militarized general purpose, digital computer with a non-volatile core memory of 32,768 16-bit words. It is expandable to 65,536 bytes. [Ref. 2: p. 1-2]

The Display Unit is a militarized flat-faced cathode ray tube (CRT) with a viewing area of 6.5 x 8.5 inches. A digital symbol generator produces easily read and accurately positioned characters. The TACNAV character set includes all letters in the alphabet, the digits 0 - 9, punctuation marks, and 19 special tactical symbols or graphics (Appendix A). [Ref. 2: p. 1-2]

The Tactical Coordinator's Control Unit is the primary control terminal for the TACNAV system. Data are entered via a numerical keypad and TACNAV functions are selected by individual push on-push off and momentary pushbuttons. Operations requiring a sequence of actions are aided by English-language cues or menus to reduce dependency on memorized procedures. [Ref. 2: p. 1-5]

The Sensor Operator's Control Unit provides a means of entering radar, sonobuoy, Magnetic Anomaly Detection (MAD), or dipping sonar contact data into the TACNAV database. [Ref. 2: p. 1-4]

The TACNAV system automatically receives inputs from some of the aircraft's navigational and tactical sensors. The navigation sensors provide aircraft heading, altitude, true airspeed, and groundspeed. The tactical sensors provide sonobuoy launch data , dipping sonar, and active sonobuoy contact data. The Processor Unit combines these inputs with system initialization data to compute the geographic position of the aircraft, sonobuoys, base ship, and other selected symbols. The appropriate TACNAV symbols are then displayed at their computed positions on the CRT.

The TACNAV system has two basic display modes: The <u>Tableau Display</u> mode and the <u>Tactical Display</u> mode. The Tableau Display mode includes the System Initialization tableau (Appendix E), the Navigation tableau (Appendix F), the Sonobuoy Launch tableau (Appendix G), and the TACNAV Equipment Status tableau (Appendix H). Only the numeric keypad is active for data entry in the Tableau Display mode. The functional pushbuttons serve no purpose and are inoperative. The Tactical Display mode is the normal presentation of TACNAV symbols in a horizontal geographic plot. The discrete functional pushbuttons and the numeric keypad are activated for data entry in this mode. [Ref. 2: p. 1-5]

The Tactical Coordinator also makes use of information external to the TACNAV system in contact prosecution. These information sources include the pilot, sensor operator, other on-board systems, and shipboard sensor processing information.

The Pilot controls the physical positioning of the aircraft via the flight control system, and aided by the aircraft's Bearing Distance Heading Indicator (BDHI), the two navigation needles on the BDHI, and the airspeed indicator.

The Sensor Operator verbally communicates passive sonobuoy detection information, as well as entering radar contact, MAD, and active sonobuoy contact data into the TACNAV from his remote station.

Other on-board systems that assist in contact prosecution are the Sonobuoy/Weapons Launch panel, which allows selective launching of sonobuoys or weapons by slot, the On-Top-Position-Indicator (OTPI), which indicates the bearing of a selected sonobuoy from the aircraft via the BDHI No. 1 navigation needle, and the Data Link, which relays sonobuoy signals to the ship for processing. The ship, after processing the sonobuoy signals, communicates detection information to the aircraft for manual entry into the TACNAV system by the Tactical Coordinator.

III. PROPOSED SIMULATOR DESIGN

A. DESIGN METHODOLOGY

In designing a real-time simulation, there is a tendency to impose, on the design, time and memory constraints. A less restrictive approach, and the one chosen for this application, allows the design to develop to a complete logical product, and postpones physical constraint decisions to as late in the design process as possible.

Once the logical design is implemented in software, system performance can be monitored to uncover bottlenecks in execution time or memory utilization. The critical areas can then be manipulated to achieve the appropriate efficiency.

This approach toward optimization is preferred for two reasons. First, most real time systems spend 80% of their time executing 20% of the code, and that region of code is not always easy to identify prior to actual implementation. Second, if a software system has been decomposed into functionally primitive modules, it is easier to identify and reconfigure the target bottlenecks [Ref. 3: p. 151].

This preliminary or architectural design requires the following to be accomplished:

- developing a conceptual view of the simulator system

- identifying the inputs and outputs
- describing the process by which inputs are transformed into outputs
- decomposing higher level functions into sub-functions
- developing a structure of relationships between the functions [Ref. 3: p. 138]

This implies a "black box" approach focusing on "what" is to be accomplished in the simulation and postpones the decisions of "how" it should be accomplished. Focusing first on the systems environment, the inputs, outputs, and user interactions required allows the design to begin with a broad, macro view. [Ref. 4: pp. 21,22]

Due to the complexity of most systems, the "divide and conquer" approach is useful in decomposing a large system into smaller, more understandable subsystems. These subsystems can be iteratively decomposed in a top-down manner to a lowest level known as functional primitives. The evolution from a broad, conceptual view to increasingly detailed, lower functional levels is known as top-down modular decomposition.

Although the process of decomposing these levels sounds rather simple, the criteria used to separate higher level functions or modules into lower levels are complex. As with any decision, there are risks involved in choosing one decomposition criterion over another. Mostly it involves trading off benefits in one area for benefits in another area, and usually an equal mixture of both is worse than all of one or the other. In the next section a discussion of design heuristics highlights desirable qualities in software design which become the basis for choosing modular decomposition criteria.

B. DESIGN HEURISTICS

Although it is possible to factor or decompose any higher level function using only one modularization criterion, a composite design approach using a combination of three major criteria was chosen for this design. The chosen criteria were information hiding, levels of abstraction, and coupling-cohesion.

A conventional method of decomposition is to divide the system into modules that correspond to sequential processing steps (e.g. initialize, input, validate, process, format, output). In this approach a small change in a data structure may require each module to be modified to accept and process the new data structure. This example illustrates how inflexible such a design would be if modularized using a processing-step or flowchart criterion.

Contrary to the flowchart approach and procedure oriented thinking, the information hiding criterion is highly function oriented, focusing on "what" the system should do rather than "how" it should do it. In this approach, modules are created to "hide" or suppress the implementation details by separating functions or design decisions that are likely to change. These decisions are partitioned so that changes can be made in one module without affecting any others. In this way, information hiding directly supports the adaptability and maintainability objectives. Design decisions that are commonly hidden are data structures, algorithms, and hardware constraints.

A "levels of abstraction" criterion creates a hierarchy of less abstract modules at each lower level of decomposition. The highest level of abstraction is the macro or context view of the simulator. The next lower level is composed of a set of less complex and less abstract modules describing "what" the simulator does. [Ref. 5: pp. 154,155]

The coupling-cohesion criterion is actually a composite criterion. Coupling is a measure of inter-modular independence, the strength or weakness of the connections between modules. A loosely coupled module is highly desirable as it does not require "knowledge" about the details contained in other modules. It requires little or no information about other modules to be singularly functional. Coupling is a critical factor in controlling system complexity and providing ease of modification.

Cohesion is a measure of intra-modular strength or functionality. It describes the binding of related internal elements within a module. These elements are not necessarily program statements or executable code, but are, more appropriately, abstract functions and sub-functions which are closely related. In this manner it is not necessary to make a design decision earlier than required because abstraction can be retained until the very lowest levels are designed. The related modularization objective is to minimize coupling and maximize cohesion. Normally, the greater the cohesion, the less the coupling between modules. This is intuitive because as modules approach singular functionality, they become less dependent on information communicated from other modules.

C. FUNCTIONAL MODULES

1. Level One Decompositions

The first decomposition, based on identifying the functions necessary to transform the system inputs into the desired outputs, includes the following five functions:

1.1 Display Simulator Introduction

1.2 Update TACNAV Tableaus

1.3 Update Tactical Display

1.4 Record Actual Geographic Positions

1.5 Display Sensor Contact

The simulator output is simply a display of introduction screens(1.1), tableaus(1.2), and a tactical horizontal plot(1.4). This factoring separated the macro or context view according to the purposes of the outputs. Flexibility and understandability is maintained by encapsulating decisions or functions that are likely to change within separate modules.

The requirement to maintain actual geographic positions of the base ship, sonobuoys, and target submarine created another function(1.4). This function is used to compare displayed positions and actual positions for variance. This allows the user to make mistakes in navigation or positon fixing, but receive accurate sensor detection data. For example, if a user did not allow for the effects of sea set and drift on the sonobuoys in his display, the actual positions of the sensors would be displaced from the displayed positions, and the user may be unable to localize the target even while holding contact on multiple sensors.

The last major function in the first decomposition is the display of sensor contact data(1.5). This was separated from the tactical plot display primarily because of flexibility considerations, since this function must be modifiable with each new sensor added to the aircraft's sensor package. This is also an area where the inclusion of different types of aircraft with different sensor packages can use the same simulator with minor modifications.

2. Level Two Decompositions

a. Display Simulator Introduction (1.1)

The display of simulator introduction screens was decomposed into three distinct functions:

1.1.1 Display Simulator Intro Text

1.1.2 Initialize Scenario Parameters

1.1.3 Display User Operating Instructions

The Simulator Intro Text function is simply a brief description of the simulator's purpose and scenario options. The Initialize Scenario Parameters function allows instructors to initialize the tactical problem parameters via a simulator-unique tableau format (Appendices B and C). The simulator will automatically generate any parameters not initialized by the instructor to complete the scenario. The Display User Operating Instructions function gives a brief description of the physical implementation details of the simulator, such as the proper keyboard entry to select a particular TACNAV function. The separation of these functions provides flexibility to enhance the simulator description, change the tactical scenario parameters, or permit a keyboard or input/output device change.

b. Update TACNAV Tableaus (1.2)

The Update TACNAV Tableaus function was decomposed into five sub-functions:

1.2.1 Display Tactical Scenario Parameters

1.2.2 Update TACNAV Initialization Tableau

1.2.3 Update Navigation Tableau

1.2.4 Update Sonobuoy Launch Tableau

1.2.5 Display Equipment Tableau

The Display Tactical Scenario Parameters function displays the tactical scenario parameters as intialized manually by the instructor or automatically generated by the simulator in a simulator-unique tableau format (Appendix D). The Update TACNAV Initialization Tableau function allows the user to intialize and update TACNAV specific data including magnetic variation, system bias, grid center, ship's planned intended movement (PIM), and datum position via a standard TACNAV tableau format (Appendix E). The Update Navigation Tableau and Update Sonobuoy Launch Tableau functions allow the user to initialize and update navigation and sonobuoy specific data, respectively. These are also entered using standard TACNAV tableau formats (Appendices F and G). The Display Equipment Tableau function reflects the operating status of navigation, sensor, and TACNAV processing equipment. The appropriate sensor package will be automatically enabled for each type of aircraft. In the actual TACNAV system this tableau (Appendix H) displays "good"or "bad" operating status, indicating functional and dysfunctional equipment. In this simulator, however, this tableau is static. It does not monitor equipment for failures, and is only intended to simulate normal TACNAV operation. It is included only because it is one of the actual TACNAV tableaus displays. If memory storage constraints require reduction in memory usage, this should be one of the first functions eliminated.

c. Update Tactical Display (1.3)

The Update Tactical Display function was decomposed into two major sub-functions:

1.3.1 Display Tactical Plot

1.3.2 Display Aircraft Systems

This decomposition was made to separate the strictly TACNAV tactical plot display and the simulator's display of aircraft system information to the user. The aircraft systems information includes Sonobuoy Launch Panel, a Bearing Distance Heading Indicator (BDHI) compass with associated navigation needles, LINK channel information, On Top Position Indicator (OTPI) channel, and aircraft airspeed. The Tactical Plot Display includes all selectable function information and graphics, problem time, hook coordinates, and four permanent symbols: the aircraft, base ship, hook, and datum. An example of the physical implementation (CRT) of the Tactical Display is provided in Appendix J.

d. Record Actual Geographic Positions (1.4)

The Record Actual Geographic Position function was decomposed into three sub-functions:

1.4.1 Record Base Ship Actual Position

1.4.2 Record Target Sub Position

1.4.3 Record Sonobuoys' Actual Positions

The base ship's actual position is computed using it's previous position, actual course and speed, and the sea current, set and drift. The displayed ship's position is computed using the last displayed position, user entered PIM, and system bias corrections. This distinction allows position variances which can be minimized by an attentive tactical coordinator. Frequent position fixing and updating the TACNAV system bias will yield a significantly more accurate display.

The target submarine's position is affected only by the initialized PIM's and the Detection Evasion function. This function provides a fully evasive capability to the target submarine when the submarine is detected by active sensors or when a torpedo is dropped.

The sonobuoys' actual positions are affected only by the sea current, set and drift. Similar to the display of the ship's position, relatively large sonobuoy position variances are possible due to the inaccuracy of the TACNAV system bias. This function maintains the actual geographic positions of all launched sonobuoys.

e. Display Sensor Contact (1.5)

The Display Sensor Contact function was decomposed into two primary sub-functions, one for each sensor group:

1.5.1 Display Sonobuoy Detection

1.5.2 Display Magnetic Anomaly Detection

Additional sub-functions for other sensors, such as dipping sonar, radar, electronic support (ESM), and infrared detectors (FLIR) can be easily appended at this level.

The Display Sonobuoy Detection function displays the appropriate detection symbol (e.g. range rings, line of bearing(LOB), fix) originating from the sensor's symbol position. Detection information such as bearing and range, although computed using actual sensor position and submarine position, originates from the sensor's symbol postion.

The Display Magnetic Anomaly Detection function displays the MAD symbol at the aircraft symbol position when sensor contact is made.

3. Level Three Decompositions

a. Initialize Scenario Parameters (1.1.2)

The Initialize Scenario Parameters function was decomposed into three sub-functions:

1.1.2.1 Initialize Ship/Sub Motion Parameters

1.1.2.2 Initialize Sensor Detection Parameters

1.1.2.3 Display Graphics

The separation of the Ship/Sub Motion parameters from Sensor Detection parameters allows either or both parameter lists to be modified without affecting other modules.

The Display Graphics module is a functionally primitive module that produces all symbols or graphics required for display. This module is used by all Level Two functions except for the functions that record actual geographic positions of the ship, target submarine, and sonobuoys.

b. Display Tactical Plot (1.3.1)

The Tactical Plot function was decomposed into eight sub-functions:

1.3.1.1 Display Aircraft

1.3.1.2 Display Hook

1.3.1.3 Display Ship

1.3.1.4 Display Datum

1.3.1.5 Display Selected Functions

1.3.1.6 Display Problem Time

1.3.1.7 Display Sonobuoys

1.3.1.8 Display Hook Coordinates

The aircraft, hook, ship, datum, problem time, and hook coordinates are displayed continuously and can not be erased. The display of the TACNAV functions and their associated graphics are only displayed when selected. Sonobuoys are displayed after they have been launched from the aircraft.

The Display Aircraft function uses the Display Graphics and Aircraft Motion modules to correctly position the aircraft symbol and orient the aircraft heading marker. The Aircraft Motion module uses the user inputs from the simulator's flight controls, corrected for wind direction and speed, to compute aircraft heading and airspeed.

The Display Hook function uses the Display Graphics and Hook Motion modules to correctly position the hook symbol. The Hook Motion module uses the user inputs from the simulator's hook control device.

The Display Ship function uses the Display Graphics and Ship Motion modules to correctly position and orient the ship symbol. The Ship Motion module uses the user-initialized and updated ship's PIM corrected for the TACNAV system bias to compute course and speed.

The Display Datum function uses the Display Graphics module and the instructor initialized or automatically generated datum position.

The Display Selected Functions module uses the Display Graphics module and the Selectable Functions Package of modules to display the appropriate function graphics originating at the correct symbol or display position. The functions used in the Selectable Function Package include the standard TACNAV functions and simulator-unique functions listed in Appendix I.

The Display Problem Time function displays the updated user initialized time in hours, minutes, and seconds format.

The Display Sonobuoys function uses the Display Graphics and Sonobuoy Motion modules to correctly position the sonobuoy symbols. The Sonobuoy Motion module uses the user-initialized but updated TACNAV system bias to compute sonobuoy drift from it's position at time of launch.

The Display Hook Coordinates displays the grid coordinates or latitude and longitude of the current hook position depending on the selection status of the LAT/LONG TACNAV function.

c. Display Aircraft Systems (1.3.2)

The Aircraft Systems function was decomposed into six sub-functions:

1.3.2.1 Display Sonobuoy Launch Panel

1.3.2.2 Display Selected Functions Panel

1.3.2.3 Display BDHI Compass and Navigation Needles

1.3.2.4 Display OTPI Channel Selected

1.3.2.5 Display LINK/MONITOR Panel

1.3.2.6 Display Aircraft Airspeed

The Sonobuoy Launch Panel display provides information to the user including sonobuoy slot number, sonobuoy type, sonobuoy RF channel, sonobuoy depth setting, and launch status for each sonobuoy.

The Selected Functions Panel displays the TACNAV function names that are currently selected or activated. This allows the user to avoid trying to select functions that are mutually exclusive.

The BDHI compass is used to display the magnetic heading of the aircraft. The No. 1 Navigation Needle is controlled by the OTPI and points to the BDHI bearing of the selected sonobuoy. The No. 2 Navigation Needle is controlled by the Fly-to-Point (FTP) function and points to the BDHI bearing of the No. 1 priority FTP symbol. These needles provide the pilot with visual position fixing information and assist in more accurate navigation.

The OTPI Channel Selected displays the RF channel of the selected sonobuoy, and reminds the user to which buoy the No. 1 needle is pointing.

The LINK/MONITOR Panel displays the simulated data link channels and the RF channels of the sonobuoys being linked and monitored. A sonobuoy must be LINK/MONITORed before the user can receive sonobuoy detection information. If a sonobuoy is removed from the LINK/MONITOR panel, detection information, such as range or bearing, ceases to be displayed.

The Display Airspeed panel is an indication of aircraft airspeed in knots. This information is necessarily displayed to aid the user in tactical navigation.

d. Display Sonobuoy Detection (1.5.1)

The Sonobuoy Detection function uses the Display Graphics module and a Buoy Detection module to display the appropriate detection symbol originating from the correct sensor.

The Buoy Detection module uses the buoy type, the Detection Range, and Buoy-to-Sub Range modules to signal a "hot" sensor. The Detection Range module uses the manually initialized or automatically generated Median Detection Range (MDR) for passive sonobuoys or the Predicted Range of the Day (PRD) for the active sonobuoys, and the Aspect module to compute a more realistic estimate of actual detection ranges. The Aspect module uses the Sub-to-Buoy Relative Bearing module to yield an aspect ratio which can increase or decrease effective detection ranges. For example, a submarine heading away from a sonobuoy can be detected at greater ranges than for the case of a sub heading directly toward the sonobuoy. If the sub could be detected at 1.2 nautical miles while heading away, at 0.8

nautical miles while heading toward, and at 1.0 nautical miles while heading perpendicular to the sonobuoy, a simple aspect profile could be developed.

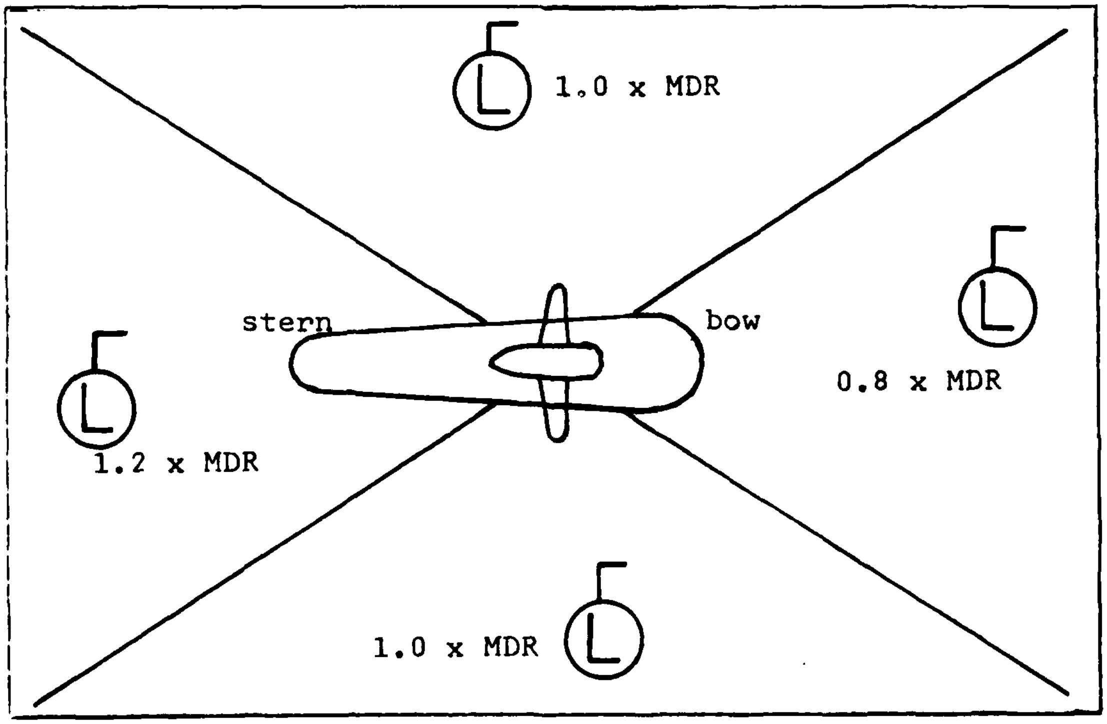


Figure 3.1 Simplified Aspect Profile

e. Display Magnetic Anomaly Detection (1.5.2)

The Magnetic Anomaly Detection function uses the Display Graphics module and MAD Detection module to display the MAD symbol at the current aircraft position. The MAD Detection module compares the manually initialized or automatically generated Magnetic Anomaly Detection range with the Sub-to-Aircraft Horizontal Range to signal sensor contact. The Sub-to-Aircraft Horizontal Range module uses the submarine's position and the aircraft's position to compute the actual distance between the two. Although much less accurate than using submarine depth and aircraft altitude to yield a sub-to-aircraft slant range, the level of tactical training is not markedly improved by the extra accuracy.

D. PACKAGING

Packaging refers to the grouping together of entities for some purpose. In software engineering, the entities are logically related data types, objects, modules, or abstractions, and the purposes are efficiency, adaptability, maintainability, and understandability of the software system. The criteria for packaging reflect similar design heuristics as the modularization criteria; information hiding, levels of abstraction, coupling and cohesion. Packaging is a bottom-up regrouping of related modules and data types. The choice of 'how' the entities are related will determine the strength or cohesion of the package, as well as the level of inter-package communication or coupling.

For efficiency's sake, it may be that the frequency or volume of module calls should be considered the paramount packaging criterion. This can be highly application dependent. In particular, in a tactical simulation environment where many changes are possible, efficiency might be subordinated to adaptability.

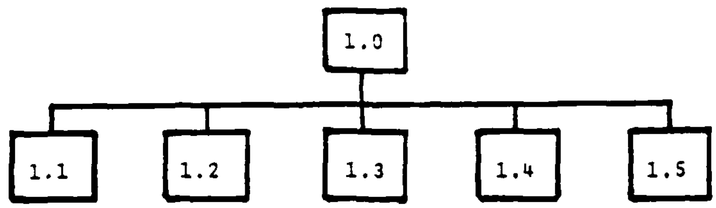
If packages were constructed for each aircraft type or sensor type the system could be easily changed to include new aircraft or new sensors, but the redundancy of modules would probably exceed the memory space constraints.

Another packaging criterion similar to frequency of call, is type of call, periodic or demand. Periodic functions are those functions that are performed continuously at a specified time interval or are started and stopped by a specific event (e.g. update display). Demand functions are those functions that are executed only on request by some event (e.g. selectable functions). Although this may be effective, it does not satisfactorily provide enough levels of distinction between packages in such a simple division. Other criteria should be used to further decompose the periodic and demand packages. [Ref. 6: p. 194]

Due to the volatility of the tactical simulation environment the primary considerations in choosing packaging criteria for this desigh were adaptability and maintainability. Modules were packaged that were likely to be affected by the same change or a particular enhancement, such as hardware implementation constraints. Appendix K reflects the packaging of some of the simulator's modules according to TACNAV demand functions (Packages 1 and 2), simulator-unique selectable functions (Packages 3 and 4), sensor functions (Package 5), motion functions (Packages 6, 7 and 8), hardware implementation (Package 9), display functions (Packages 9, 10 and 11), a super-package of display functions (Package 12), and a super-package of selectable functions including both TACNAV and simulator-unique demand functions (Package 13).

E. DESIGN STRUCTURE

The decomposing of a system develops a hierarchical relationship between the modules. This relationship is displayed in a "uses" and "used by" structure. Higher level modules "use" lower level modules, and conversely, lower level modules are "used by" higher level modules. Fairley distinguishes the structure chart from a typical flowchart in two ways: "a structure chart has no decision boxes, and the sequential ordering of tasks inherent in a flowchart can be suppressed in a structre chart." The "uses" relationship allows the details of the other modules to be hidden and focuses on "what" is accomplished (function), rather than "how" (implementation) or "when" (processing sequence). The structure charts for the simulator design are included in Appendices L - P. [Ref. 3: p. 153] The following macro or context view structure chart shows the first level decomposition of the simulator.



MODULE NUMBER	MODULE NAME
1.0	Tactical Flight Simulator
1.1	Display Simulator Introduction
1.2	Update Tableaus
1.3	Update Tactical Display
1.4	Record Actual Geographic Positions
1.5	Display Sensor Contact

Figure 3.2 Context View Structure Chart

The structure charts show the intermodular relationships where upper level functions use lower level functions. The module number and module name are included in tabular form below the chart for easier reading. Level One functions are numbered 1.1, 1.2, etc., Level Two functions are numbered 1.1.1, 1.1.2, etc., Level Three functions are numbered 1.1.1.1, 1.1.1.2, and so forth for the remaining structural levels.

IV. RECOMMENDATIONS AND SUMMARY

A. IMPLEMENTATION RECOMMENDATIONS

1. Man-Machine Interface

As previoulsy mentioned, in order to ensure that the product meets the user's needs it is critical to continuously validate decisions made in the design process with the user. Interviews with several regular users of the TACNAV system formed the validation basis for the requirements specifications (Appendix S), system logical design, enhancements (Appendix T, and recommendations for physical implementation. [Refs. 7,8,9] Although there was some disagreement concerning which TACNAV functions were desirable, the design reflects a consensus on those functions considered necessary (Appendix I).

The proposed enhancements reflect the interviewees' perceptions of technological and tactical changes likely, and provided a basis for modular decomposition and packaging strategies.

All interviewees agreed that a personal computer-based simulator would be accessible to more people more often than the actual equipment or aircraft systems. The use of TACNAV display symbology and graphic functions was also accepted. The interviewees did, however, express concern over the method of function selection and deselection. They wanted to ensure that a single button or key push-on/push-off method was used for function selection and that the function cues and selection sequence remained the same as those in the actual TACNAV system.

2. Proposed Physical Implementation

The following proposals reflect tha author's and the interviewees' views concerning the physical implementation of the simulator.

a. User Inputs

Aircraft flight controls should be implemented using a joystick. Left and right movement of the stick would signal left and right turns, respectively. Forward and aft movement would signal acceleration and deceleration, respectively. The neutral position would maintain present heading and airspeed. The Fire button on the joystick should be used to launch selected sonobuoys or weapons.

Hook control should be implemented using a rolling ball, mouse, or second joystick. The keyboard cursor arrows were thought to be too cumbersome and less responsive, particularly in diagonal movements of the hook.

Function selection/deselection should be implemented using a single key for each function if possible. The push-on/push-off method of selection and deselection should also be implemented. A simple keyboard overlay should label the appropriate keys with the function name. Function keys are activated only in the tactical display mode.

The keyboard or numeric keypad should be used to enter all initialization data and responses to function cues. Care must be exercised to ensure that keys which are necessary for data entry in response to function cues are not function keys themselves (e.g. digits 0-9).

b. Simulator Outputs

The only outputs of the simulator are the introduction, tableau, and tactical displays. Samples of each are included in Appendices B-H, and J. The Ship/Sub Motion and Sensor Detection Parameter Initialization, and the Tactical Scenario Parameters tableaus are simulator-unique formatted displays. The TACNAV Initialization, Navigation, Sonobuoy Launch, and Equipment Status tableaus are actual TACNAV system formatted displays. The Tactical Display format is simulator-unique and includes the TACNAV horizontal plot in the upper two-thirds and aircraft systems information in the lower one-third of the display. This design allows an almost actual size horizontal plot on a 12 or 13 inch monitor.

B. SUMMARY

Although this thesis targets a solution for a specific problem, there is a basic similarity in all airborne navigation systems used for tactical missions. There exists a strong potential for this same solution, although implemented differently, to be effective for all tactical simulation applications. The heuristic design principles of information hiding and levels of abstraction defer design decisions concerning 'how' functions will be implemented until later in the design process. This concentrated effort in specifying 'what' functions are necessary to fulfill the requirements allows design to remain abstract until the lowest levels. It highlights the decisions that are likely to change and forces designers to deal with issues of modifiability early in the design process.

APPENDIX A

TACNAV GRAPHIC SYMBOLS

[Ref. 2: p. 1-4]

TYPE	SYMBOL	DISPLAY MAXIMUM
AIRCRAFT	.25 DIA; .47; (DOUBLE BRIGHTNESS)	1
BASE SHIP	0.375; .25; 0.5	1
DATUM	⋈	1
FLY-TO-POINT	△01 — SEQUENCE NO. (TYP)	10 250 YDS TO CAPT.
SAR OR DTD FTP	▲01 — SEQUENCE NO. (TYP, SAR FTP ONLY)	500 YDS TO CAPT.
SONOBUOY	(C) 26; BUOY TYPE; RF CHANNEL (TYP); A - ACTIVE; C - CASS; S - DICASS; D - DIFAR; V - VLAD; L - LOFAR	24
AIRCRAFT CURSOR	CONNECTED TO HOOK SYMBOL UNTIL MARKED; READOUT (TYP) DEPENDING ON DISPLAY SCALE; R02200 (OR R001.1) B019T; BEARING	1
VECTOR CURSOR	CONNECTED TO HOOK SYMBOL UNTIL MARKED; READOUT (TYP) DEPENDING ON DISPLAY SCALE; R02200 (OR R001.1) B019M; BEARING	5 MARKED +1 REMAINING ON HOOK
RANGE CIRCLES (HOOK)	READOUT (TYP) DEPENDING ON DISPLAY SCALE; R02200 (OR R01.1); HOOK SYMBOL UNTIL MARKED	5 MARKED +1 REMAINING ON HOOK
EXPANDING CIRCLE	R02200 (OR R001.1); READOUT (TYP) DEPENDING ON DISPLAY SCALE	1
TARGET	>	1
RADAR CONTACT	R01 — SEQUENCE NO. (TYP)	19 +1 PENDING
SONAR, ACTIVE CONTACT	·01 — SEQUENCE NO. (TYP)	5 +1 PENDING
BOAT	B01	10
MAD CONTACT	M	8 +1 PENDING
TARGET ENTRY	X01 — SEQ NO. (TYP)	10
ESM BEARING	100 SCALE MILES; SEQUENCE NO. (TYP); E01	4
RANGE CIRCLES, ACTIVE CONTACT (BUOY)	SEQUENCE NO. (REF); C08 R16000 (OR R07.9); RANGE YDS OR NM DEPENDING ON SCALE; (A) 06	6 (1 PER BUOY) +2 PENDING
DIFAR BEARING	DIRECTIONAL MARKER; D07; CONTACT NO. (TYP); (D) 27	3 (1 PER BUOY) +1 PENDING
SONAR, PASSIVE CONTACT	0.125; P03; CONTACT NO. (TYP); DIRECTIONAL MARKER	2 +1 PENDING
DICASS, PASSIVE CONTACT	DICASS BUOY; (S) 30; S02; CONTACT NO. (TYP); DIRECTIONAL MARKER	3 (1 PER BUOY) +1 PENDING
DICASS, ACTIVE CONTACT	10; ACTIVE CONTACT MARKER; DICASS BUOY; (S) 30; S03; CONTACT NO. (TYP); DIRECTIONAL MARKER	3 (1 PER BUOY) +1 PENDING
VLAD BEARING	DIRECTIONAL MARKER; V08; CONTACT NO. (TYP); (V) 29	4 (1 PER BUOY) +1 PENDING
INTERCEPT POINT	I (FLASHING) OR	1
WEAPONS RELEASE POINT	[W] (W FLASHING)	

APPENDIX B

SHIP/SUB MOTION PARAMETER INITIALIZATION TABLEAU

Ship/Sub Motion Parameters Initialization

*** MANUAL MODE ***

Instructor Inputs

1. INITIAL SHIP/HELO POSIT		LAT xx xx xxY
		LONG xxx xx xxY
2. SHIP PIM CHANGES		
	INITIAL PIM	xxMIN/xxxTDEG/xxKTS
	PIM 2	xxMIN/xxxTDEG/xxKTS
	PIM 3	xxMIN/xxxTDEG/xxKTS
	PIM 4	xxMIN/xxxTDEG/xxKTS
	PIM 5	xxMIN/xxxTDEG/xxKTS
3. INITIAL SUB POSIT		LAT xx xx xxY
		LONG xxx xx xxY
4. SUB PIM CHANGES		
	INITIAL PIM	xxMIN/xxxTDEG/xxKTS
	PIM 2	xxMIN/xxxTDEG/xxKTS
	PIM 3	xxMIN/xxxTDEG/xxKTS
	PIM 4	xxMIN/xxxTDEG/xxKTS
	PIM 5	xxMIN/xxxTDEG/xxKTS

ENTER INITIAL SHIP/HELO POSIT

xx xx xxY

xxx xx xxY

APPENDIX C

SENSOR DETECTION PARAMETERS INITIALIZATION TABLEAU

Sensor Detection Parameters Initialization

*** MANUAL MODE ***

Instructor Inputs

1.	MEDIAN DETECTION RANGE (passive)	MDR: xxxxxYDS
2.	PREDICTED RANGE OF DAY (active)	PRD: xxxxxYDS
3.	MAD DETECTION SLANT RANGE	MAD: xxxxYDS
4.	MAGNETIC VARIATION	xx.xY
5.	WIND (DIR/SPD)	xxxTDEG/xx.xKTS
6.	SEA (SET/DRIFT)	xxxTDEG/xx.xKTS
7.	LAUNCH TRIGGER	DATUM
		LAT xx xx xxY
		LONG xxx xx xxY

ENTER MDR

xxxxxYDS

APPENDIX D
TACTICAL SCENARIO PARAMETERS TABLEAU

Tactical Scenario Parameters

1.	MAGNETIC VARIATION		xx.xY
2.	INITIAL SHIP/HELO POSIT	LAT	xx xx xxY
		LONG	xxx xx xxY
3.	SHIP PIM		xxxTDEG/xx.xKTS
4.	WIND (DIR/SPD)		xxxTDEG/xx.xKTS
5.	SEA (SET/DRIFT)		xxxTDEG/xx.xKTS
1.	MEDIAN DETECTION RANGE (passive)	MDR:	xxxxxYDS
2.	PREDICTED RANGE OF DAY (active)	PRD:	xxxxxYDS
7.	LAUNCH TRIGGER		DATUM
		LAT	xx xx xxY
		LONG	xxx xx xxY

APPENDIX E

TACNAV INITIALIZATION TABLEAU

INITIAL TABLEAU

1.	MAG VAR	xx.xX
2.	BIAS	xxxTDEGxx.xKT
3.	GRID CTR	xx xx xxY
		xxx xx xxY
4.	PIM	xxxTDEGxx.xKTS
5.	DATUM	xx xx xxY
		xxx xx xxY

ENTER MAG VAR

xx.xY

APPENDIX F
TACNAV NAVIGATION TABLEAU

NAV TABLEAU

1.	SHIP POSIT	xx xx xxY xxx xx xxY
2.	ACFT POSIT	xx xx xxY xxx xx xxY
3.	ZULU TIME	xx xx xx
4.	ALTITUDE	xxxxFT
5.	WIND D/SP MODE - MANUAL	xxxT/xx.x
6.	ACFT CS/SP	045T/000

ENTER SHIP POSIT

xx xx xxY

xxx xx xxY

APPENDIX G

TACNAV SONOBUOY LAUNCH TABLEAU

SONOBUOY TABLEAU

SLOT	TYP	RF	D	L	TIME
01	L	17	D	3	
02	L	15	D	3	
03	L	13	D	3	
04	L	19	D	3	
05	L	21	D	3	
06	L	23	D	3	
07	L	25	D	3	
08	L	27	D	3	
09	L	29	D	3	
10	L	20	D	3	
11	L	22	D	3	
12	A	02	S	-	
13	A	04	S	-	
14	A	09	S	-	
15	A	11	D	-	
16	TORPEDO				

1-A	3-S	5-V	1-DEEP
2-C	4-D	6-L	2-SHALLOW

SLOT xx TYP x RF xx
DEP x LIFE x

APPENDIX H

TACNAV EQUIPMENT TABLEAU

PROCESSOR STATUS

--GOOD--

EQUIPMENT		ENABLE	STATUS
1.	APN-182	YES	GOOD
2.	TAS	YES	GOOD
3.	AHRS	YES	GOOD
4.	AQS-13B	NO	
5.	AQS-13E	NO	
6.	H-2 MODE	YES	GOOD
7.	ASA-26	YES	GOOD
8.	CLASS	UNCLASSIFIED	

NUMBER x   ENABLE y

APPENDIX I
SIMULATOR SELECTABLE FUNCTIONS

TACNAV functions:

1. VERIFY
   * locks in memory the screen position of the hook
   * causes verified symbol to flash

2. ERASE
   * hooked and verified symbol no longer displayed
   * aircraft, ship, and datum symbols can not be erased
   * there is no deselect for this function

3. CORRECT
   * repositions verified symbol to current hook position
   * there is no deselect for this function

4. RECENTER
   * recenter display on current aircraft position
   * hook,verify, then recenter display on verified position
   * there is no deselect for this function

5. SCALE changes
   * 0.5, 1, 2, 4, 8, 16, or 32 nm/inch display scale
   * scale up, scale down by a factor of 2 each time selected
   * there is no deselect for this function

6. CIRCLE

* origin at hook
* radius displayed at top of circle
* fixed radius
  - enter radius (xxxxxYDS)
  - moves with hook
* expanding radius
  - entered at current hook position
  - enter initial radius (xxxxxYDS)
  - enter expanding rate (estimated speed) (xx.xKTS)
  - radius displayed at top of circle
  - updated circles appear every second
  - old circles disappear when updated
* only one expanding circle at any one time

7. VECTOR

* vector origin at aircraft unless
  - hook and verify different vector origin
* only one vector may be attached to aircraft symbol
* line displayed between origin and hook
* bearing and range displayed along line

8. MARK

* vector or fixed radius circle permanently displayed until erased (maximum of 5 each)
* there is no deselect for this function

9. CONTACT points

* increasingly numbered symbol displayed on hook
  - symbol (X 01)

10. <u>FLY-TO-POINTS</u> (<u>FTP</u>)

* increasingly numbered symbol displayed at designated position
  - lat/long
  - local grid
  - hook position
  - dip point
* PRIORITY ? prompt upon function select only
  - Priority FTP is placed in sequence ahead of all non-priority FTP's and at the end of other priority FTP's
* Until function deselected, non-priority may be displayed at hook position by pressing ENTER only
* Estimated Time Enroute (ETE) to priority FTP displayed in lower right corner of tactical display
  - ETE display changes from hours and minutes to minutes and seconds when ETE less than 2 minutes
  - when aircraft is stationary (hover, on deck) ETE displays 99 59
* priority symbol disappears when overflown by aircraft
  - aircraft posit within 250 yards of symbol position
  - all other FTP numbers decremented automatically

11. <u>ATTACK</u>

* when engaged, 2 most recent MAD fixes used to generate estimated sub position (< symbol), estimated sub course and speed, intercept point (flashing I symbol) and intercept bearing and range from helo
  - sub estimated position symbol moves

at estimated course and speed

- intercept symbol(I) moves according to helo range and bearing from sub estimated position

* estimated target course and speed, and intercept bearing and range are displayed in lower left corner of tactical display
* additional accuracy can be gained by verifying additional MAD fixes or CONTACT points
  - sub estimated course, speed, and position will be computed using all verified points

12. MARK-ON-TOP (MOT)
  * initial selection activates user's aircraft control and aircraft sensors
  * used for tactical plot stabilization
  * enter buoy RF in OTPI, verify sonobuoy, select MOT when "on-top"indicated by BDHI #1 needle swing of at least 90 degrees
  * displays old bias, new bias , bias error
  * cue area menu: reject, bias correct, buoy correct, aircraft correct, pattern correct?
  * there is no deselect for this function

Simulator-unique functions:

13. Magnetic Anomaly Detection (MAD) fix
  * when helo passes within MAD detection range, MADMAN symbol displayed at helo position
    - symbol flashes for first 10 seconds, then steady
  * this is an automatic function, and therefore cannot be selected/deselected

14. MAGNETIC (headings/bearings)

* when selected, all brgs/hdgs displayed in degrees Magnetic
* degrees True corrected for Magnetic Variation (MAG VAR)
  - add west, subtract east

15. LAT/LONG

* when selected all tactical display coordinates will be in latitude/longitude format

16. LINK/MONITOR

* enter buoy RF into link/monitor display
* begin monitoring sub-to-sonobuoy bearing and range
* only "link/monitored" buoys can be designated "HOT"
* "HOT" buoys indicated by shaded RF channel in link/monitor display

17. OTPI (On Top Position Indicator)

* select function, then enter sonobuoy RF channel
* BDHI #1 needle points to buoy's relative bearing from aircraft
* used to geographically mark-on-top (MOT) selected buoy

18. SONOBUOY SLOT SELECT

* after selecting function, select buoy slot to be fired
  - selected slot on sonobuoy panel display is highlighted (e.g. by hashing outline of cube)

19. FREEZE

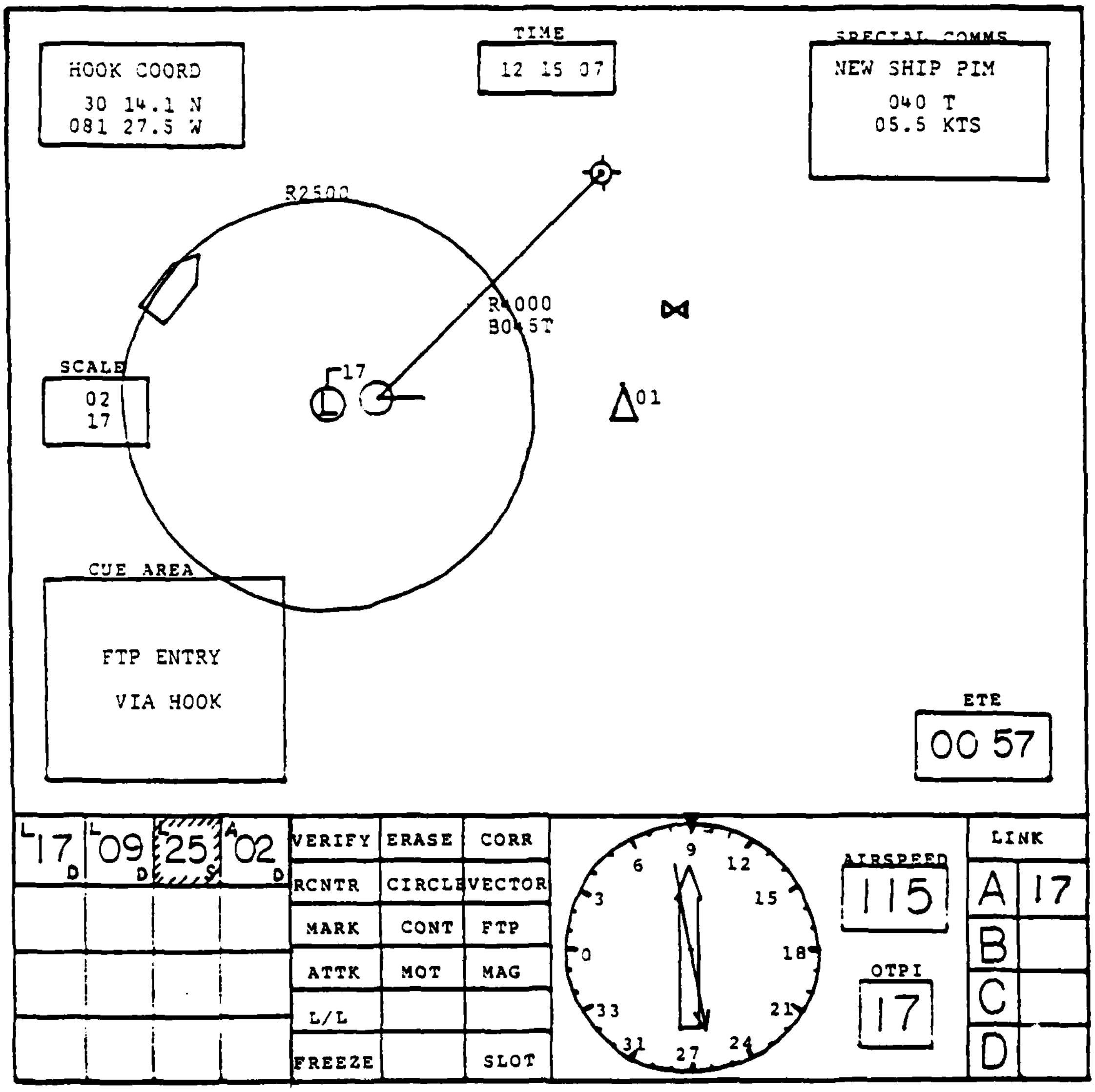
* may be selected at any time

* halts problem execution
* when deselected, problem continues without change

20. QUIT
    * may be selected at any time
    * terminates problem execution, will not return to problem
    * prompts user for DEBRIEF? (torpedo drop data)

APPENDIX J

PROPOSED TACTICAL DISPLAY



APPENDIX K

PROPOSED PACKAGES

Package 1 (TACNAV functions)

a. VERIFY
b. ERASE
c. CORRECT
d. RECENTER
e. MARK
f. SCALE UP/DOWN
g. VECTOR
h. CIRCLE
i. FLY-TO-POINT
j. CONTACT
k. ATTACK
l. LAT/LONG
m. MAGNETIC

Package 2 (TACNAV/Simulator functions)

a. ON-TOP-POSITION INDICATOR (OTPI)
b. MARK-ON-TOP

Package 3 (Selectable Simulator functions)

a. SONOBUOY SLOT SELECT
b. SONOBUOY/WEAPON DROP
c. LINK/MONITOR

Package 4 (Selectable Simulator functions)

a. FREEZE
b. QUIT/DEBRIEF

Package 5 (Sensor functions)

a. BUOY DETECTION
b. MEDIAN DETECTION RANGE
c. MDR

d. PREDICTED RANGE OF DAY

e. PRD

f. ASPECT

g. BUOY-TO-SUB RANGE

h. SUB-TO-BUOY RELATIVE BEARING

i. MAGNETIC ANOMALY DETECTION

j. MAD

Package 6 (Aircraft Position)

a. AIRCRAFT POSITION

b. AIRCRAFT MOTION

c. WIND DIRECTION/SPEED

Package 7 (Ship/Sub/Sonobuoy Displayed Position)

a. SHIP POSITION

b. SHIP MOTION

c. SHIP PIM

d. SUB POSITION

e. SUB MOTION

f. DETECTION EVASION

g. EVASIVE MANEUVERING

h. SONOBUOY POSITION

i. TACNAV SYSTEM BIAS

Package 8 (Ship/Sub/Sonobuoy Actual Geographic Position)

a. SHIP ACTUAL GEOGRAPHIC POSITION

b. SONOBUOY ACTUAL GEOGRAPHIC POSITION

c. SEA SET/DRIFT

Package 9 (Input functions)

a. KEYBOARD (data entry)

b. FUNCTION SELECTION

c. AIRCRAFT FLIGHT CONTROL

d. HOOK POSITIONING CONTROL

Package 10 (Display Output functions)

a. SIMULATOR INTRODUCTION TEXT

b. INITIALIZE SHIP/SUB SCENARIO PARAMETERS (instructor)

c. INITIALIZE SENSOR DETECTION PARAMETERS (instructor)

d. USER OPERATING INSTRUCTIONS

Package 11 (Display Output functions)

a. DISPLAY TACTICAL PLOT

b. DISPLAY AIRCRAFT SYSTEMS

c. DISPLAY SELECTABLE FUNCTIONS

Package 12 (Output Tableau functions)

a. TACTICAL SCENARIO PARAMETERS TABLEAU

b. TACNAV INITIALIZATION TABLEAU

c. NAVIGATION TABLEAU

d. SONOBUOY LAUNCH TABLEAU

e. EQUIPMENT STATUS TABLEAU

Package 13 (Composite Output functions)

a. Package 9

b. Package 10

c. Package 11

d. Package 12

Package 14 (Composite Selectable functions)

a. Package 1

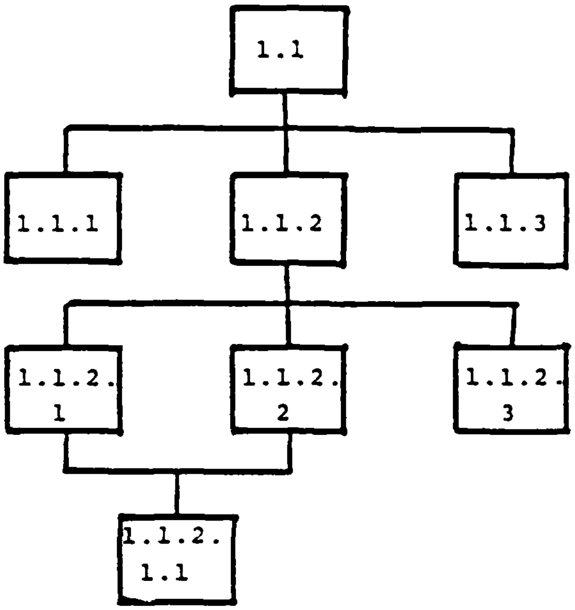
b. Package 2

c. Package 3

d. Package 4

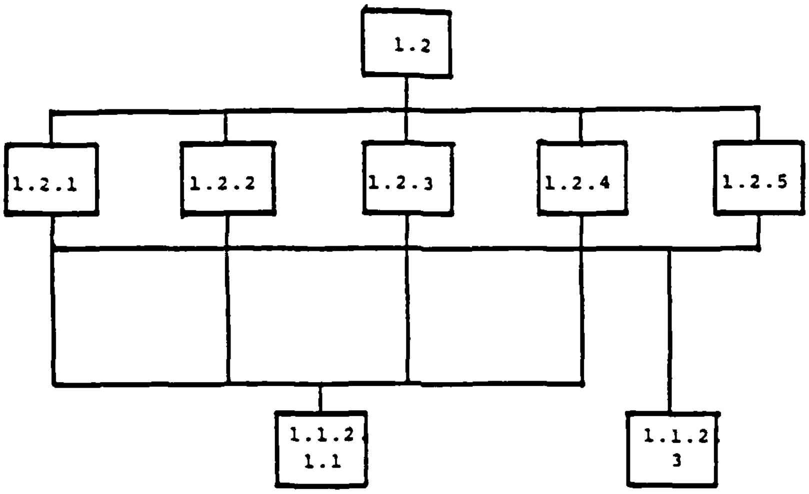
APPENDIX L

SIMULATOR STRUCTURE CHART (1.1)



MODULE NUMBER	MODULE NAME
1.1.1	Display Simulator Intro Text
1.1.2	Initialize Scenario Parameters
1.1.2.1	Initialize Ship/Sub Motion Parameters
1.1.2.1.1	Validate Input Data
1.1.2.2	Initialize Sensor Detection Parameters
1.1.2.3	Display Graphics
1.1.3	Display User Operating Instructions

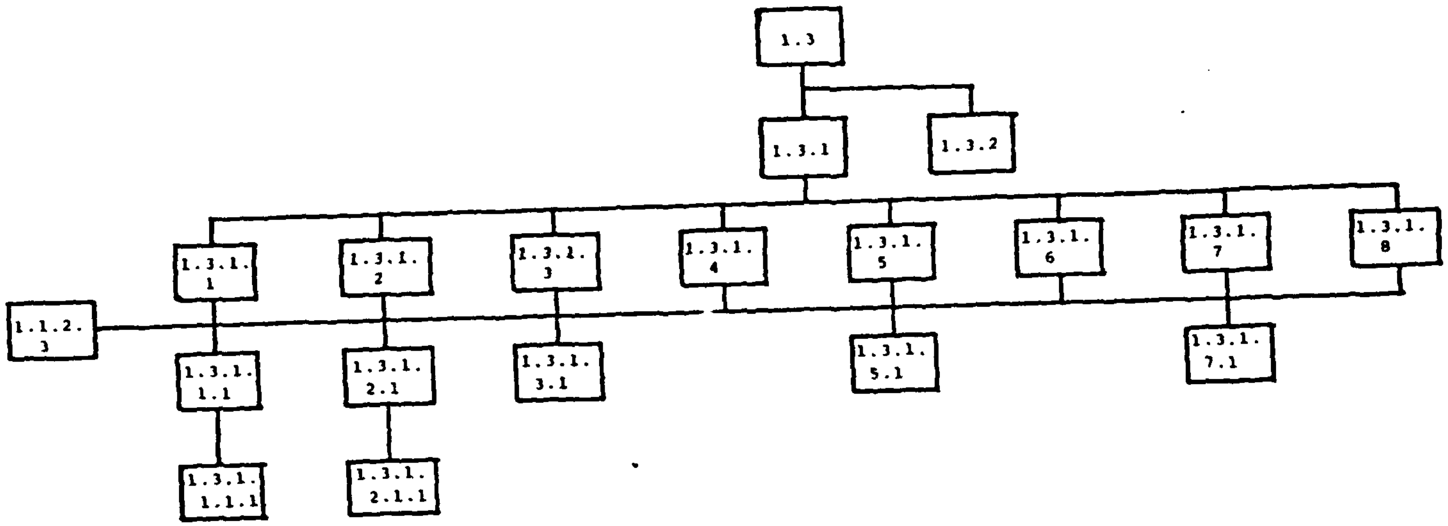
APPENDIX M
SIMULATOR STRUCTURE CHART (1.2)



MODULE NUMBER	MODULE NAME
1.2	Update Tableaus
1.2.1	Display Tactical Scenario Parameters
1.2.2	Update TACNAV Initialization Tableau
1.2.3	Update Navigation Tableau
1.2.4	Update Sonobuoy Launch Tableau
1.2.5	Display Equipment Status Tableau
1.1.2.1.1	Validate Input Data
1.1.2.3	Display Graphics

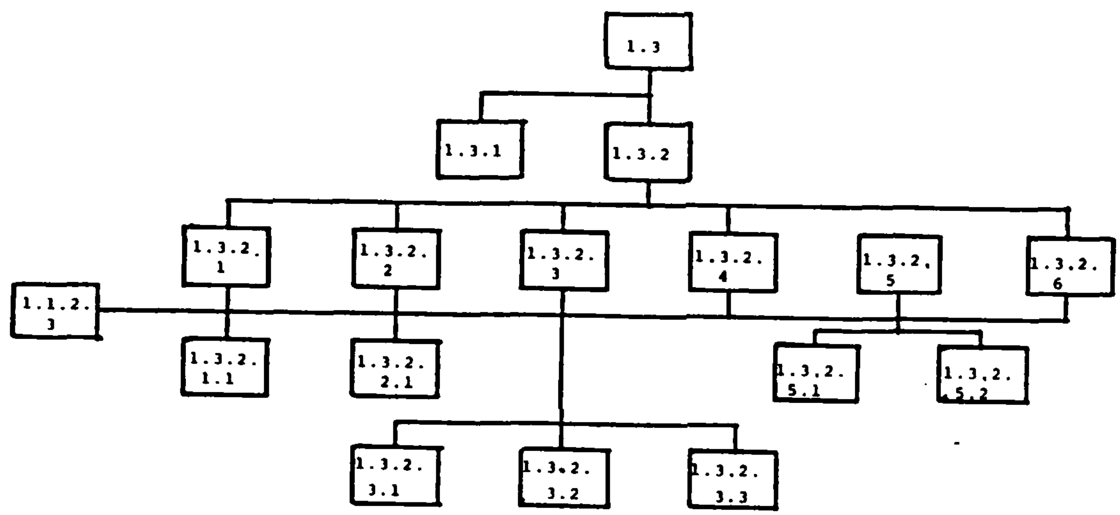
APPENDIX N

SIMULATOR STRUCTURE CHART (1.3.)



MODULE NUMBER	MODULE NAME	MODULE NUMBER	MODULE NAME
1.3.1	Display Tactical Plot	1.3.1.4	Display Datum
1.3.1.1	Display Aircraft	1.3.1.5	Display Selected Functions
1.3.1.1.1	Aircraft Position	1.3.1.5.1	Selectable Function Package
1.3.1.1.1.1	Aircraft Motion	1.3.1.6	Display Problem Time
1.3.1.2	Display Hook	1.3.1.7	Display Sonobuoys
1.3.1.2.1	Hook Position	1.3.1.7.1	Sonobuoy Motion
1.3.1.2.1.1	Hook Motion	1.3.1.8	Display Hook Coordinates
1.3.1.3	Display Ship		
1.3.1.3.1	Ship Motion	1.1.2.3	Display Graphics

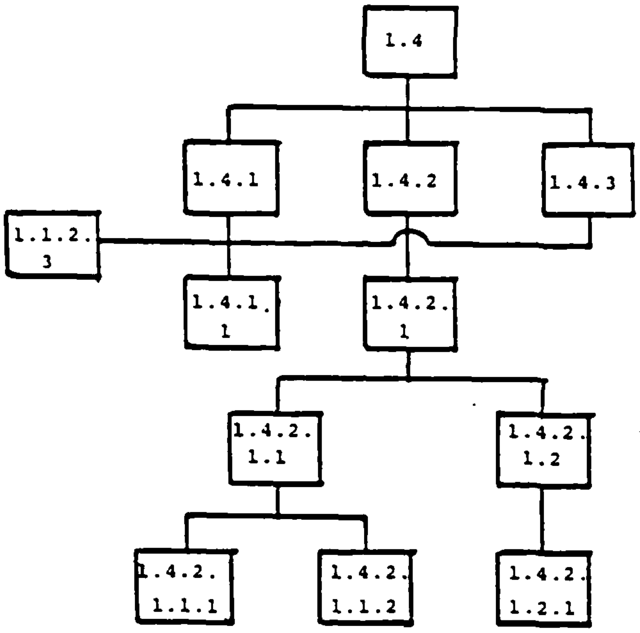
Simulator Structure Chart (1.3) (continued).



MODULE NUMBER	MODULE NAME	MODULE NUMBER	MODULE NAME
1.3.2	Display Aircraft Systems	1.3.2.3.3	Display #2 Nav Needle
1.3.2.1	Display Sonobuoy Panel	1.3.2.4	Display OTPI Channel
1.3.2.1.1	Display Sonobuoy Slot Selected	1.3.2.5	Display LINK/MONITOR Panel
1.3.2.2	Display Functions Selected Panel	1.3.2.5.1	Display LINKed Buoy RF
1.3.2.2.1	Functions Selected	1.3.2.5.2	Display "HOT" Buoys
1.3.2.3	Display BDHI & Nav Needles	1.3.2.6	Display Aircraft Airspeed
1.3.2.3.1	Display BDHI Compass		
1.3.2.3.2	Display #1 Nav Needle	1.1.2.3	Display Graphics

APPENDIX O

SIMULATOR STRUCTURE CHART (1.4)

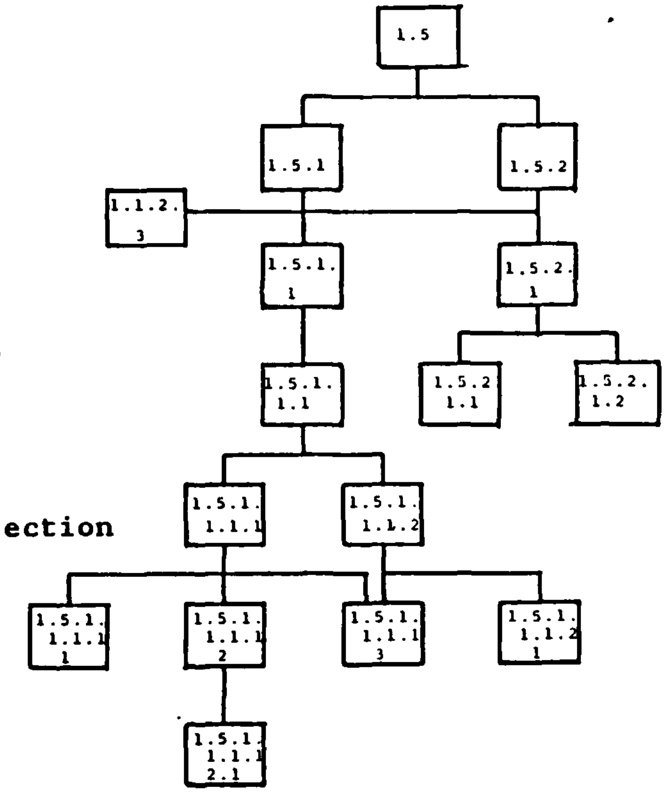


MODULE NUMBER	MODULE NAME
1.4	Record Actual Geographic Positions
1.4.1	Record Ship's Actual Position
1.4.1.1	Ship Motion
1.4.2	Record Sub's Position
1.4.2.1	Sub Motion
1.4.2.1.1	Detection Evasion
1.4.2.1.2	Evasive Maneuvering
1.4.2.3	Record Sonobuoys' Actual Positions
1.5.1.1.1.1.2	ASPECT
1.5.1.1.1.1.3	Buoy-to-Sub Range
1.5.1.1.1.2.1	PRD

APPENDIX P

SIMULATOR STRUCTURE CHART (1.5)

MODULE NUMBER	MODULE NAME
1.5	Display Sensor Contact
1.5.1	Display Sonobuoy Detection
1.5.1.1	Buoy Detection
1.5.1.1.1	HOT Buoy
1.5.1.1.1.1	Median Detection Range
1.5.1.1.1.1.1	MDR
1.5.1.1.1.1.2	ASPECT
1.5.1.1.1.1.2.1	Sub-to-Buoy Relative Bearing
1.5.1.1.1.1.3	Buoy-to-Sub Range
1.5.1.1.1.2	Predicted Range of the Day
1.5.1.1.1.2.1	PRD
1.5.2	Display Magnetic Anomaly Detection
1.5.2.1	MAD Detection
1.5.2.1.1	Sub-to-Aircraft Range
1.5.2.1.2	MAD
1.1.2.3	Display Graphics



APPENDIX Q

REQUIREMENTS SPECIFICATIONS

MACRO Requirement Specifications

1. Simulate single aircraft ASW tactical scenario against single fully evasive submarine

2. Simulate AN/ASN-123 TACNAV operations

3. Provide both manual(instructor input) and automatic(software) generation of tactical scenario paramet · s

4. Unclassified

5. Portable for use personal microcomputer systems.

6. Easily modifiable

7. Use AN/ASN-123 TACNAV display symbology

8. Use AN/ASN-123 TACNAV functions, menus, and tableaus

9. Function select and deselect must be by same method

10. Functions should be selected as simply as possible

11. Provide for mutually exclusive function selections as in AN/ASN-123 TACNAV

12. Function symbols and menus should be displayed or erased within 0.5 seconds of selection or deselection

13. Flashing symbols should blink (on/off) at 0.5 second intervals

14. CRT display should include:
    - normal TACNAV display (tactical plot and tableaus)
    - BDHI compass and #1 and #2 navigation needles
    - sonobuoy launch panel

- link/monitor information
- OTPI channel selected
- TACNAV functions selected
- Aircraft airspeed

15. Detection models should be as realistic as possible without sound-velocity or magnetic disturbance information

16. Detection models should be aspect dependent

17. Do not provide detection information unless sonobuoy is being link/monitored

18. Provide for at least LOFAR, ACTIVE, DIFAR, and DICASS sonobuoy types

19. Simulate time required for sensor operator to determine/input contact bearing/range for each buoy (45 seconds between active buoy range ring updates)

20. Simulate time for hydrophone descent before providing detection information

21. Easily modifiable to add new sensors or platforms

22. Easily modifiable sensor detection algorithms

23. Understandable internal documentation including
    - functional module description
    - input parameters
    - output parameters
    - called by what modules
    - calls what modules
    - block functional descriptions

24. Short and simple user's manual including
    - step-by-step logon, startup, initialize, execute, exit, shutdown
    - description of TACNAV functions incorporated

- brief sample ASW tactical problem showing display snapshots

25. Automate sensor operator functions (MAD, Passive sonobuoy contact, Active sonobuoy range rings)

26. Log torpedo drop data for debrief including drop time, torpedo-to- sub range and bearing, sub course, aircraft course

27. Provide FREEZE of problem execution at any time, problem may be continued unchanged by deselecting FREEZE

28. Provide EXIT of problem which terminates execution at any time

29. Provide capability to easily position "hook" on CRT display

30. Student user must be able to easily maneuver aircraft symbol on CRT display

31. Capability to select and drop sonobuoys randomly by slot, automatic update sonobuoy panel in CRT display

32. Time of sonobuoy/torpedo drop automatically recorded in Sonobuoy Launch Tableau (SLT) under the TIME heading

33. Provide OTPI control of BDHI #1 needle to simulate geographic fixing of selected sonobuoy

34. Provide FTP control of BDHI #2 needle to indicate bearing of #1 priority FTP

35. Provide for MOT and BIAS corrections for plot stabilization

36. Provide for Ship PIM changes (5 max)

37. Provide for effects of wind on aircraft

38. Provide for effects of sea set and drift on ship and buoys

39. Automatically disable/enable equipment in EQP tableau according to aircraft type selected

40. Validate keyboard entries character by character, do not allow invalid data to be accepted (e.g. Course > 359 degrees)

41. Allow original problem parameters to be recalled by user at any time

42. Allow user to update data in INITIAL, NAV, and SLT tableaus at any time

43. Aircraft position and heading are the same as ship position and course, respectively, until aircraft takeoff.

44. Simulate both datum and ship passive LOB launch triggers

45. Update every 30 seconds
    a) Sonobuoy-to-Sub ranges
        1) Active range rings
        2) Passive contact (hot or cold)

46. Update every second
    a) Expanding circle radius
    b) Expanding circle symbol
    c) Helo-to-Sub range (MADMAN)
    d) ATTACK symbol (<)
    e) Intercept symbol (I)
    f) Intercept bearing and range (lower left corner of display)
    g) Estimated Time Enroute (ETE) to priority FLY-TO-POINT (FTP)
    h) Ship position

47. Update every 50 milliseconds

    a) Helo position and symbol

    b) Sub position

48. From the moment of entry in the NAV tableau, the ship's position is updated using PIM data

49. Tactical plot is initially displayed with a scale factor of 4 nm/inch and both the grid center and hook symbol are located at the center of the screen

50. Time is always displayed at the top of the screen after initialized

51. Aircraft control method is activated only after initial Mark-on-Top (MOT)

52. Only one vector may be attached to the aircraft symbol

53. Only one circle may have any expanding radius

54. True North orientation when MAGnetic function not selected

55. Local grid coordinates are displayed when LAT/LONG function not selected

56. Display simulated Ship and Sensor Operator verbal communications to aircraft in special comms area of tactical plot display (e.g. MADMAN, BUOY 17 HOT, NEW SHIP PIM 315T/12.0KTS, SHIP LOB 330T, etc.)

APPENDIX R

PROPOSED ENHANCEMENTS

1. Additional aircraft mode capability
   - H-3
   - H-60(CV)
   - LAMPS MKIII

2. Additional Sensors and Equipment
   - Additional Sonobuoy types
   - ESM
   - Dipping Sonar
   - FLIR
   - Radar
   - Datalink
   - Inflight Mission Recorder
   - Ship sensors

3. Multi-unit Operations
   - Multiple prosecuting ships
   - Multiple prosecuting aircraft
   - Multiple submarine targets
   - Multiple ship targets

4. Additional TACNAV functions/features
   - Bearing (BRG) function
   - Radar Contact function
   - Manual Buoy Entry (BUOY) function
   - Coordinate (COORD) display function
   - Embedded Decision Support System
   - Detection probability models

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