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An Analysis Of Capabilities And Criteria For Aircrew Debrief Stations: Final Report CDRL A002

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INSTITUTE FOR SIMULATION AND TRAINING

PREPARED UNDER CONTRACT NUMBER N61339-92-C-0033
for
Naval Air Warfare Center Training Systems Division

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Final Report
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January 16, 1996

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1.0 INTRODUCTION

"An Analysis of Capabilities and Criteria for Aircrew Debrief Stations", Contract No. N61339-92-C-0033, was sponsored by the Naval Air Warfare Center Training System Division (NAWCTSD) in support of the joint Navy/Air Force Advanced Display and Debriefing System (ADDS) project. The three and one-half year project provided Human Factors expertise in support of the government's contract activities. The project was conducted by personnel at the University of Central Florida Institute for Simulation and Training. This report provides the final report on the project activities.

The Advanced Display and Debriefing Subsystem (ADDS) is an upgrade to the existing Display and Debriefing System (DDS) currently used on the Tactical Aircrew Combat Training System and the Aircrew Combat Maneuvering Instrumented ranges (TACTS/ACMI) by the U.S. Navy, Air Force and Air National Guard. ADDS will be used to debrief aircrew participants after missions, either at the local facility or a remote site, as well as for providing monitoring, control, and recording capabilities as missions occur on the TACTS/ACMI ranges. Hence, the ADDS functionality must support both live and replay modes of operation,. Because of the varying skill levels and experience of its intended operators, the ADDS was designed to be easy to use. Debrief systems are an essential component of high technology training systems. The ADDS program was initiated to support future tactical training requirements to improve aircrew proficiency in tactical air combat.

Since much of aircrew training consists of briefing, practice, and debriefing sessions, the training effectiveness of a well designed user-friendly debrief system is extremely important. In modern air training programs, practice occurs with a variety of systems which include high fidelity flight simulators, weapons systems trainers, part task trainers, training and operational aircraft, and actual mission profiles flown on instrumented ranges. Complex maneuvers and tactics, which require only minutes to execute while airborne, can be examined at length during debrief sessions. Debrief systems which accurately replicate maneuvers and tactics, and display pertinent data to both instructor and student are invaluable tools.

A deficiency analysis of the current debrief systems revealed many shortcomings. For instance, the system is too complex to be used by squadron instructors without considerable training. Necessary training on the system is both time consuming and costly. Ideally, instructors should be able to operate the system with an acceptable level of proficiency with little or no training. This could be accomplished with the use of an intuitive, "user-friendly" interface. Another characteristic of the current system found to be inadequate involves the lack of play back control features (e.g., fast forward, pause, time search). It is essential for instructional purposes to have any portion of the training exercise available and readily accessible for display. The ADDS project was designed to address these deficiencies and develop an enhanced user interface which exploits state-of-the-art hardware and software technology.

2.0 ADDS HUMAN ENGINEERING DESIGN PROCESS

2.1 OBJECTIVE

The main objective of this project was to develop capabilities and criteria for the development and evaluation of aircrew debrief stations. The ADDS was intended as a test case. The objective was to be accomplished first by identifying and evaluating deficiencies in existing debrief stations. Capabilities and criteria for new debrief stations were to be developed drawing off the knowledge and expertise of engineers, pilots, and human factors specialists. It was hoped that the ADDS final design would set the criteria standard for future aircrew debrief systems. Extensive problems throughout the ADDS project did not permit the intended goal to be completely achieved. As a result, the modified objective was to develop a thorough documentation and evaluation of the ADDS design, and provide lessons learned and recommendations that could be used to guide future display and debriefing system projects.

2.2 APPROACH

The capabilities and criteria for the user interface of the ADDS were identified using a systems approach. Existing display and debriefing systems were examined to assess the state-of-the-art and identify relevant user interface issues and deficiencies. In addition, a Systems Level Users Group (SLUG), comprised of Navy and Air Force pilots, was established to provide subject matter expertise and identify potential capabilities and enhancements for new display and debriefing system designs.

2.3 MODIFICATION OF EXISTING SYSTEM

The current display and debriefing system has been in operation for over 15 years. Much of the technology for that system is old and outdated. However, as with any system, individuals become accustomed to the old technology and may be reluctant to change. In some ways this was the case with ADDS. On the other hand, many found the idea of applying radically new technology intriguing. The promises of this new technology may be overly glorified, raising expectations beyond that which is achievable. These and other problems are addressed in Section 4.0.

Throughout the design process, the user interface went through many revisions. Paper-and-pencil mockups of the many menu screens were presented. Whereas this method of design enabled the pilots to see an accurate representation of the screens, it did not offer the pilots any sense of how they would interact with the system. That is, because the screens were not dynamic, they could not be realistically demonstrated prior to the final product. The use of rapid prototyping would have helped alleviate this problem. Had rapid prototyping been used, as originally proposed by the contractor, the pilots could have experimented with different screen layouts. Performance times and mistakes, as well as suggestions and comments, could have been recorded and used to revise the design. Although testing the design at various stages of the project may be time consuming, a mistake detected further along would be potentially devastating in terms of time and cost. The benefits of rapid prototyping would have been immeasurable in the design of such a sophisticated system as ADDS.

The treatment of ADDS as an update to an existing system also introduced a number of constraints. In some cases the system specification required features to be identical with the existing display and debriefing system even when they did not comply with human engineering guidelines. In addition, since the ADDS project did not address the control simulation software, many enhancements desired by the SLUG could not be addressed because the data was not available within the system.

2.4 APPLICABLE DOCUMENTS

The following documents were used in the analysis and design of the Advanced Display and Debriefing Subsystem user interface.

- MIL-STD-1472D - Human Engineering Design Criteria for Military Systems, Equipment and Facilities.
- Air Force System Command DH 1-3 - Human Factors Engineering.
- MIL-H-46855B - Human Engineering Requirements for Military Systems, Equipment and Facilities.
- ANSI/HFS 100. American National Standard for Human Factors Engineering of Visual Display Terminal Workstations, 1988.
- The DoD Common Operating Environment Guideline, Draft 1992.
- AFMRTL-TR-85-013 - Personal Computer Dialogue: A Human Engineering Data Base Supplement.
- ADDS Control Graphical User Interface Guidelines
- ESD-TR-86-278 - Guidelines for Designing User Interface Software.

- NTSC-062090-1 & 2 - Government off-the-shelf Software Guide.

The first five documents provided the core guidance for the human engineering activities on the ADDS project.

3.0 EVALUATION OF ADDS HUMAN ENGINEERING APPROACH

There were a number of shortcomings in the overall human effort related to ADDS. These shortcomings were not restricted to any one area. There were problems asociated with the overall process, the design, and the testing. This section describes the human engineering approach and make recommendations on how the human engineering process could be improved on future projects.

3.1 THE HUMAN ENGINEERING PROCESS

The primary cause of the human engineering problems on ADDS can be traced to the human engineering process. The following paragraphs summarize some of the observations from the ADDS program.

3.1.1 Contractor Attitude

It is questionable whether the contractor ever committed to the human engineering process. It seemed to be viewed as a touchy-feely, public relations process rather than a design requirement. They had to conduct some level of human engineering activities because it was called out in the contractual requirements. However, the contractor did not appear to understand what the human engineering activities were and often ignored its recommendations.

3.1.2 Human Engineering Program Plan

The Human Engineering Program Plan developed for ADDS did not provide adequate guidance for the human engineering activities. The contractual requirement for multiple submissions of the Human Engineering Program Plan kept the human engineering activities in flux and weakened their effectiveness. The normal procedure is to develop the plan at the beginning of the program and then carry it out. With multiple submissions the contractor kept changing their approach. The multiple submittals of the program plan appeared to reinforce the contractor's belief that the human engineering activities were simply a game.

The major problem with the Human Engineering Program Plan was that the contractor never implemented what they proposed. For example, the contractor made repeated reference to the use of rapid prototyping to conduct timely human engineering evaluations. However, even though every iteration of the program plan emphasized rapid prototyping, it was never used on the program. If rapid prototyping had been used, the SLUG could have experimented with different screen layouts and control panel organizations. Performance times and mistakes, as well as suggestions and comments, could have been recorded and used to revise the design. Many of the deficiencies found during Factory Qualification Testing (FQT) could have been avoided by the use of rapid prototyping. The benefits of rapid prototyping would have been immeasurable in the design of such a sophisticated system as ADDS.

A requirement to make the Human Engineering Program Plan effective is to provide for human engineering sign-off authority. This is a normal procedure in most program plans.

3.1.3 Flow of Requirements

There was a basic problem with the flow of human engineering requirements throughout the program. The most fundamental example of this concerned the guidelines used in the development of the Computer Graphical User Interface (CGUI) for ADDS. The contractor's Human Engineering Program Plan proposed to replace the CGUI guidelines originally proposed for ADDS with a more up-to-date set of guidelines. However, when the program reached FQT, the contractor did not want to test the CGUI against the contractual guidelines, since they had not followed these guidelines, but the also did not want to test against the guidelines that they had proposed and followed in the Human Engineering Program Plan because they were not in the specification. Hence, the CGUI was not actually evaluated against its design guidance.

The contractor did not understand the intent of a MIL-H-46855 compliant Human Engineering Program Plan. Because MIL-H-46855 was identified as a requirement in the ADDS System Specification, the normal interpretation is that all processes and procedures proposed by the contractor in the Human Engineering Program Plan automatically flow into the contract requirements. They become part of the System Specification by inclusion.

The second example of the poor flow of human engineering requirements on the ADDS program is that the human engineering design presented at CDR and various SLUG meetings was not implemented by the contractor. Many of the human engineering deficiencies cited at FQT were not part of the human engineering design. They were the result of changes made during implementation or failure to follow the specified human engineering requirements.

3.1.4 Response to Government Comments

The review process for human engineering documentation also introduced process problems. Response to government review comments were not required until the next submittal of the human engineering document. Often the contractor's response, after months of delay, was that they disagreed with the comment and were not going to take action. As a result, many comments were never resolved. As recommended later, the contractor should have to resolve comments before a submittal is accepted.

3.1.5 System Level User Group (SLUG)

The SLUG was a very useful tool in the ADDS program. The shortcoming of the SLUG was that due to the extensive program delays, there was no continuity of membership. Normal rotation of military personnel resulted in a total turnover in SLUG members during the course of the program. This was a benefit to the contractor because there was no one to recall design decisions and requirements made by the SLUG early in the program. AS a result several requirements that the contractor did not agree with were forgotten in the final design. This problem reinforces the need for a formal audit trail on programs such as ADDS.

3.1.6 MIL-STD-1472D

The contractor did not always follow MIL-STD-1472D even though it was a contractual requirement. Several ADDS features simply ignored the requirements in this standard. This was in part due to the departure of the contractor's human engineering expert in the middle of the program. It is unlikely that the software implementers ever read MIL-STD-1472D, and without a human engineer on the program there was no one to provide guidance. Human Engineering signature authority in the program plan would have alleviated this problem.

An example of the contractor not following MIL-STD-1472D is exemplified by the audio test for FQT. MIL-STD-1472D specifies three tests for intelligibility of audio systems. The contractor did not follow these test requirements. There needs to be strong justification why the prescribed tests are not being used. The non-compliance of the audio test procedures with the contractual requirements of MIL-STD-1472D was identified in each review of the ADDS test plan. However, the contractor never responded to the comments. The final test was essentially a subjective "sounds good to me" evaluation.

3.1.7 Audit Trail

On a project such as ADDS, there is a need for a detailed audit trail to document and trace design decisions. As pointed out earlier, the turnover of personnel on the SLUG resulted in the loss of early design decisions and requirements.

3.1.8 Design Documents

Human Engineering Design Documents were often not coordinated very well with programs reviews and SLUG meetings. Design documents were often due slightly after critical meetings. As a result, the meetings often did not examine the current design, but rather the design as of the last submittal of the design document.

3.1.9 Test And Evaluation

3.1.9.1 Human Engineering Tests

During the development of the test plans, it appeared that the contractor personnel writing the test plan were going through a mechanical process where they included standards and procedures as called out in the System Specification without any real idea of what they meant. The omission of test requirements suggested that the contractor never really looked at MIL-STD-1472D, and what it required. The test plans also gave the impression that the contractor only wanted to evaluate those human factors parameters that they wanted to test, rather than all requirements that were identified by the System Specification.

For example, in one iteration of the human engineering portion of the FQT Test Plan, the contractor wanted to claim that all ADDS was commercial-off-the-shelf (COTS), since it was hosted on COTS equipment. The obvious motivation was that the contractor could invoke the "except where justified on a cost or technical basis" clause for COTS in the System Specification and avoid testing most human engineering requirements. On this basis, the contractor claimed that almost 2/3 of the MIL-STD-1472 requirements were not applicable.

Another interesting observation was the approach that the contractor adopted to address comments on the human engineering portions of the test plan. In many cases, items that were questioned were simply dropped from the next iteration of the test plan.

The contractor also exhibited difficulty is formulating appropriate human engineering test criteria. For example, one test procedure state that the quality and intelligibility of the UHF audio received by the airborne aircrew and generated by the ADDS operator shall not be noticeably different than that generated by an existing DS console operator. This is a new system and legally should be tested against the MIL-STD-1472D requirements. The existing system is a minimal baseline and not very relevant. What was interesting in the proposed test was that if tested as written and **if the system is noticeably better** (whatever that subjective criteria means) **they failed the test.** Different does not mean worse. The whole idea is to make things better.

3.1.9.2 Human Engineering Test Process

The actual test process for ADDS FQT was well organized and provided the opportunity to evaluate all critical ADDS features. The process weakness in the conduct of the human engineering portion of the FQT was that there was no procedure to correct identified deficiencies or areas of non-compliance. Unlike other portions of ADDS, correction of human engineering issues were simply targeted for future upgrades. Only in two cases were the problems identified as serious enough to be immediately addressed by the contractor.

3.2 RECOMMENDATIONS

The following paragraphs provide a number of recommendations for future projects which should minimize the human engineering process problems encountered on the ADDS project.

3.2.1 HUMAN ENGINEERING PROGRAM PLAN

Experience indicates that many contractors do not really understand what a Human Engineering Program Plan is, and why it is done. The inclusion of MIL-H-46855 in a contractual system specification is a requirement for a formal human engineering process. It is never possible to pre-specify all user or human engineering requirements because they evolve as part of the design process. The Human Engineering Program Plan is designed to provide a method to identify additional requirements which could not be specified within the System Specification.

As such, the intended interpretation is that any requirement identified as part of the contractual human engineering process becomes part of the System Specification by inclusion. The allowances for additional requirements within the proposed effort.

It is recommended that in future projects the Human Engineering Program Plan be included as a proposal requirement. This approach has been used on many major government programs. This permits the government to evaluate the contractor's understanding of human engineering requirements and processes. This also forces contractor make a commitment to properly scope and fund the human engineering effort. If the Human Engineering Program Plan is submitted as part of the proposal, the government has the option to incorporate it directly into the contract. This ensures that human engineering has the contractual authority to accomplish its required activities. The government should provide comments and changes to the program plan at contract award, and the contractor should have thirty days to submit the final Human Engineering Program Plan.

The Human Engineering Program Plan needs to be implemented immediately to be responsive to the design process. Revisions to the program plan during the contract are not required unless the entire program is restructured.

The Human Engineering Program Plan should provide sign-off authority for human engineering.

3.2.2 Critical Design Review (CDR) Requirements

Essentially, at CDR, the government should be looking for an overview of the continuous audit trail of the human engineering design. The contractor should identify the initial guidelines, criteria, rationale, standards, and specifications that were to be met in the contractual documents, or that the contractor established as design goals. Next, the process that was followed by the contractor should be reviewed, showing results of studies, analyses, tradeoffs (this includes problems and how they were resolved), etc. Then the resulting design should be presented, i.e. displays, control operation , etc.; relating them back to the design criteria. In summary, the CDR presentation should discuss what the contractor was supposed to do, what were the constraints, how they did it, what they came up with, and how well the product meets the initial goals(validation of the design). Government personnel should come away convinced that contractor knew and understood the problem, that the contractor had a systematic approach to solve the problem, and that the contractor came up with a logical design which can be defended and satisfies the contractual requirements. A short discussion of how the contractor will validate (test and evaluation) and refine the design, if necessary, after CDR should also be required

A detailed list of the things that the government should expect in the human engineering presentation at CDR are presented below.

- A concise summary of the human engineering design requirements from specifications, standards, etc.
- An overview of contractor's design philosophy
- A brief overview of the approach used per Human Engineering Program Plan
- Summary of analyses that were used in the design process and how they impacted the design.
- A summary of problems encountered during the process and how they were resolved to the benefit of the program and a better human engineering design.
- A detailed discussion of the human engineering design

    1. Complete set of menus (Interface design)
       A simple series of menus is not sufficient. Contractor needs to graphically depict flow such as a tree diagram. An operational prototype of the menu/display interaction should be available.
        - Menu organizational flow
        - Derived from functional flow diagrams
        - Design Philosophy
        - Menu prototyping - to demonstrate user friendliness

    2. Complete set of displays
        - Coding & Symbology Philosophy
          Color
          Intensity
          Patterns/symbols
          Icons
          Aircraft
          Ground threats
          Sun & Terrain
        - Example Displays
          The sample displays should clearly illustrate the coding and symbology philosophy.

    3. Audio control

4. Ergonomics issues data
   - Hardware layout (table, monitors, mouse, keyboard, headphones, etc.)
   - Lighting
     Illumination levels required, glare
   - Sound
     Fidelity and clarity of transmissions
     Test procedures per MIL-STD-1472D
   - Anthropometrics
     Reach envelopes
     Clearances

3.2.3 Audit Trail

Future projects should include a formal audit trail which archives all human engineering activities. Changes in contractor personnel or normal rotation of members of the SLUG should not result in the loss of critical decisions or data. Without a proper audit trail it is difficult to conduct an adequate human engineering test and evaluation of the system. It is recommended that the audit trail be implemented as an on-line capability with remote access for government personnel.

3.2.3.1 Human Engineering Memos

It is recommended that the Human Engineering Program Plan include a provision for issuing all design inputs, studies and analyses, and design decisions be documented as Human Engineering Memorandums. These memorandums should be included as part of an on-line electronic audit trail accessible remotely by government personnel or be submitted monthly as a Human Engineering Status Report.

3.2.4 Document Review

The review of human engineering documentation should follow the same process as other deliverable documentation. In the ADDS project, the human engineering documentation reviews were treated differently. In this project, government comments, generated during document review, did not have so be addressed until the next issue of the document. In some case this resulted in a delay of six months or more before the government knew how the contractor had responded to the comments. In many cases the contractor simply disagreed with the government comment and did not take action. Hence, the same problem could remain unresolved for the successive iterations. Some concerns on ADDS human engineering documentation remained unresolved for the entire project. The human engineering documentation should be subject to a thirty day review period, with the contractor having thirty

Engineering Memorandums. These memorandums should be included as part of an on-line electronic audit trail accessible remotely by government personnel or be submitted monthly as a Human Engineering Status Report.

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3.2.5 Test and Evaluation

Given the critical nature of the user interface in display and debriefing systems, it is recommended that a separate human engineering test plan be developed. This approach is more in keeping with the intent of MIL-H-46855 and the Human Engineering Program Plan that is derived from this specification. When the human engineering tests are buried within the overall system test plan, it is easy for requirements to get lost or buried. AS occurred within ADDS, it can become very difficult to trace test procedures to requirements in a massive test plan. It also becomes more difficult to review changes in successive iterations of the test plan In addition, the Human Engineering Program Plan normally calls for a separate Human Engineering Test Report, so a separate test plan would aid in cross referencing to the test report.

Test and evaluation requirements should include not only those standards, specifications and guidelines specifically called out in the system specification, but any additional guidelines identified by the contractor as part of the Human

Engineering Program Plan. The Human Engineering Program Plan was a contractual requirement, through the specification of MIL-H-46855 in the system specification. Under normal interpretations of the requirements of this specification, anything process, procedure, analysis, guideline, etc., included by the contractor in the government approved Human Engineering Program Plan becomes a contractual requirement by inclusion.

4.0 HUMAN FACTORS ISSUES

The operation of a complex system, such as ADDS, requires the incorporation of a number of different human interfaces working together. In order to maximize the efficiency of the system, the displays and controls must be compatible with the capabilities of the human operator, as well as with the environment in which it is to be used. Particular areas of concern to the human factors team include display design, information presentation, graphical user interface, and characteristics of the physical environment such as workspace layout and lighting.

Human factors design and analysis emphasizes user friendly operation, logical sequencing, feedback (e.g., error messages), and prevention of crashing the system. Ultimately, a first time user will be able to effectively use the system without the potential of causing damage due to incorrect input by the operator.

The human factors design was governed primarily by the guidelines set forth in MIL-STD-1472D and AFSC DH 1-3. In addition, new standards were derived based on the prototype ADDS. However, specific guidelines for some tasks do not exist, or are inappropriate due to task or environmental interactions or because of a conflict between two or more mutually exclusive guidelines. For instance, many of the lighting guidelines for console design may be in conflict with that of large screen displays. This is problematic in that in some of the proposed ADDS environments both consoles and large screen displays are used. For this reason, the criteria established during the design and development of ADDS may be used as a guideline for the design of future aircrew debrief and display systems.

4.1 LIGHTING

MIL-STD-1472D illumination requirements call for luminance levels in the range of 325 lux to 540 lux for "ordinary seeing tasks." However, this requirement does not take into account the required contrast levels needed to read from CRTs and large screen displays. Because CRTs and large screen displays are employed in the ADDS design, lighting becomes a primary concern in regard to the physical environment in which the system is to be used. Room lighting for display and debriefing systems may be treated similarly to that of radar rooms. Currently, the DDS is housed in a dimly lit room, usually without windows. These darkened rooms are used to compensate for the low luminance levels of the projection screens in an effort to improve visual display contrast and decrease glare. The walls and flooring surfaces should have dull finishes to reduce specular glare and capitalize on diffuse lighting. The recommended surface reflectances are 60% - 95% for ceilings, 40% - 60% for walls, and 15% - 30% for floors. Because the light sources are generally ceiling mounted, the use of these recommended reflectance levels will provide the appearance of an evenly illuminated room.

Any task that requires the use of a CRT is subject to the effects of glare. However, there are several measures that can be taken to minimize glare. For instance, the careful placement of equipment could help minimize some sources of glare. That is, bright light sources or light colored materials should be placed such that they do not reflect back to the CRT user. If possible, the work surface should be colored and textured in such a way as to minimize specular glare. A matte finish with dark coloring, particularly green or blue, produces the least amount of reflected light and is therefore recommended for the ADDS work surface. The tilt and swivel bases of the CRTs can also help to reduce glare by altering the reflectance angle. However, one must be careful that in the adjustment of the CRT bases, the recommended viewing angles and distances are not violated.

A dimly lit room will provide enough light to complete most debriefing tasks. However, when the user must perform other tasks such as reading from hardcopy, this arrangement may require the use of localized task lighting (e.g., gooseneck lamp). To achieve the requirements for display resolution, luminance and contrast, ambient luminance in the range of 200 lux to 500 lux is recommended. In instances where the user does not need to read from hardcopy (i.e., task lighting is not required), luminance levels less than 200 lux may be used. Luminance levels can be adjusted for individual preferences using a rheostat control. Alternatives to darkened rooms have been successfully employed for radar operation tasks. In some cases, light sources of different wavelengths combined with color filters have been used. However, this approach is not recommended as it interferes with color discrimination which is an important component of many debriefing tasks. Instead, a cross-polarization lighting system may be used. This system uses two sets of polarized filters, 90 degrees out of phase. One set of filters is placed over the CRT screens and the other over the luminaires. Proper placement of these filters will prevent specular reflection off the CRT screens.

4.2 Large Screen Projection Display

Because training missions and debriefings may need to be viewed by several people at one time, display and debriefing systems are housed in rooms with theater-type seating and large display screens to accommodate these spectators. Some ADDS facilities may use forward projection large screen displays, while others may use rear projection displays. The lighting requirements for these two types of large screen display differ. Forward projection systems are more susceptible to the effects of room lighting. These systems use reflective screens designed to enhance and diffuse the light from the projector. For this reason, rooms must be dimly lit to reduce glare and maintain contrast. Room lighting has much less of an effect on the contrast and resulting display resolution of the self contained rear projection units.

Another concern when using large screen displays is that many spectators will be viewing the display from different distances. Therefore, the information presented on the screen must be legible to those viewing from the most distant seat. However, the information on the large screen is the same as that presented to the user seated in front of a CRT. Consideration must be given to the size of text and graphics used for both viewing from CRT and from the large screen.

4.3 NOISE

Because the buildings in which ADDS systems are to be housed should already meet all military standards regarding noise transmission, the effects of prolonged noise exposure on the auditory system should not be a problem. However, because radio communication is a vital function of aircrew debriefing operation, and mission, special attention should be paid to the effects of noise on communication. Much of the audio used in a debriefing session will be radio communication recorded from a source which often times may not be highly intelligible. Any extraneous noise (e.g., passing aircraft, humming of a machine, etc.) may add to the problem of this already difficult task. Sound absorbing materials should be used on the walls and equipment to minimize extraneous sounds.

4.4 TEMPERATURE

Room temperature in which an ADDS user must operate is partially determined by how the temperature will effect the equipment, but more importantly to consider is how temperature affects the user. The system specification calls for the ADDS to be operational in a room between 10 degrees C and 35 degrees C with a relative humidity between 20 and 80 percent. Although tolerable, temperatures at either end of the range would not be considered comfortable nor conducive to performance. The range of clothing worn by ADDS users may vary from short sleeve shirts and long pants to full flight suits and jackets. Considering the range of insulation provided by these clothing (clo values), a room temperature of 21 to 26 degrees C should be maintained to maximize comfort and performance.

4.5 AUDIO SYSTEM

The audio reproduction system for ADDS was selected at the SLUG meeting. Three different systems were demonstrated using several audio scenarios (communications between pilots and RTO). The pilots rated the systems based on sound clarity and fidelity. Although none of the systems were rated as outstanding, the system developed by Motorola was deemed acceptable. The audio signal is compressed to 4.8 Kb per channel using the Code Excited Linear Predictive (CELP) approach. This system works well when the source audio quality is good, but in instances when cockpit noise levels are high, the resultant CELP may be poor.

4.6 MENU DESIGN

The ADDS was designed to be used by operators who vary in the amount of experience they have with debriefing systems and computers. One of the requirements of the ADDS was to have the system be primarily software driven and easy to use for even the naive operator. Therefore, very little training would be required to enable operators to become proficient in the use of the ADDS. To accomplish this goal, it was determined that a graphical user interface (GUI) would have to be employed. The design of the windows, menus and display formats was developed in accordance to standardized human computer interface conventions and in conformance with Motif guidelines and the DOD Common Operating Environment Guidelines. By using a standardized set of guidelines, the users are ensured that there is consistency in positioning of important information within and between displays screens. In addition, emphasis was placed on the design of a help menu to ease learning of the system's operation.

To determine the commands that would need to be included in the GUI, the critical tasks which describe the functions that an ADDS operator must perform were identified. These critical tasks were used to create a set of functional flow diagrams. The menu structure was developed from these diagrams.

Paper-and-pencil mockups of the different menu screens were developed and presented in sequence to the System Level Users Group. The users and human factors team worked together to critique the many menu screens on such characteristics as intuitiveness, consistency, legibility, and aesthetics. These drawings were then revised to accommodate comments and suggestions.

4.7 VIEWS

ADDS operators choose from which perspective they wish to view a live or replayed mission. The operator may change views at any time during the mission depending on which view provides the most applicable information at the time. Each of the different views are defined below.

- **Centroid** - A three-dimensional view which allows the operator to center on two or more aircraft. The view remains centered on group of aircraft regardless of size or spacing of group.
- **Ground Target** - Same as centroid view except that view is centered on a specified ground target.
- **Missile End Game** - Allows the user to view a centroid point which is the geometric mean of target and missile positions. This view is available in replay mode only.
- **Pilot** - By selecting a particular aircraft, the operator can see what a pilot in the selected aircraft would see.
- **Chase** - A three-dimensional viewpoint which is the geometric mean of up to 2 aircraft. The operator may vary lag time/distance from chased aircraft.
- **Plan** - A two-dimensional (flat) bird's eye view of participants and terrain.

4.8 SYMBOLOGY

ANSI/HFS and MIL-STD-1472D standards should be followed regarding size of text and symbols. Therefore, all text should be sized to subtend 16 to 24 degrees of visual arc. Given the average viewing distance of 16 to 18 inches, all text and symbols shall be no smaller than 1/8 of an inch in height.

4.9 INTERFACE CONTROL

The ADDS system allows the operator to display different views of a mission both in live and replay mode. The operator can switch from one mode to another (e.g., centroid to plan) by simply selecting the mode with the mouse and pressing a button. The mouse is also used to rotate the three dimensional centroid view. The user selects the point around which the view is to be rotated and clicks the mouse button.

Originally, the ADDS specification required that all system functions be controlled by mouse, therefore, a keyboard would not be incorporated into the design. ADDS was developed to meet this specification. That is, all functions could be handled with a mouse; no keyboard is required. However, it was later determined that the use of a keyboard may save time while performing certain functions. Therefore, the use of keyboard was allowed into the design as long as the requirement that all functions be accessible with the mouse was met. The final design, incorporating both mouse and keyboard, will enable some operations to be performed more quickly by using the keyboard, but still allow the user to perform the same functions with the mouse.

4.10 AUDITORY CONTROL

When flying a training mission on a range, it is critical to the safety of the pilots that they maintain communication with the range training officer in charge on the ground. Using the display and debriefing system, the RTO has the best view of where all aircraft involved in the mission are at a given time and can relay this information back to the pilots.

Originally, it was proposed that all functions of the ADDS, including auditory control, would be controlled through the software. However, pilots raised concern over this plan during the System Level Users Group (SLUG) meeting, June 9-11, 1992.

Specifically, the pilots viewed the software control of the radio communication as a major safety of flight concern. Their fear was that a single point computer failure would knock out all communication between pilots flying a mission and the RTO. This especially concerned the Air Force pilots who would be using a single dedicated monitor configuration. This configuration, without a backup monitor readily available, would make communication more susceptible to the effects of a monitor failure.

The concerns raised by the pilots during the SLUG meeting led to a revision of the ADDS design. The new design called for a hardware dedicated audio control system. This new design would allow pilots and RTO to retain communication links in spite of software failure.

4.11 USER PREFERENCES

To increase the likelihood of user acceptance, a new system should allow the user to make some adjustments and alterations to the system to fit individual preferences. By providing this option, users may feel more comfortable using a system with settings that they have chosen. For instance, a user may have certain color associations in which a particular color has a special meaning to this individual, whereas the same color may have a different meaning or no meaning at all to someone else. The user may choose to take advantage of this association if that option is provided.

Prior to a debrief session, the ADDS user can set up the system to incorporate individual preferences. That is, the operator can choose to use different colors of terrain (i.e., winter or summer settings), aircraft colors, participant filters, participant pairings, or the user may select the default settings which were designed for ease of operation.

4.12 PARTICIPANT COLORIZATION

The intended purpose of this feature is to create a display in which participants are colored as to be easily distinguishable from surrounding terrain, backgrounds, and labels. In order to highlight particular aircraft in a debriefing session, the ADDS operator may choose to change the color of those aircraft from the default setting. Using the mouse, the operator simply selects the appropriate aircraft, then chooses the desired color from a limited palette. The palette is limited to only certain highly saturated colors to avoid confusion and to maximize color contrast with other objects and the unsaturated colors used for terrain. The ability to choose aircraft for colorization via identification number would be useful in instances where manually tracking the aircraft with a cursor becomes difficult.

4.13 TERRAIN COLORIZATION

Users may choose from two sets of terrain colors: One representing winter colors (e.g., shades of white) and the other representing summer colors (e.g., shades of green). These colors should be unsaturated so as to be highly distinct from the saturated colors used for aircraft. Coloring of the terrain in plan view should provide indication of altitude, similar to a relief map. That is, the different shades of a color at specified intervals would represent appropriate levels of elevation.

4.14 PARTICIPANT FILTERS

Filtering allows the ADDS user to reduce the number of participants displayed enabling the user to focus on only relevant information. Some initial filtering can be accomplished simply through the user's choice of viewpoint (e.g., plan, pilot) or zoom. In addition, the system specification calls for the operator to be able to filter by mission, aircraft numbers, threat and target pairings, activity type, participant type, color, location, event type, event recency, and proximity to fixed and moving points such as threats or geometric mean of a specified group of aircraft. Predefined filters must be made available to users or users should have the option to define their own set of filters. Once filters are set up, the operator should be able to store and recall them from a list for future missions or change them depending on the requirements of the particular mission.

4.15 PAIRINGS

One of the functions of a display and debriefing system is to monitor how pilots work with and against other pilots. To accomplish this function, the display and debriefing operator needs some way to denote which pilots are being paired. Pairings may be set up before or during a training mission. The ADDS specifications require that the user be able to set up to 512 participant pairings. Through MicroSaint workload analyses conducted by the IST team, it was determined that due to the time required to set up 512 pairings (even in optimum conditions), this capability would likely never be used to capacity.

Under the current debriefing systems, the procedure for setting up aircraft-aircraft pairings involves the selection of five different buttons located in various sections of the keyboard. The new mouse driven interface of the ADDS should require less time to perform the same function. Using only the mouse, the operator should be able to select "aircraft to aircraft pairing" from a short list of procedures, then select the aircraft , either by selecting the appropriate aircraft numbers from a number palette or by moving the cursor to the image of the desired aircraft (in plan view), then selecting the appropriate column number in which the user would like the designated pairing to appear. Unlike on current debriefing systems, this entire procedure can be accomplished without the operator shifting view away from the screen. Other pairings (e.g., aircraft to target, threat to aircraft) should be performed in the same manner.

4.16 OTHER FUNCTIONS

4.16.1 REARM/REBIRTH

The procedure for rearming or rebirthing an aircraft during a live mission is very simplistic on the current display and debriefing system. This function should remain easy to perform on the new ADDS. The only difference between the new and old systems should be that instead of the operator searching for the correct buttons on the keyboard, the new system should display the options on the screen in front of the operator. The operator can then select "Rearm" or "Rebirth" from this list of options using the mouse to move to the appropriate option and clicking to select. Unlike the old system, the CGUI of the ADDS can eliminate irrelevant options once the required procedure is selected. That is, once Rearm is selected, the only options that should be presented to the user would be to select all aircraft, select a subset of individual aircraft, or cancel the rearm function without selecting any aircraft. In this manner, the user would not have to hunt for the next appropriate response key, thereby minimizing the time required to perform the sequence.

4.16.2 TIME-SEARCH CAPABILITY

The ability to rapidly locate and display any segment of mission data is one of the most beneficial features required of an aircrew display and debriefing system. To expedite this feature, the user should have the option of using either the mouse or the keyboard to request a specific time search. Once time search is selected, a dialogue box should be displayed that requests the user to select the specific time. The user should then be able to either type the desired time (minutes and seconds) in an input box or use the mouse to select the time. The mouse would be used to move a pair of slide bars (one for minutes, one for seconds). As the slide bars are moved, the corresponding time selected would be displayed to the user (e.g., 15:30). In addition, a scroll down menu containing a list of previously marked mission events would give the user the option of clicking on the event by name rather than by event time. The search time would then be confirmed by clicking the mouse on the "Okay" button or pressing "Enter" on the keyboard or the user can cancel the procedure by clicking on the "Cancel" button.

5.0 HUMAN ENGINEERING ANALYSES

A number of human engineering system analysis techniques were accomplished as part of the ADDS design process. Applicable techniques included function analysis, information/action requirements analyses, task analysis, time line analysis and workload analysis. These analyses were accomplished in a joint effort between contractor and government consultants. The following sections provide an overview of several critical analyses conducted for ADDS.

5.1 INFORMATION/ACTION REQUIREMENTS

The information/action requirements analysis focused on two basic activities. The first analysis examined the frequency of control usage on the current debriefing system. This analysis used a structured questionnaire to gather data from members of the SLUG. The intent of the analysis was to determine how pilots use the current system, i.e., how they configure displays on the three monitors, and what controls they use most frequently. Table 5-1 summarizes the data for each display position. The frequency of use data (number in parentheses) for the six pilots who completed the questionnaire illustrates a high degree of consistency in the way pilot's use the system.

TABLE 5-1
FREQUENCY OF CONTROL USAGE BASED ON CURRENT DEBREIFING SYSTEM

Left Panel	Center Panel	Right Panel
Plan View 100nm (4)	Centroid Select (5)	Flight Data (4)
Zoom/Pan (3)	50nm (5)	Page (3)
Forward (3)	25nm (5)	Transfer 1 (3)
Hold (3)	12.5nm (4)	Transfer 2 (3)
Event Marker (3)	6nm (4)	
Plan View 50nm (3)	Elevation Control (4)	
	100nm (3)	
	3nm (3)	
	Centroid Shift (3)	
	Rearm (3)	
	Rebirth (3)	
	Acknowledge (3)	
	Fire (3)	

Table 5-2 summarizes the desired enhancements to the debriefing system capabilities identified by the members of the SLUG during two design review meetings. As the table shows, only a small portion of the enhancements were incorporated by the contractor in the design of the ADDS. Contractor rationale for not incorporating an enhancement were that the enhancement was not part of the System Specification so it was outside the contract effort, or since the ADDS contract did not include the Control and Computation Subsystem (CCS) portion of the system, the data did not exist to implement the feature. The first reason for non-inclusion is part of the process problem encountered in ADDS, as discussed earlier. The second reason is a result of constraints imposed by a project which involves the upgrade of an existing system.

TABLE 5-2
SLUG IDENTIFIED CONTROL AND DISPLAY ENHANCEMENTS

Pilot Identified Requirements that are implemented or partially implemented in ADDS.

1. Delete CGI View from Debriefing System (radar sweep) - implemented.
2. Delete Shrike training capability - implemented.
3. Delete operator query for threat ranges - implemented.
4. Threat coverage indication by aircraft history trail change versus pyramids/cones emanating from threats - implemented.
5. Continuous readout of Azimuth and Elevation in pilot View with reset position - implemented.
6. Pilot View direction 0-90 degrees elevation and +180 to -180 degrees azimuth to nearest degree - implemented.
7. Toggle between solid fill/wire framE.

Pilot Identified Requirements not implemented in ADDS.

1. Display of throttle settings and afterburner.
2. Display of radar status and selected target.
3. List of last four lock-ons.
4. Display of decoy and Harpoon tracking.
5. Display of Laser Guided Bomb designation including angle to target - straight red line implemented for ADDS.
6. Visual cues to indicate weapon mode change.
7. Capability to filter participants by level of organization.
8. Display of Above Ground Level (AGL) on alphanumeric displays.
9. Display of gun footprints and bomb fragment patterns.
10. Display of longer or "permanent" history trails within 7.5nm from ground target.
11. Additional alphanumeric display which provides pairing data for aircraft and ground targets. Includes reverse bearings and ground range.
12. Display of UTM versus lat/long for NTC.
13. Capability to filter participants by geographical airspace.

TABLE 5-2 (con't)
SLUG IDENTIFIED CONTROL AND DISPLAY ENHANCEMENTS

14. Display of hard deck delineation and indication of aircraft violations of this limit.
15. Instant replay capability at DS.
16. Phoenix and HARM display support.
17. Enroute display.
18. Additional Quick Look Display of threats.
19. Countermeasures display support, e.g., chaff and flares.
20. AT long distance, when group overlaps, to be shown as one aircraft with all Ids.
21. Selection of aircraft or objects for pairing or other actions by mouse on Plan View Display.
22. Representation of Low Activity Aircraft in 3-D displays.

The large number of desired enhancements that were not incorporated into ADDS provide significant inputs to future display and debriefing system developments. The two enhancements which appeared to have the highest priority were the display of hard deck information and the ability to pair aircraft or objects by mouse selections on the graphics displays. The second enhancement is a natural outgrowth of the transition to a graphical user interface for display and debriefing systems.

5.2 TASK ANALYSIS

The task analysis is a major, if not the most important, step in the design of a system in that it is used to define, in detail, what functions the system will serve. It provides detailed descriptions of the activities or tasks performed by system operators and maintainers. The process of task analysis consists mainly of listing the gross requirements of the system and breaking them down into more useful and detailed chunks. The chunks are then used to describe individual system functions and the demands these functions place on both personnel and equipment. The detail to which this analysis is produced can vary depending on how the data is to be used.

A task analysis was performed which lists the various intended functions of the ADDS. The global function of ADDS is to display TACTS/ACMI mission data live and in play back modes. The focus of the human engineering aspect of the ADDS project is to develop a graphical user interface which provides the naive, as well as the skilled, user the capability to select, navigate and manipulate the displays for debriefing purposes. In order to better understand what is required of this user interface, the individual tasks which will be performed must be described in detail. Tasks that were described in detail for this purpose include the use and manipulation of the various views available to the ADDS operator (e.g., Plan View, Pilot View, Missile Endgame View, etc. The basic task analysis accomplished for ADDS is documented in Appendix B.

5.3 WORKLOAD ANALYSIS

Several types of analyses are important in verifying the appropriateness of design requirements, to evaluate an evolving design, to determine operator procedures, and to establish personnel skill requirements. Workload analyses are especially useful in estimating whether the demands placed upon the operator by the system design are of an optimal level to insure safe and efficient use of the system. In addition, these analyses are useful in determining the allocation of functions to hardware, software, or human operator in a human-machine system.

One simulation tool that utilizes time line data of critical tasks to conduct a workload analysis is MicroSAINT. MicroSAINT uses a detailed description of the task sequence, the task time, the priority and other tasks characteristics as input. The input is then modeled using a graphical network model referred to as a Task Network. Task Networks are developed from Task Sequences and Task Descriptions that are part of the task analysis. Task Networks describe the relationships between task elements, the characteristics of the tasks, the personnel and equipment performing the task, task priority, and the time characteristics of the task, and other factors impacting workload.

MicroSAINT uses the network model and data to simulate a large number of iterations of a task segment sampling from the variations in the time required to perform each task. The program provides descriptive histograms of the distribution of calculated task times. The output from MicroSAINT includes time statistics for each iteration and across all iterations.

Several tasks considered critical to the operation of ADDS were identified. These tasks include the following operations described below. Because much of the time spent operating the ADDS would involve performing these tasks, these tasks, among others, were analyzed to determine the level of demand they would exert on an operator.

1. Fire/Release Weapon - The ADDS operator observes an engagement on graphics display and listens for the UHF audio call to release weapons. After identifying which aircraft is intended to launch weapon, the operator checks the alphanumeric Flight Data Display to determine which weapon station to release. The weapon station is then selected on the Live Control Panel and the aircraft is selected from the number palette.

2. Rearm/Rebirth Participant - The ADDS operator watches an engagement on graphics display and monitors UHF communication. The operator, acting as Mission Controller, may then decide to rearm or rebirth an aircraft or wait for the UHF call from the mission commander to do so. The Rearm/Rebirth sequence involves the selection of the appropriate button from the Live Control Panel and selecting the appropriate aircraft from the number palette.

3. Manual Threat Launch - The ADDS operator observes an engagement, then selects threat from the Live Control Panel. The contents of the Threat Dialog Box are then displayed. The user selects the manual control option and then selects an aircraft from the number palette as the target. When the threat acquires a target, the operator sets the control mode to Track. The user sets the control mode to illuminate so that when the threat has the target illuminated, the user initiates launch.

4. Pairing Procedure - Upon observation of an exercise on graphics display, the ADDS user decides where to place pairing columns, and determines which pairs have been set up. The user then selects the Pair Button on the Flight Data Display View Controls. After noting the contents of the Pairing Dialog Box, the user selects the launching platform (shooter) and the target participant. The paired shooter/target is placed in an appropriate Flight Data Display column.

Workload analyses were performed on each of these critical tasks and several others. The tasks were broken down into their individual operations. Each operation was classified by the type of human action it required. That is, each operation requires the user to either listen (auditory), monitor (visual), verbally respond (voice), or perform a physical response (motor skill). The amount of time allocated to performing each type of action and the amount of workload it entailed was then simulated

5.3.1 MicroSAINT Analyses

A series of simulations were performed using the MicroSAINT software package. These simulations were developed to analyze the time it would take a human operator to perform certain custom setup functions as part of a debriefing session using the ADDS. For example, prior to the development of the actual system, these MicroSAINT analyses were used to estimate how long it would take to set up (AC - AC, AC - threat, AC - Ground) pairings in replay mode. MicroSAINT output data includes frequency distributions, histograms, means and standard deviations, and flow diagrams of the sequence of tasks involved. These analyses permitted an assessment of potential workload problems. ADDS has a critical time factor in its operation and the system specification permits complex set-up procedures. The tasks selected for analysis were based on issues and questions that arose during the various SLUG meetings. Only the time results of the simulations, i.e., time distributions, are included here.

5.3.1.1 Pairing - Specification

The first simulation estimated how long it would take a single operator to set up 512 pairings (the maximum number required to meet the software specifications). This simulation involved the time required for a human operator to make a decision, the time required to carry out the physical movements involved, as well as the system's response time. The human times were estimated from the experimental psychology literature. In this particular analysis, times for human decisions were sampled from normal distributions, physical movements from a rectangular distribution, while system response times were sampled from gamma distributions. The simulation was run for 100 iterations. Figure 5-1 shoes the distribution of estimated times to complete this task. The mean time to perform this task was estimated to be 2805.57 sec (46.76 min) with a standard deviation of 5.31 sec (a fairly normal distribution), as calculated by the MicroSAINT software. From this data it is clear that the operator cannot set up 512 pairings and expect to complete a debriefing session in an hour. One hour was identified as a representative length for a debriefing session based on Red Flag exercises.

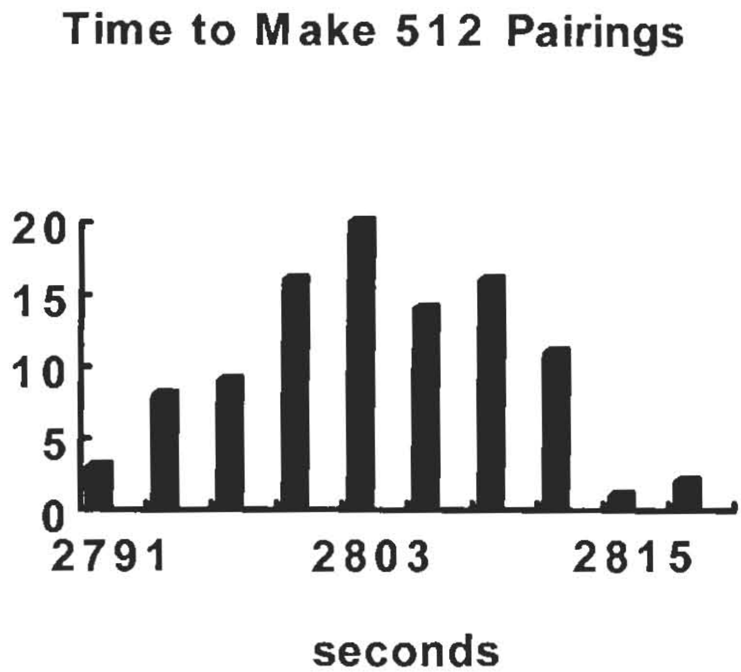


Figure 5-1. Distribution of times for making 512 pairings per the ADDS design specification.

5.3.1.2 Parings - Typical Session

The second simulation follows the same basic network of tasks. The simulation estimated how long it would take an operator to set up 8 pairings on the ADDS system, a more likely occurrence than the previous simulation (pilot's indicated that this is representative of most missions). For this analysis gamma distributions were sampled to estimate human decision making. After running the simulation for 500 trials (Figure 5-2), the times to complete the task formed a skewed distribution with a mean of 90.53 sec and a standard deviation of 59.33. This analysis estimates a maximum performance time of 301.42 sec, however, the distribution of times is skewed toward the low end where most of the performance times fall below the mean. This analysis indicated that the time to complete a "normal" number of parings is acceptable.

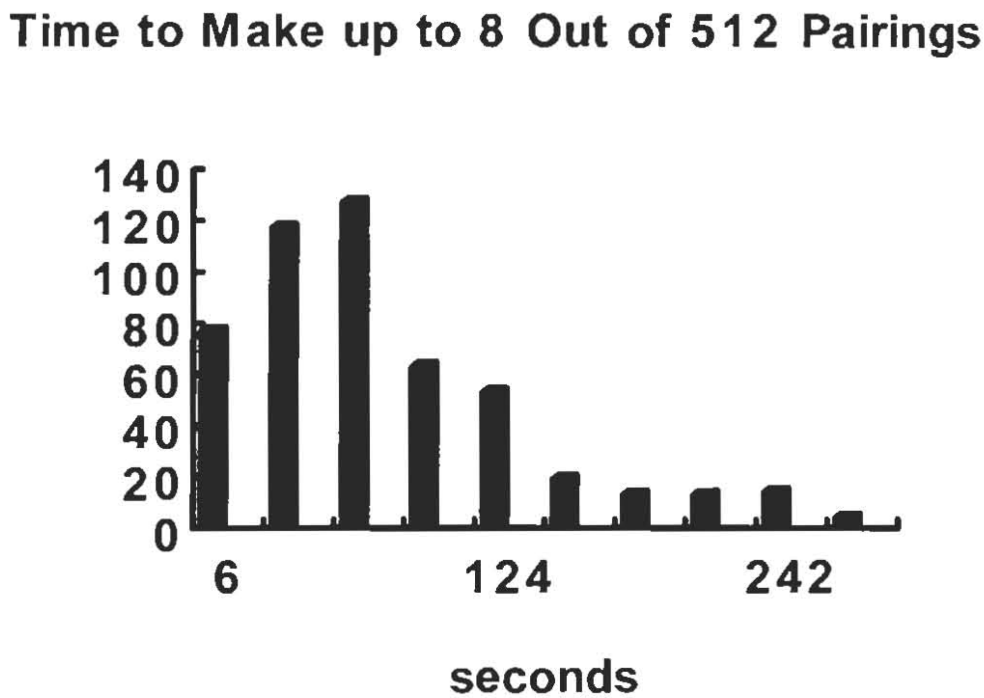


Figure 5-2. Distribution of times to make a representative number of pairings.

5.3.1.3 Changing Colors

The next analysis estimated the time it would take an operator to change the color of 8 aircraft on the ADDS system as part of the custom setup capabilities. The total time includes the time to decide on a color (from a limited palette), time to select the color and the aircraft to be changed, and the system response time. After running the simulation for 100 trials (Figure 5-3), the simulation estimated that this task can be performed in as little as 50.5 sec and should take no more than 70.2 sec. The mean time to perform the task was calculated to be 60.54 sec, with a standard deviation of 3.88, forming a fairly normal distribution. These time estimates appear somewhat long for the task. As discussed in Section 7.0, these times are due to the excessive mouse movements demanded by the default locations of the control panels used to change colors of objects.

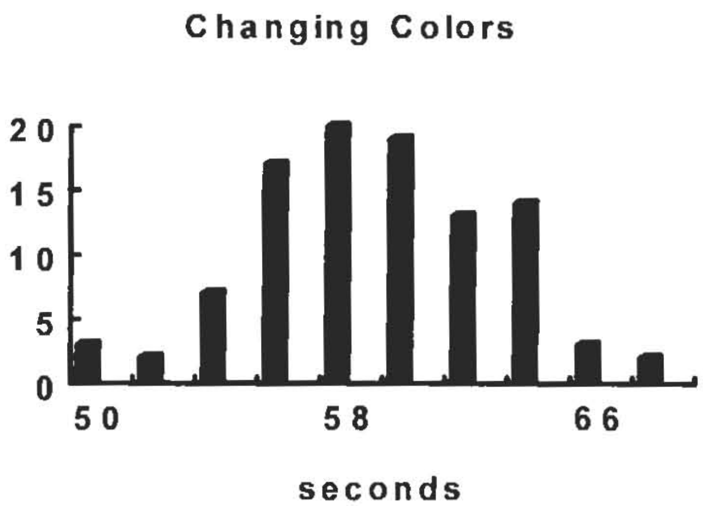


Figure 5-3. Distribution of times to change the color of objects.

5.3.1.4 Weapons Release

The fourth analysis estimated the time it would take an operator to release a weapon in response to a UHF call. Times include human response times plus system response time per the specification. After running the simulation for 500 trials (Figure 5-4), the simulation estimated that this task can be performed in as little as 3.4 sec and should take no more than 8.2 sec. The mean time to perform the task was calculated to be 5.7 sec, with a standard deviation of .90, forming a fairly normal distribution. These time estimates are clearly within acceptable limits.

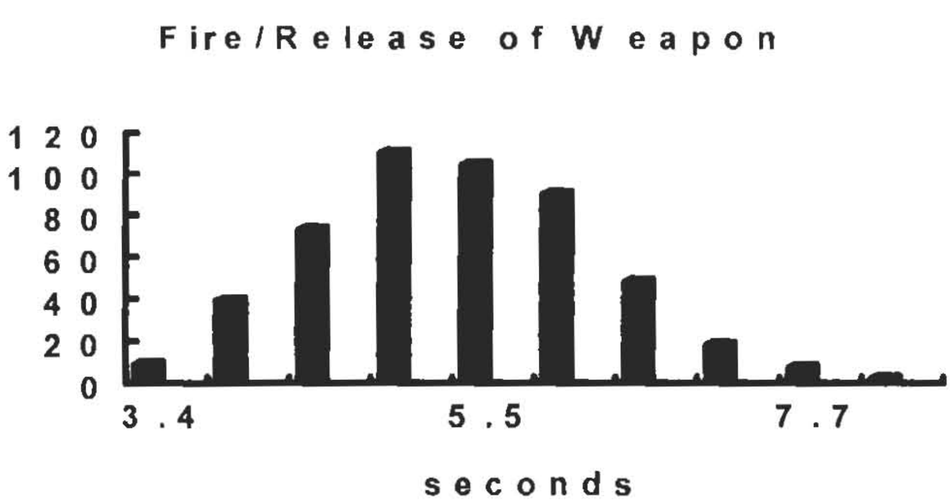


Figure 5-4. Distribution of times for release of weapons.

5.3.1.5 Rearm/Rebirth

The next analysis estimated the time it would take an operator to initiate the rearm or rebirth sequence. Times include human response times plus system response time per the specification. After running the simulation for 500 trials (Figure 5-5), the simulation estimated that this task can be performed in as little as 1.3 sec and should take no more than 5.2 sec. The mean time to perform the task was calculated to be 3.5 sec, with a standard deviation of .69, forming a fairly normal distribution.

Figure 5-5. Distribution of times for rebirthing an aircraft.

5.3.1.6 Manual Threat Launch

The sixth analysis estimated the time it would take an operator to initiate a threat event. Times include human response times plus system response time per the specification. After running the simulation for 500 trials (Figure 5-6, the simulation estimated that this task can be performed in as little as 4.1 sec and should take no more than 8.5 sec. The mean time to perform the task was calculated to be 6.5 sec, with a standard deviation of .79, forming a fairly normal distribution.

Manual Threat Launch

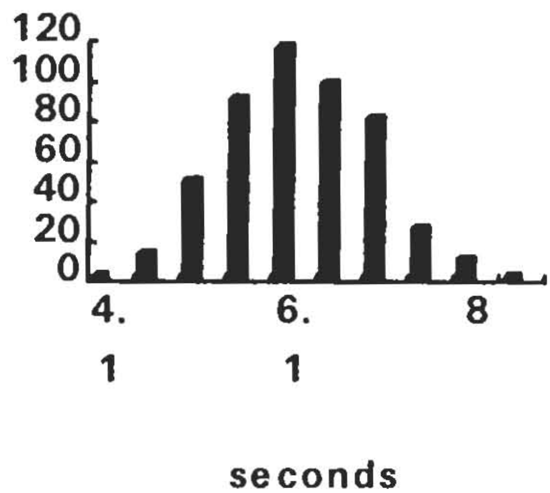


Figure 5-6. Distribution of times for manual threat launch.

5.3.1.7 Live Exercise Pairing

The next analysis estimated the time it would take an operator to pair players in real-time during an exercise. Times include human response times plus system response time per the specification. After running the simulation for 500 trials (Figure 5-7), the simulation estimated that this task can be performed in as little as 5.7 sec and should take no more than 8.9 sec. The mean time to perform the task was calculated to be 7.5 sec, with a standard deviation of .66, forming a fairly normal distribution.

Live Pairing

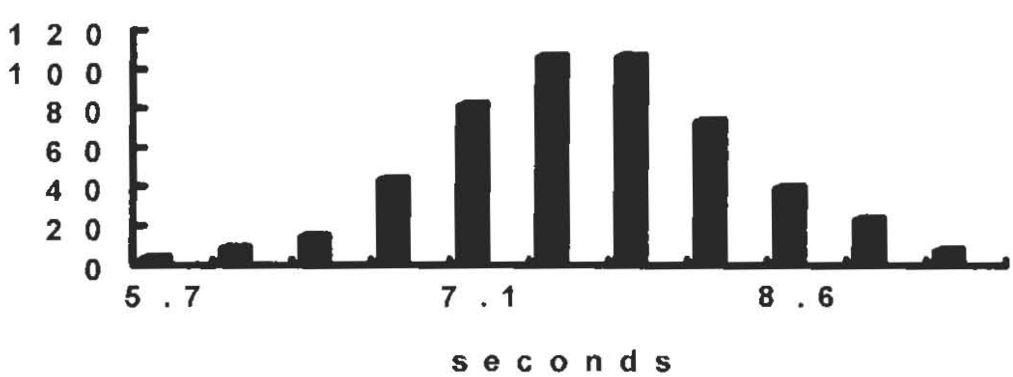


Figure 5-7. Distribution of times to make live pairing.

5.3.1.8 Select Pilot View

The next analysis estimated the time it would take an operator to select the pilot view display during an exercise. Times include human response times plus system response time per the specification. After running the simulation for 500 trials (Figure 5-8), the simulation estimated that this task can be performed in as little as 5.6 sec and should take no more than 8.9 sec. The mean time to perform the task was calculated to be 7.5 sec, with a standard deviation of .57, forming a fairly normal distribution.

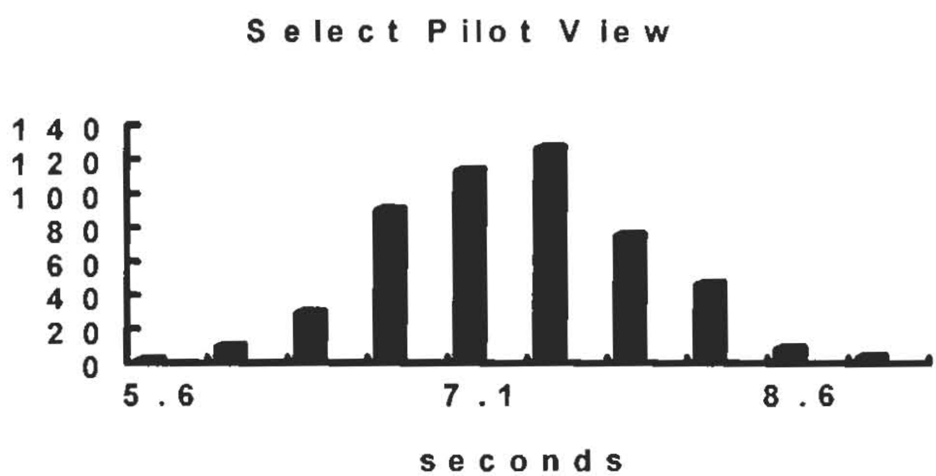


Figure 5-8. Distribution of times to select the pilot view.

5.3.1.9 Changing Kill Color

The final analysis estimated the time it would take an operator to tag a player with the kill color. Times include human response times plus system response time per the specification. After running the simulation for 500 trials (Figure 5-9), the simulation estimated that this task can be performed in as little as 2.7 sec and should take no more than 5.0 sec. The mean time to perform the task was calculated to be 4.0 sec, with a standard deviation of .39, forming a fairly normal distribution.

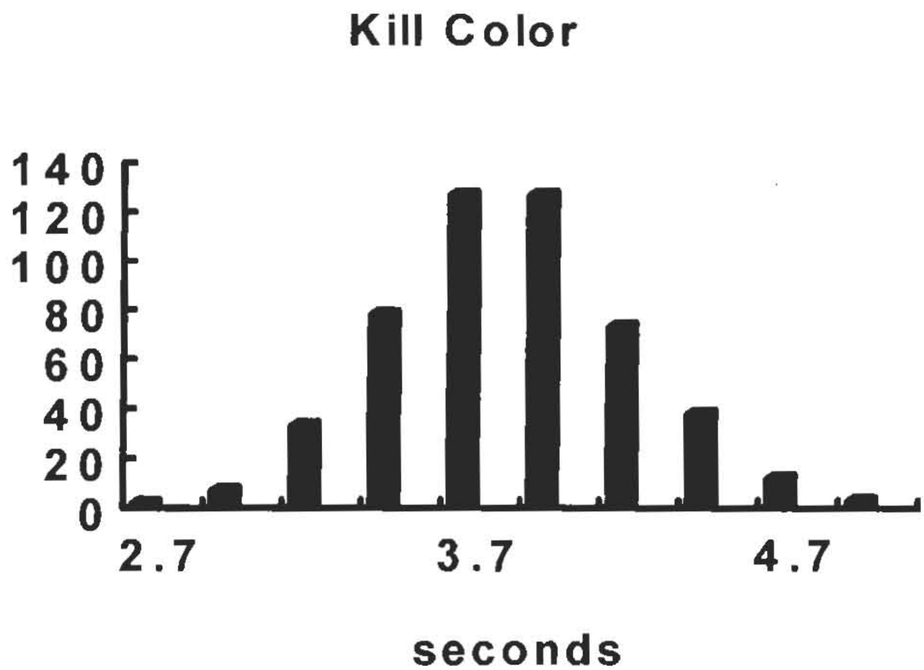


Figure 5-9. Distribution of times to select kill color.

5.3.1.10 Summary

These analyses translate most of the static time lines documented in the ADDS Human Engineering Design Document into dynamic MicroSAINT analyses. Overall, most basic information management task do not look like they impose any significant workload problem. The set up procedures, as required by the system specification, were shown to be a potential problem area. However, since few people will ever exercise the full capabilities of the system, it may not be a practical problem. As the second analysis shows, even during set-up, if conditions are constrained to how the operator uses the system, rather than the maximum specified capability, workload appears reasonable.

6.0 ADDS COMPUTER GRAPHICAL USER INTERFACE (CGUI)

The introductions for this section was extracted and edited from material prepared by Dr. Amanda Williams as part of the ADDS Human Engineering Design Document. It summarizes the design philosophy and several features for the ADDS CGUI.

The basis for the design of the windows, menus and display formats was laid in the series of System Level User Group (SLUG) meetings. These concepts were then developed into the CGUI design according to standardized human computer interface conventions, Motif design guidelines and the DoD Common Operating Environment Guidelines. Appendix A presents a tailored set of the DoD Common Operating Environment Guidelines developed for the Advanced Display and Debriefing System project by Dr. Amanda Williams. These sets of guidelines ensure consistency in the display formats so that the user knows where to look for information within and across displays.

In addition, due to the fast pace of the TACTS/ACMI training, environment and safety of flight issues, the display formats are designed to display no more information than the user needs. This is accomplished through the use of the dialog boxes. The user is always provided with a subset of a known list of actions with which to respond. The options: OK, cancel, help, apply and close quickly become known to the user. The actions of each become obvious in whatever context they are provided. Furthermore, as with many of the other interactive features, these options are always placed at the same place in the dialog box.

A subset of the Motif widget set is also used to interact with the user. Again through consistency and standardization, the user quickly knows what is being requested when each one appears. In addition to the standard Motif widgets, the ADDS has some specific features which are standardized from display to display and from state to state. The control panels which are presented to the user vertically along the left side of the display screen offer a quick way to manipulate displays and features. There are three Control Panels, one each for Live Exercise, Replay and Remote/Replay. Where these states have functions in common, the widget has remained constant on the panel from state to state.

Another feature developed for ADDS is the concept of the View Controls. Each of the displays has unique features that are manipulated from the View Controls for that display. Some of the displays are quite similar, so the View Controls for these various displays are either exactly the same or very similar.

Similar View Controls are provided for Centroid, Ground Target, Missile End Game, Pilot View and Chase View. The Plan View, which is the only two dimensional graphic display in the ADDS has a unique View Control set. Missile Boresight which offers limited user control, basically allows the user to change only the selected threat site. The alphanumeric Data Displays all offer similar controls with minor variations.

Flexibility in terms of <u>filtering</u> the displays to reduce the number of participants is provided by the Participant Filter option on the Edit Menu and is set and saved in a template users file for successive use. This capability allows the user to set up filter options once and then have them preset for all following use. They can also be changed at any time. In addition, certain decluttering is possible directly from the View Controls for each display. This filtering is display dependent and can be toggled on and off. The User Preference option on the Edit Menu allows the user to preset defaults, such as displays, mouse settings, etc.

The current design for colorization limita the number of colors that the user can assign to either eight. The available colors provide maximum contrast with the selected terrain colors. (Note that this design goal was not achieved.) All sites will receive two versions of terrain color. One will be the terrain as it appears in summer and the other in winter. These are the only terrain color options available to the user. To further enhance the contrast between the terrain background and the participants, the participant colors will be highly saturated while the terrain colors will be very unsaturated.

Labeling colors with respect to display labels will not be easily changed by user. According to Motif guidelines color will be used to indicate highlighting of selected displays and other possible grouping information. Since the CGUI constitutes both a "'look" and a "behavior" it is important for the interface designer to retain control of this type of coloring.

With respect to labeling, data displays and symbology legibility, ANSI/HFS and MIL-STD-1472D standards will be followed. This requires that text be in the range of 16 to 24 degrees of visual arc. Given the average viewing distances of 16 to 18 inches, this equates to symbols of no less than 1/8 inch. Participant labels will be the color of the participant model. Labels will not overlap to an extent that the overlap interferes with training. As a group of AC, for example, move far away and appear smaller and smaller, they will eventually be represented by one AC but all labels will be retained. Note that, as will be discussed in Section 7.0, this design goals was not adequately achieved.

While the design goals and process produced a well organized CGUI and display design approach, the final implementation of ADDS contains a number of human engineering deficiencies. As noted earlier, the lack of design authority by contractor human engineering personnel, lead to a non faithful implementation of the CGUI and display designs. Software developers both failed to follow the specified guidelines and changed elements of the CGUI. The following sections provide illustrations and discussions of various elements of the CGUI and displays as implemented by the contractor. The examples do not represent an exhaustive set of CGUI and displays, but rather a representative set which illustrates major elements of the CGUI and specific areas of deficiency that should be documented.

6.1 DISPLAY SUBSYSTEM(DS) CGUI

The ADDS CGUI provides a hierarchical structure for the control of exercises and management of various display functions. Figure 6-1 illustrates the ADDS opening menu. It reflects a logical ordering of basic ADDS functions based on frequency of use. It illustrates the basic appearance of a Motif button panel.

6.1.1 Activity

The activity panel meets minimal contrast requirements for depicting button state. One of the shortcomings of Motif is that it provides very fine visual cues for state detection. This can be greatly impacted by the color palette selection. The baseline grayshade palette provides sufficient though minimal contrast, especially in the ADDS dim room environment. Under higher illumination conditions color contrast would need to be increased. Activities are selected by clicking on the desired function with the mouse. Each of the functions accesses a lower level control function.

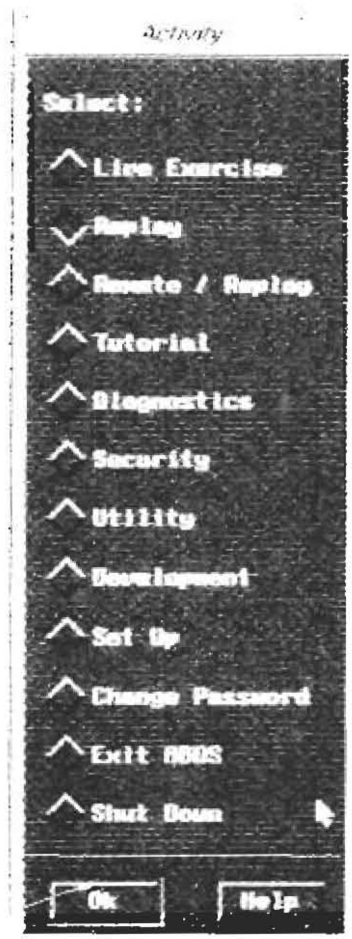


Figure 6-1. The ADDS opening menu.

6.1.1.1 Tutorial

The tutorial function is not illustrated in this document. It is a simple scrolling menu of topic areas. Selection of a topic area provides a text based narrative of the function. This type of tutorial is an inadequate implementation for a system such as ADDS. The inadequacy is compounded in that the narrative is drawn from a system users manual written for software personnel rather than the end user. A second basic shortcoming of the tutorial function is that you must already know the first several topic areas in order to get to the activity control panel where you can select the tutorial function.

A good tutorial for ADDS should be based upon a computer based training approach that incorporates graphics, as well as text. The tutorial should be interactive providing examples of ADDS displays and control actions. From a usability standpoint, the acceptability of incorporating the tutorial as a on-line function for ADDS is questionable. The dedication of an ADDS to conduct user training does not appear efficient. Tying up an expensive and limited resource for extensive user training is not cost effective. This was one of the drivers for a very limited, both in scope and utility, on-line tutorial. This shortcoming could be offset to some degree by a quality user manual for ADDS, but that does not exist at this time. It appears that an off-line, stae-of-the-art personal computer-based tutorial is a better approach.

6.1.1.2 Diagnostics

Figure 6-2 illustrates the control panel accessed by selecting Diagnostics on the Activity control panel. It is a similar Motif-based control panel.

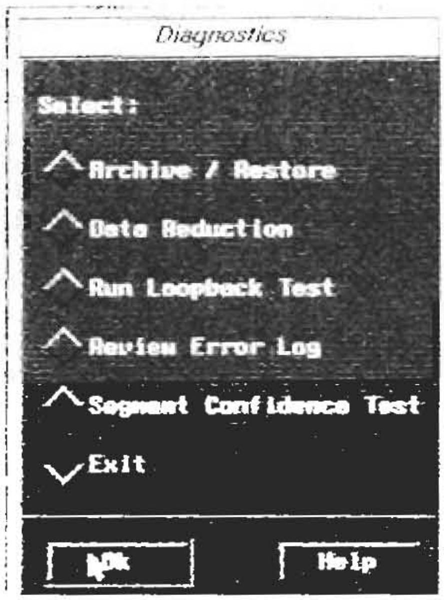


Figure 6-2. The Diagnostics control panel.

6.1.1.2.1 Data Reduction. Figure 6-3 depicts the selection panels associated with the Data Reduction function accessed through the Diagnostics control panel. It illustrates the basic structure of selection based control panels incorporated in the ADDS CGUI. When the number of selections exceeds the default size of the control panel window, sliders are provided to scroll to the additional options. This multi-window function is unique within the ADDS design. One of the common human engineering problems in ADDS is the use of over-lapping pop-up windows. This is the one ADDS function that uses the better design approach of tiled pop-up windows. The basic human engineering guidelines developed for ADDS reflected the SLUG desire for the tiled window approach, but this approach was not generally followed by the software implementers.

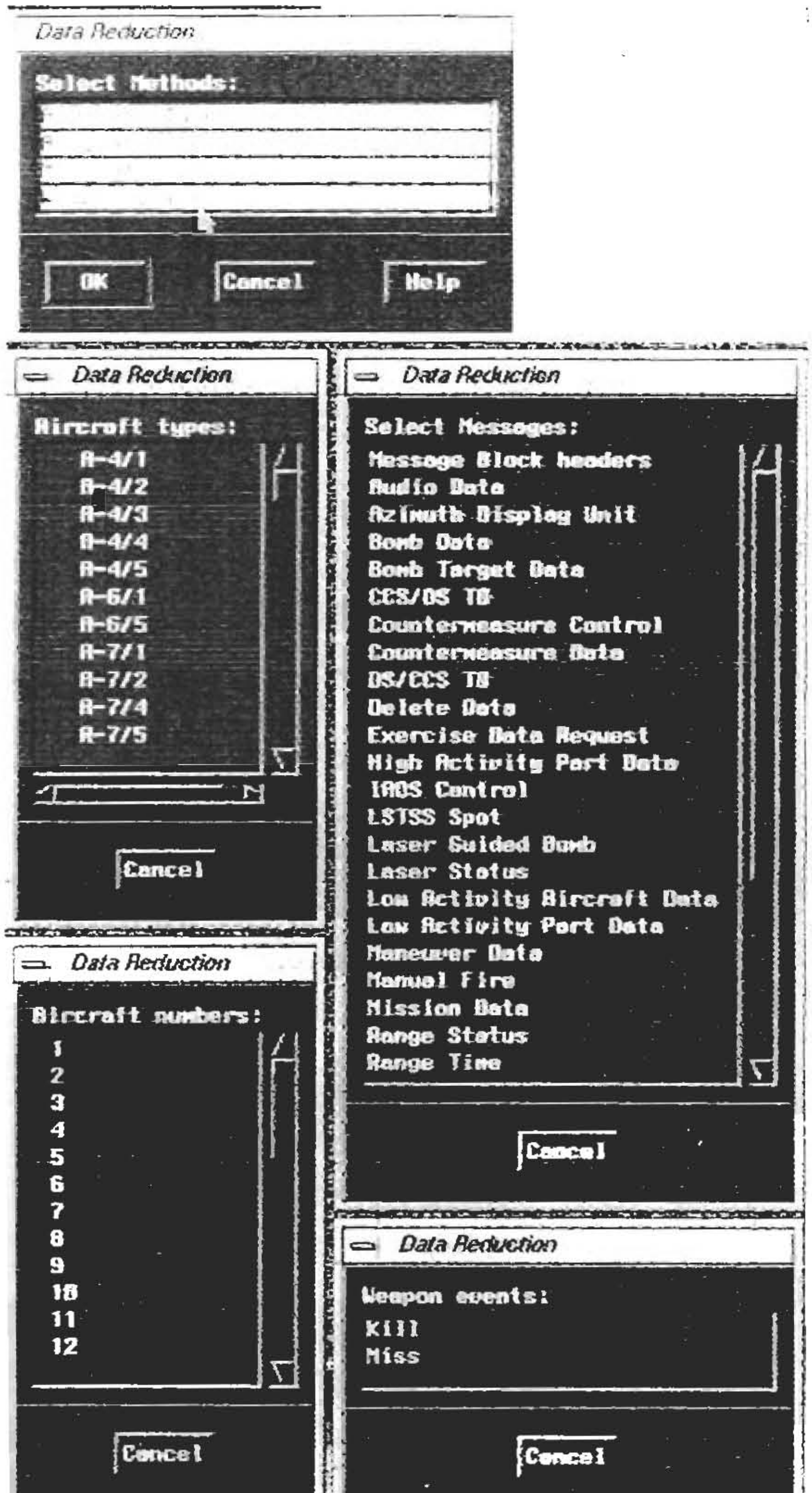


Figure 6-3. The Data Reduction selection panel.

6.1.1.3 ADDS Administration

Figure 6-4 illustrates the system administration function in ADDS. This figure shows the potential problems in using commercial-off-the-shelf (COTS) software. COTS software does not permit maintenance of a consistent interface appearance. While not apparent in this gray shade picture, the color scheme provided by the COTS software is very different that the rest of ADDS. This color scheme also provided marginal contrast between the text in the body of the window and the background. The contrast in this figure far exceeds the contrast on the actual ADDS display. The other major appearance inconsistency with the basic ADDS CGUI is the fonts used in the COTS. This window also incorporates a slide design which varies slightly from Motif. While this sub-function does not follow the normal guideline for consistency in a user interface, the differences should not result in a performance decrement.

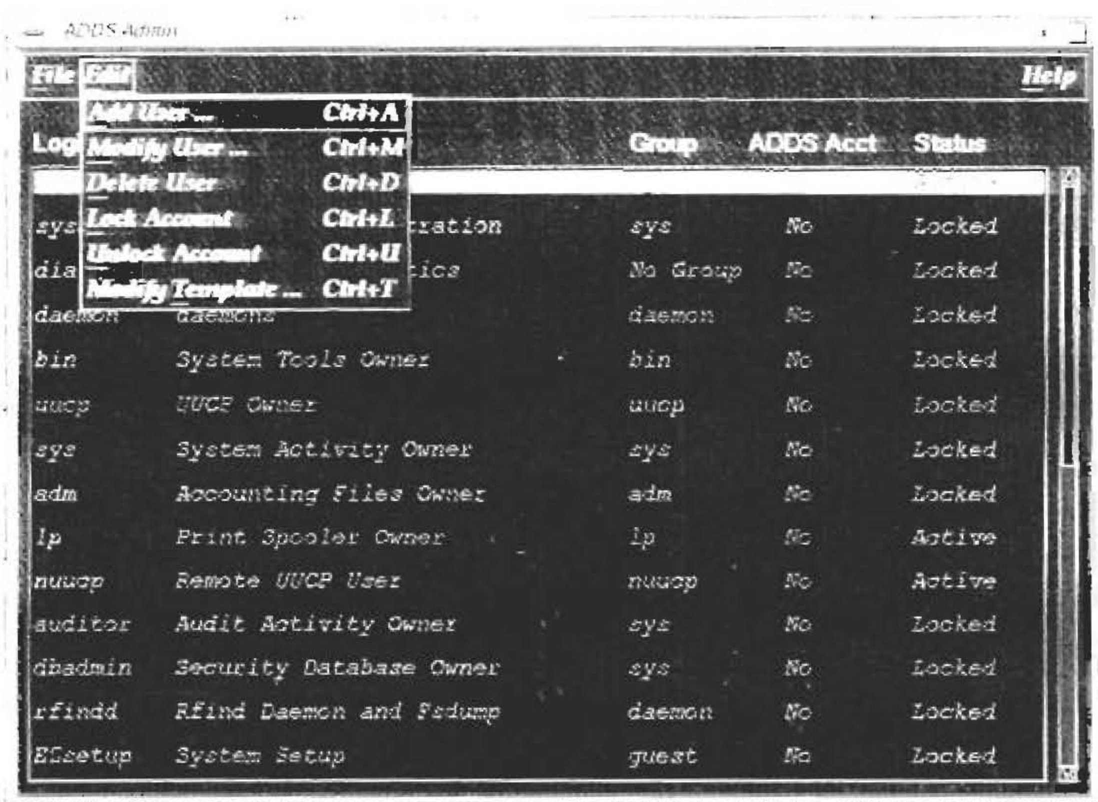


Figure 6-4. The system administration function in ADDS.

6.1.2 Menu Bar

Figure 6-5 illustrates the top level choices for the CGUI. The layout represents a good combination of frequency of use and menu conventions. Each of the pop-down menus for these choices will be described in the following paragraphs.

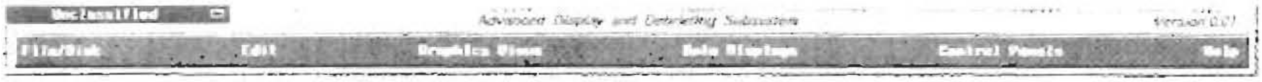


Figure 6-5. The ADDS Menu Bar.

6.1.2.1 File/Disk

Figures 6-6 illustrates the pop-down menus for the live and replay modes. The only differences in the two menus are "End " and "Exit" which reflect the mode. The menus reflect frequency of use and are consistent across all displays.

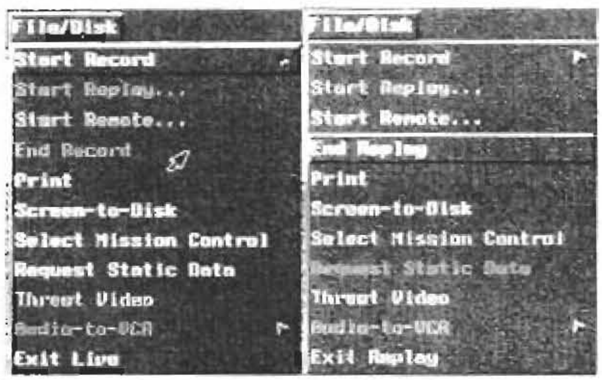


Figure 6-6. The pop-down menus for the live and replay modes.

6.1.2.2 Mission Selection

Figure 6-7 illustrate the control panel which pops ups when the Select Mission Control option is selected on the File/Disk menu. This control panel is one of several panels which violates a CGUI guideline that recommends that the label for the control panel correspond to the menu choice label.

Figure 6-7. The Select Mission Control panel.

6.1.3 Edit and User Preference Menus

Figure 6-8 illustrates the Edit menu and the User Preference submenu. In the edit menu, as well as others, those selections which are not available have been de-emphasized. The organization of the Edit menu is based on frequency of use estimates.

This figure also illustrates the User Preference submenu. Selection of items in this menu either pop up additional control panels or activate a binary choice. Options which have a lower level menu are indicated by the triangular arrow to the right of the label. Binary choice options are indicated by the radio buttons beside a selection. Options which have a control panel with more choices are indicated by the three dots after the label.

While not shown in the figure, these second level menus have a consistent design feature in the ADDS CGUI design. When the control panels associated with second level options, like Mouse Settings, pop up on the screen they default to a position of the far left of the screen. Hence, the mouse positions move successively to the right with each level of menu, but when the final option is selected, the mouse must be moved all the way back to the left in order to make choices on the control panel. This design introduces unnecessary mouse movements, and consequently, increases workload.

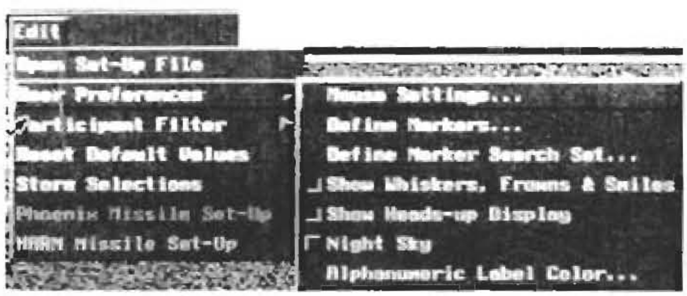


Figure 6-8. The User Preference menu.

6.1.3.1 Open Set-up File

Figure 6-9 illustrates the pop-up window which is activated by selecting the Open Set-up File choice on the Edit menu. This selection window incorporates accepted CGUI conventions, where the desire file can be selected with the mouse or typed in the selection window. Scroll Bars are provided to scroll through the available selections when the number of potential selections exceeds the size of the window. The window is fixed size.

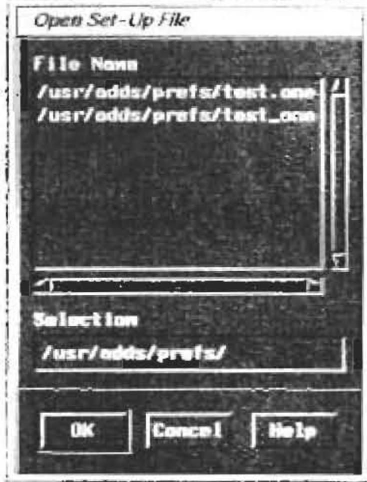


Figure 6-9. The Open Set-up File window.

6.1.3.2 Participant Filter

Figure 6-10 illustrates the submenus associated with the Participant Filter selection on the Edit menu. It has the cascading hierarchy of submenus reflective of the ADSDS CGUI design and accepted conventions. This set of menu options has the same problem identified earlier on the User Preference menus. Selection of options on the lowest menu level, e.g., High Activity AC or Threats, pop up control panels which default to the far left of the screen. As noted above this introduces unnecessary mouse movement and increases workload.

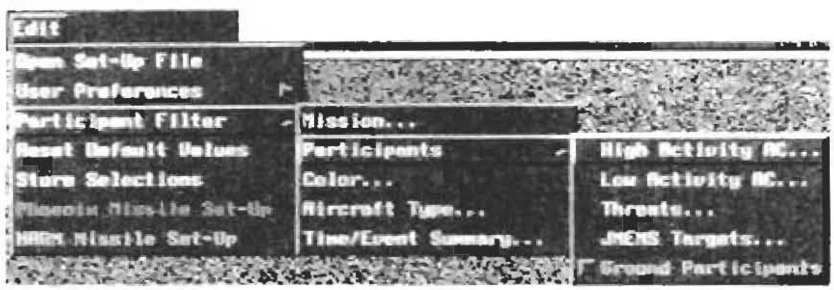


Figure 6-10. The submenus associated with the Participant Filter selection on the Edit menu.

6.1.4 Graphics Views

Figure 6-11 illustrates the pop-down menu for the Graphic Views choice on the top level Menu Bar. Items on this menu are organized in estimated descending frequency of use. The active selection is highlighted as show in the figure.

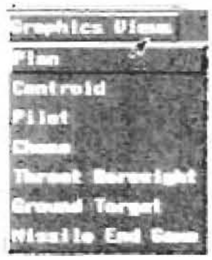


Figure 6-11. The pop-down menu for the Graphics Views.

6.1.5 Data Displays

Figure 6-12 illustrates the pop-down menu for the Data Displays option on the top level Menu Bar. This pop-down menu is organized into two parts. Choices that are associated with normal ADDS missions are located on the first level pull down menu. Data displays which are not used during live or replay missions are grouped on a second level menu accessed by the Other Data choice on the first level menu.

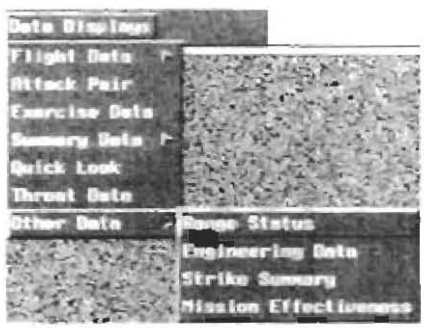


Figure 6-12. The pop-down menu for the Data Displays.

6.1.6 Control Panels

Figure 6-13 shows the pop-down menu for the Control Panels option on the Menu Bar. Those options which are not available are de-emphasized. The order of the selections are based on estimated frequency of use. The first two options are somewhat redundant since these control panels are automatically activated by the log-in mode on ADDS.

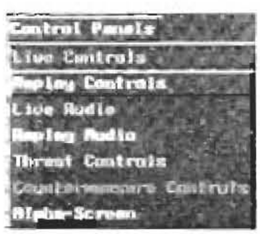


Figure 6-13. The pop-down menu for the Control Panels.

6.1.6.1 Live and Replay Control Panels

Figure 6-14 illustrates the Live Control Panel and the Replay Control Panel . Options on both panels are logically organized. They provide access to functions which need to be quickly activated during the control of an exercise. The lack of state indication in the title of the control panel does not follow accepted CGUI guidelines. The user determines state by the functions available on the control panel and knowledge of the log-in mode.

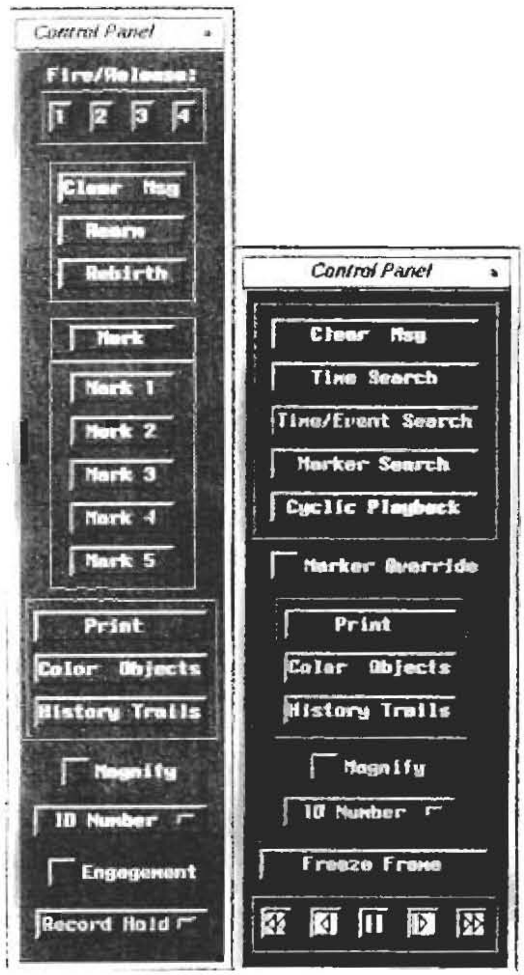


Figure 6-14. The Live Control Panel and the Replay Control Panel.

6.1.6.1.1 History Trails. Figure 6-15 illustrates the sub-control panel which pops up when the History Trails function is selected on the Live or Replay Control Panel. It provides binary selection of objects to display history trails. It also provide slider control of trail length.

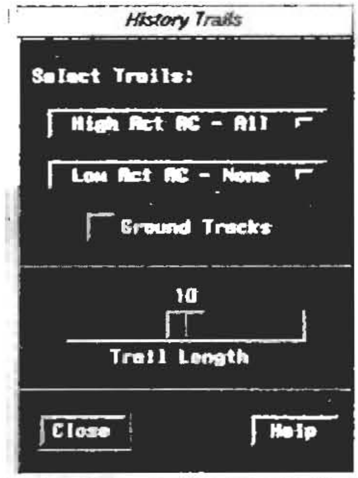


Figure 6-15. History Trails control panel.

6.1.6.1.2 Marker Search. Figure 6-16 illustrated the sub-control panel which pops up when the Marker Search function is selected on the Replay Control Panel. This panel uses sliders and radio buttons to control actions.

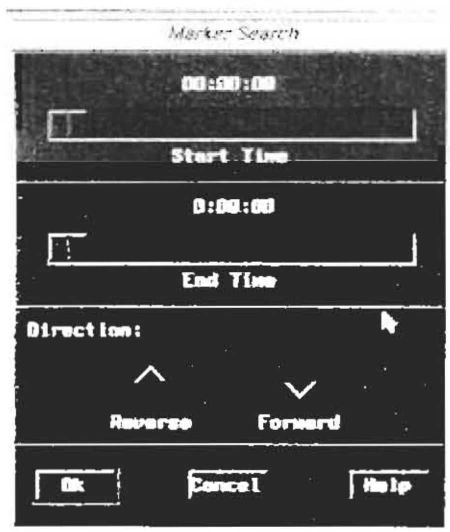


Figure 6-16. The Marker Search control panel.

6.1.6.2 UHF Audio Control Panel

Figure 6-17 depicts the Audio Control Panel accessed from the Control Panel menu.

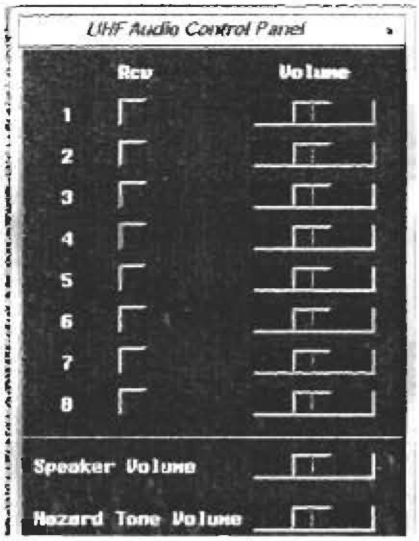


Figure 6-17. The Audio Control Panel.

6.1.6.3 Threat Control

Figure 6-18 shows the Threat Control panel accessed from the Control Panels menu. It is logically organized and provides clear indication of state. The Select Threat button pops up the CGUI Number Panel, which permit the user to select the threat number by mouse click.

Figure 6-18. The Threat Control panel.

6.1.6.4 Countermeasure Controls

Figure 6-19 illustrates the Countermeasure Control panel accessed from the Control Panels menu. Countermeasures are activates by radio buttons. The Select Aircraft button pops up the CGUI Number Panel, which permit the user to select the aircraft number by mouse click. This panel violates label guidelines for CGUIs. The option on the Control Panels menu is Countermeasure Controls, while the control panel label is Countermeasure Control. The label is plural in one case and singular in the other. Both labels should be plural.

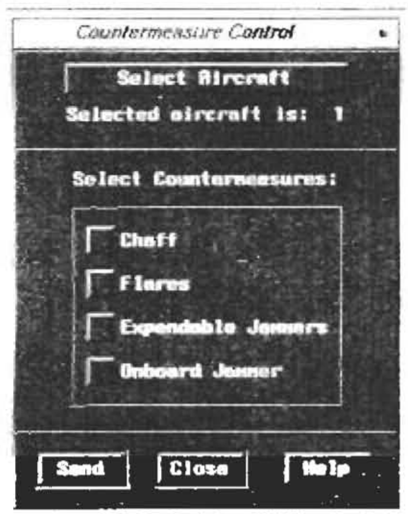


Figure 6-19. The Countermeasure Control panel.

6.1.6.5 Alphanumerics Screen Control

Figure 6-20 shows the Alphanumerics Screen Control. The scroll control on this panel is unique within the ADDS CGUI design, but it is in general compliance with CGUI guidelines. Again this control panel has a labeling inconsistency with the selection label used to access it on the Control Panels menu.

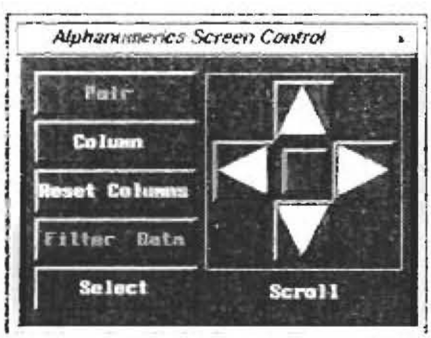


Figure 6-20. The Alphanumerics Screen Control.

6.1.7 DS Help Selection

Figure 6-21 illustrates the help option window accessed by the Help selection on the top level Menu Bar. This control panel is a simple scrolling list of options. This is not a user friendly implementation for a help menu because it require tedious scrolling through a long list of options. This makes it time consuming to use. Help functions should incorporate a key word search to help the user jump to the desired help option. This panel also exhibits a labeling inconsistency with the Menu Bar selection label.

Figure 6-21. The Help selection.

6.1.8 Display Control Panels

Figure 6-22 illustrate the control panels associated with four of the primary graphics views. ADDS refers to these panels as dashboards, but for consistency in this report they will be treated the same as other classes of ADDS control panels. These panels contain a number of implementation problems. Comparing the ordering of options on the panels shows a number of positional inconsistencies. For example on the Chase Display control panel the order of the Declutter and Solid Terrain options is different from the other control panels. This violates basic CGUI design guidelines. Note that this was identified as an implementation problem. Review of the Human Engineering CGUI Design, as presented to the SLUG and at various design reviews, does not have this positional inconsistency problem. The design was changed and errors introduced by the software implementers.

The pan function is an inside-out control, but all of the ADDS displays, except the pilot view, are implemneted as outside-in display/ control relationships. The control/display relation is implement backwards. Users would adapt to this but it should be implemented logically.

An examination of the Chase Control Panel shows a very hard to see small button on the upper right corner of the control panel. This button is the window shade control. The attention getting characteristics of this control are insufficient. The user essentially has to discover the control by accident. The users manual is not a help in this instance since the control is not discernible in the figures because of the low contrast. Dragging this control with the mouse increases or decreases the size of the control panel. It is possible to reduce the size of the control panel to the point where controls are no longer visible. This design feature is not in compliance with human engineering guidelines.

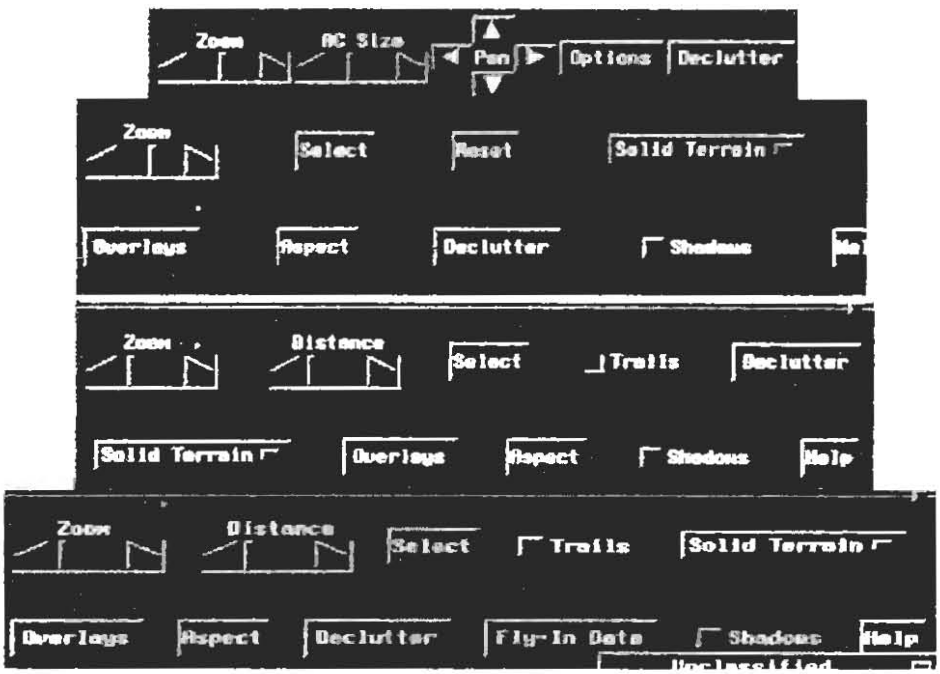


Figure 6-22. Control panels associated with four of the primary graphics displays.

6.2 Low-speed Interface Subsystem (LIS) CGUI

The following subsections provide examples of a number of LIS control panels. This system is much simpler than the DS. In general, the LIS provides relatively a logical and straightforward interface. However, the LIS has a very different appearance from the DS in that it employs a very distinct color scheme.

6.2.1 LIS Main

Figure 6-23 shows the LIS Main Menu display. The basic menu bar organization is consistent with the menus on the DS. The unique features in the display window are the LIS logo and progress indicator. The major inconsistency with the DS is the color scheme.

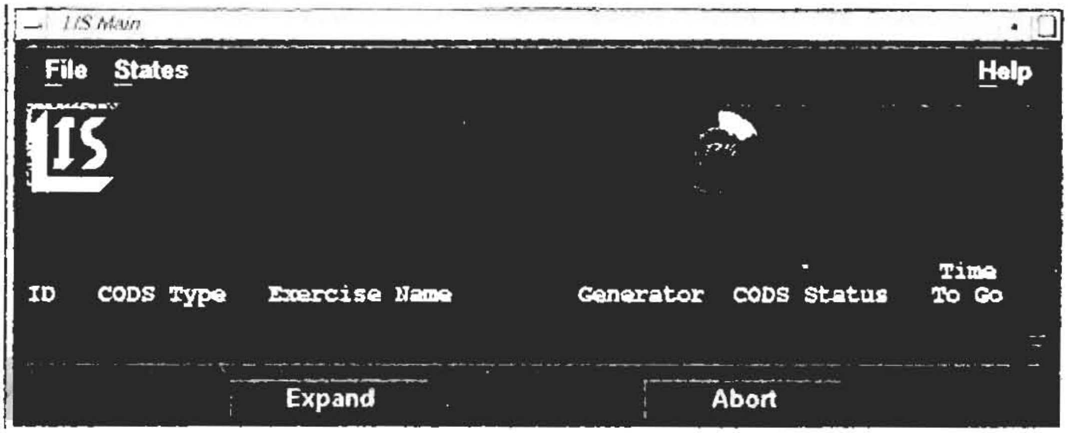


Figure 6-23. LIS Main Menu display.

6.2.1.1 LIS Main States

Figure 6-24 illustrates the pop-down menus for the selection of States on the LIS Main display. The structure and operation of these menus is consistent with the overall ADDS design.

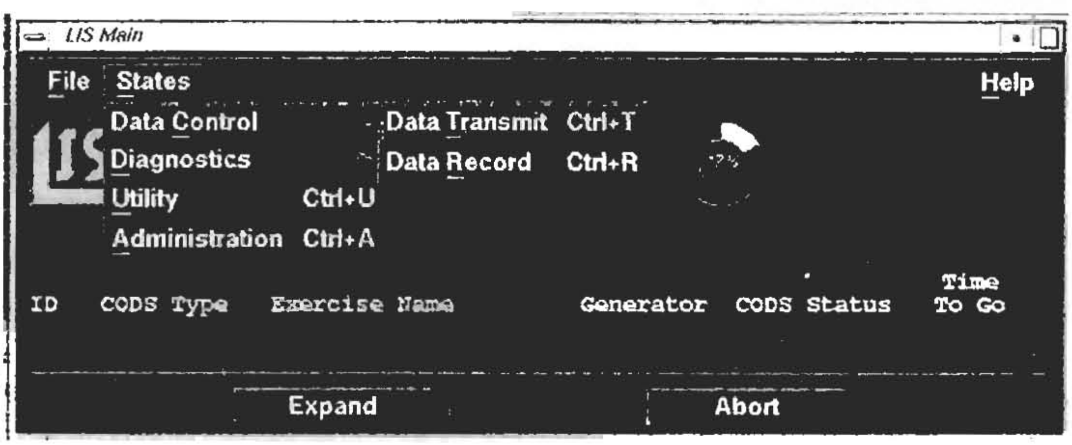


Figure 6-24. Selection of States on the LIS Main display.

6.2.2 LIS Status and Error

Figure 6-25 shows the LIS Status & Error window. The structure of this selection window is not consistent with other selection windows on the ADDS DS. The major difference is the sliders on the window. The style is slightly different and the vertical slider is on the left side of the window rather than the right side of the selection window. These differences would not be considered in compliance with human engineering guidelines for the overall ADDS.

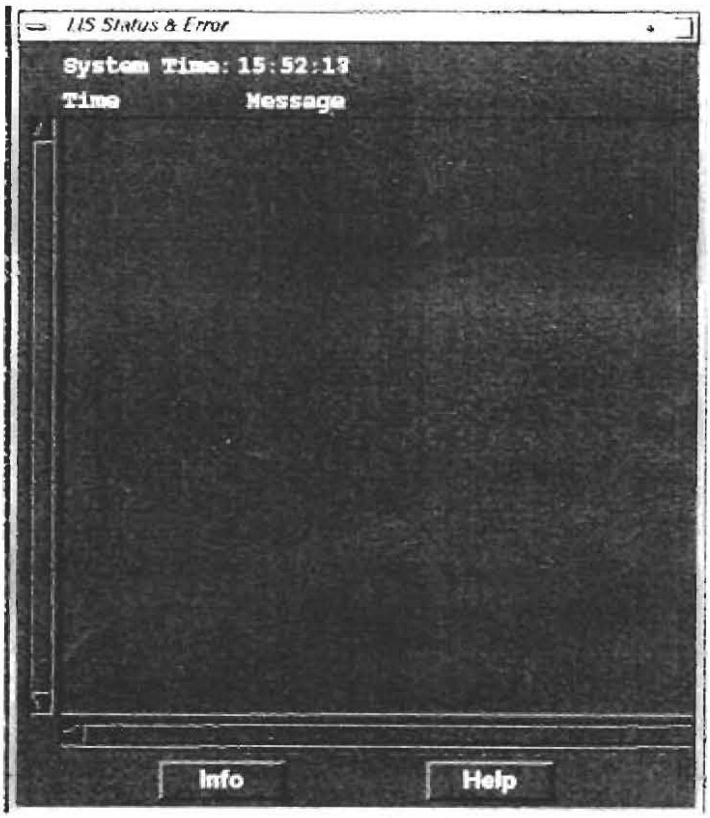


Figure 6-25. LIS Status & Error window.

6.2.3 CODS Definition

Figure 6-26 illustrates the CODS definition control panel.

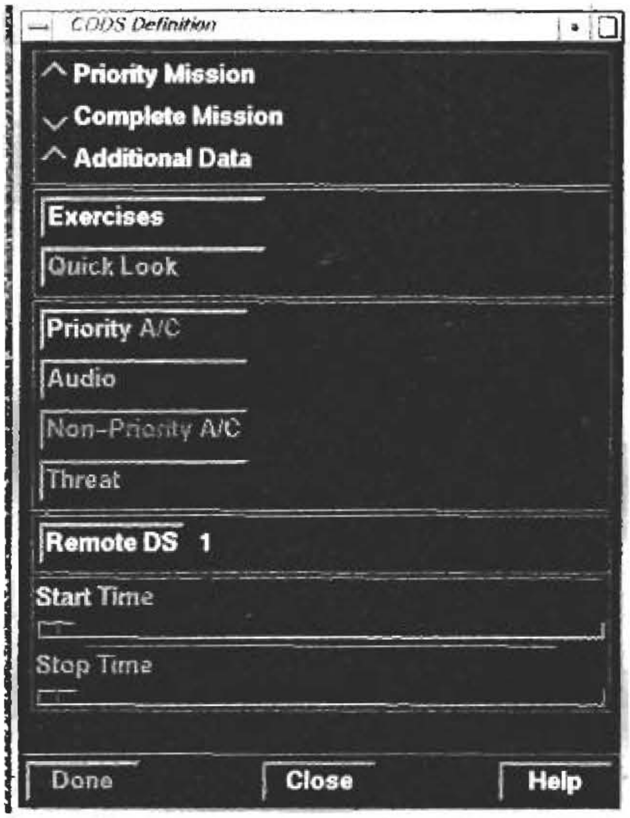


Figure 6-26. CODS definition control panel.

6.2.4 Remote DS Selection

Figure 6-27 illustrates the window used for Remote DS Selection. Its structure and operation is consistent with the overall ADDS design.

Figure 6-27. LIS Remote DS Selection.

6.2.5 Record Control

Figure 6-28 shows the control panel for performing Remote Control on the LIS. Its structure and operation is consistent with the overall ADDS design.

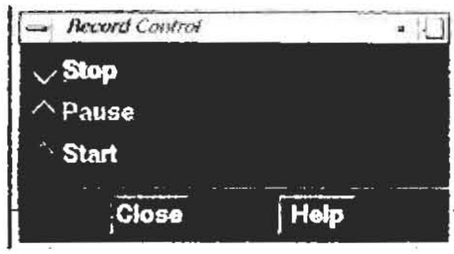


Figure 6-28. LIS Record Control.

7.0 ADDS DISPLAYS

7.1 ADDS GRAPHICS DISPLAYS

The major shortcoming associated with the ADDS graphics displays is color contrast. This is due to in part the default color palette, and in part the variable background colors. The default color palette is a design problem. It does not appear that human engineering evaluations were conducted to optimize the color palette. Achieving good color contrast when the background colors vary, i.e., includes both dark and light colors, is more difficult. One of the more recent human engineering recommendations to deal with this issue is to make symbols bi-color. In the bi-color scheme one color is picked to have good color contrast against light color backgrounds, and the other is picked to have good color contrast against dark color backgrounds. This technique should be considered for future display and debriefing system designs.

The following figures depict a number of possible ADDS screen layouts. Figure 7-1 depicts a representative screen that ADDDS users would configure for a live exercise. This screen provides the Live Control Panel, a Plan View display, the Audio Control Panel, and the Alphanumerics Screen Control panel. This screen layout would be used as the graphics screen on a Type A ADDS configuration or the middle screen on a Type B ADDS configuration.

Figure 7-2 illustrates an ADDS screen with both Plan View and Pilot View displays. Each display is shown in its default size to illustrate the overlap of graphic display windows that can occur in ADDS.

The Pilot View display contains the HUD symbology. There are two basic problems with the HUD implementation. The first problem is contrast. The color contrast for the HUD is marginal. Combined with the default character size, the HUD is difficult to read. This problem is accentuated in the HUD by a second implementation problem. The HUD has been linked to the external world. As a result, when the Zoom function is activated, the size of the HUD and its symbology get bigger and smaller. The HUD can quickly become unusable because the symbols are too small, negative zoom, or not enough of the HUD is visible, positive zoom. The HUD is part of the aircraft and should be linked to the design eye point. It should remain fixed in size independent of the zoom function.

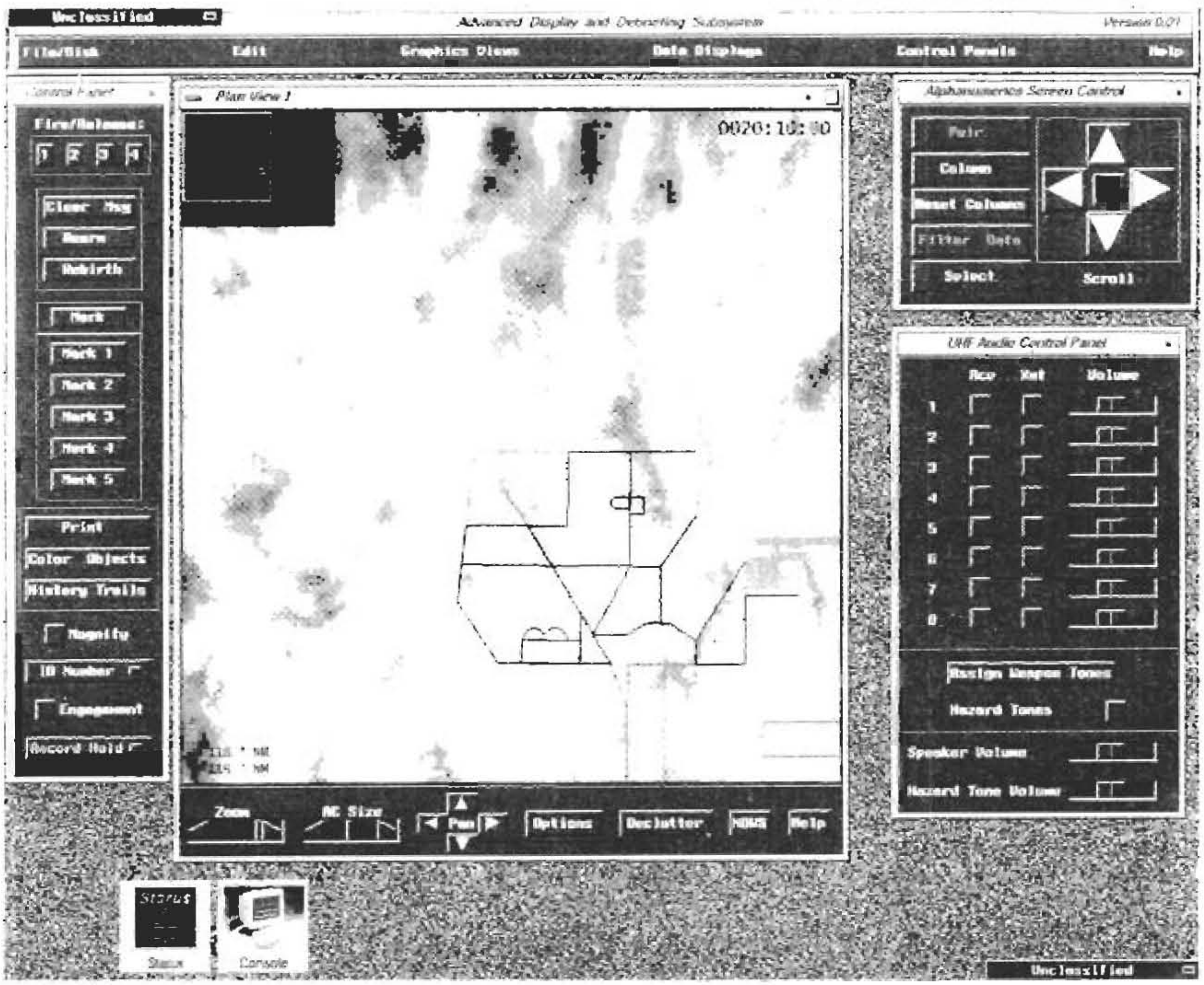


Figure 7-1. Representative Live Exercise screen.

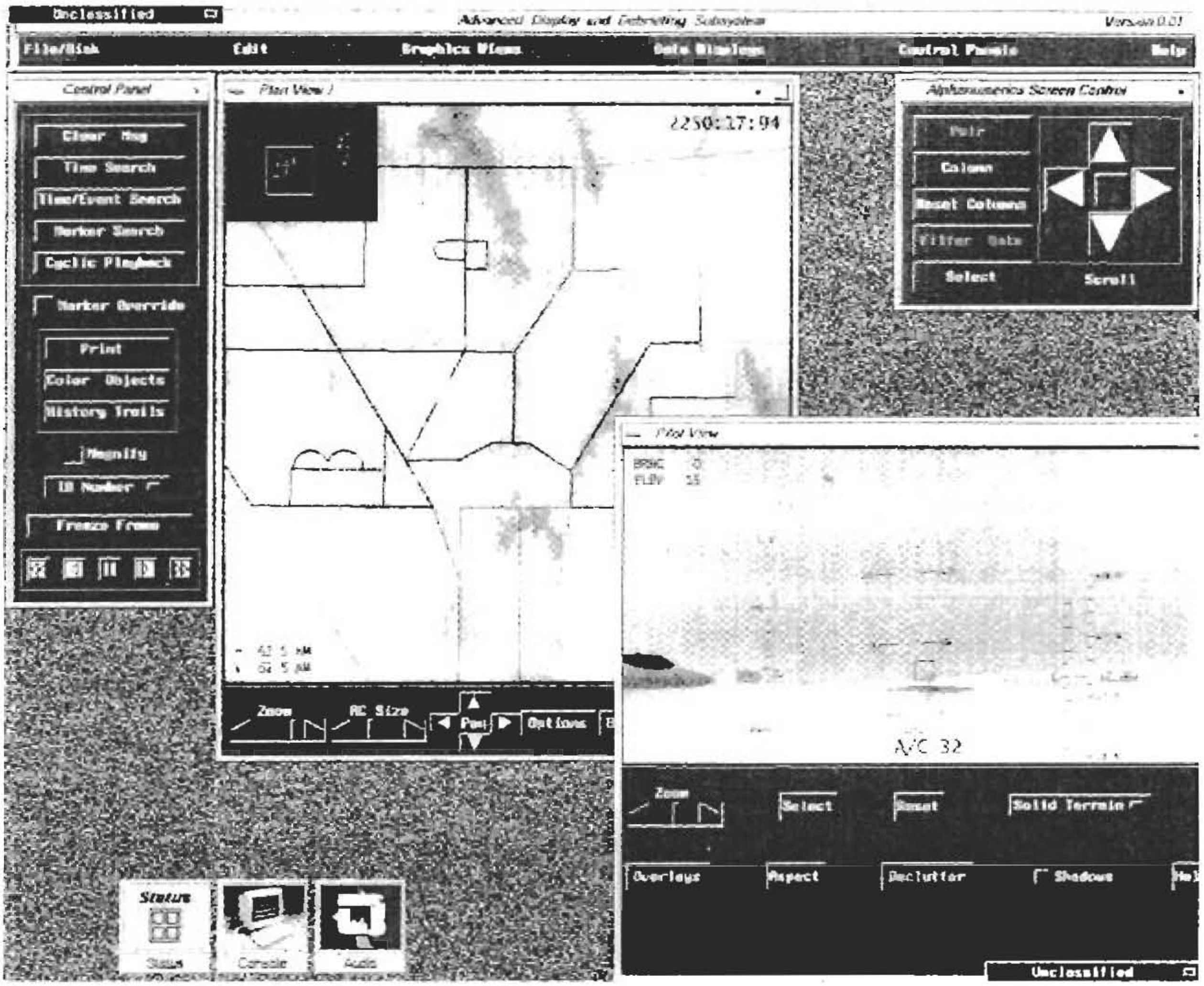


Figure 7-2. Example of Plan View and Pilot View displays.

Figure 7-3 illustrates the problem mentioned earlier concerning the HUD. Note that at this level of Zoom, the characters and HUD symbology is extremely small. This level of Zoom was set up to reflect a common operational setting.

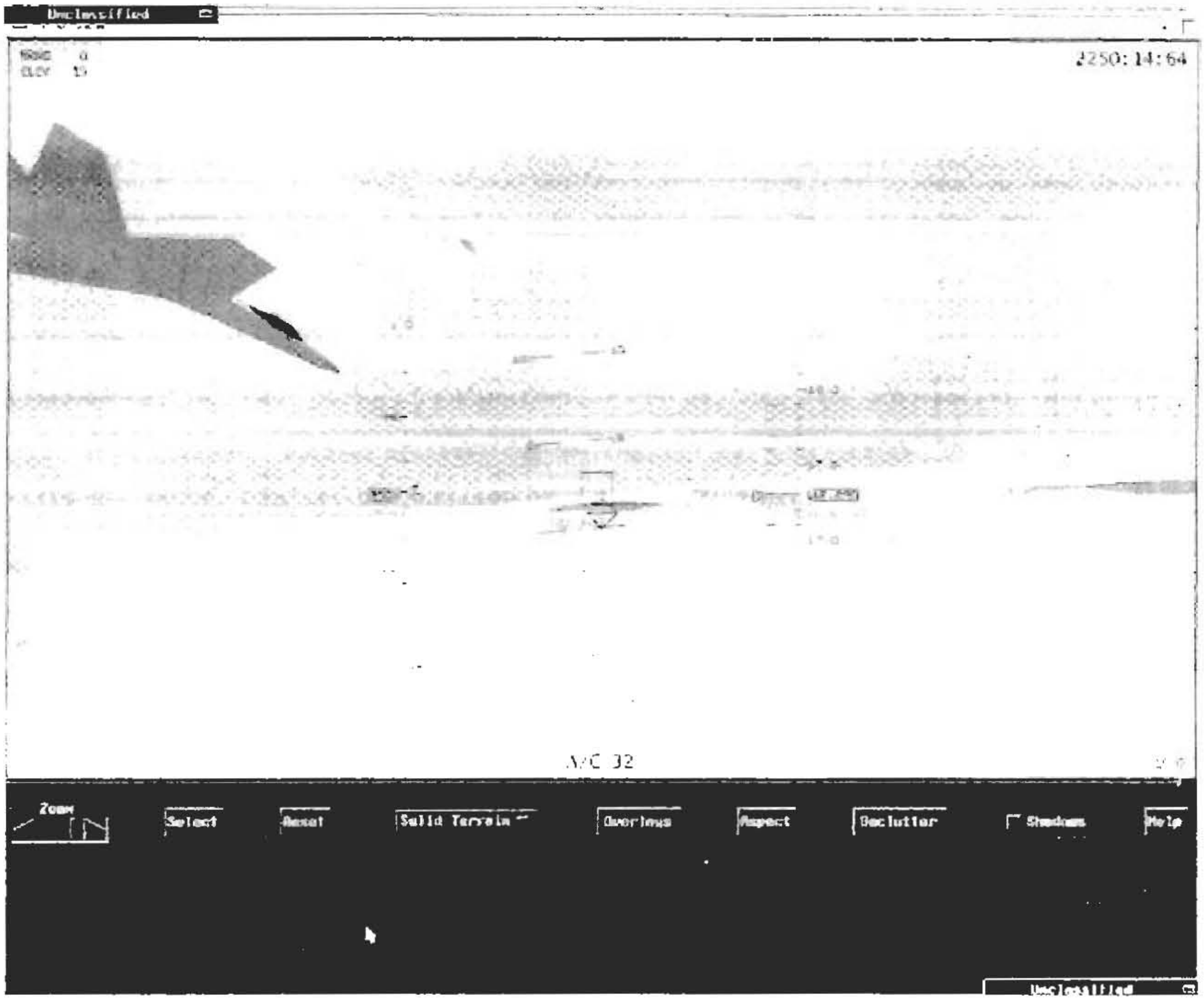


Figure 7-3. Illustration of the problem with the Pilot View HUD.

Figure 7-4 illustrates a screen layout with examples of Centroid View and Missile End Game View displays. The low color contrast in the Graphic displays is clearly depicted in this figure, even though it is a grayshade representation. The symbology in this example were in yellow and red.

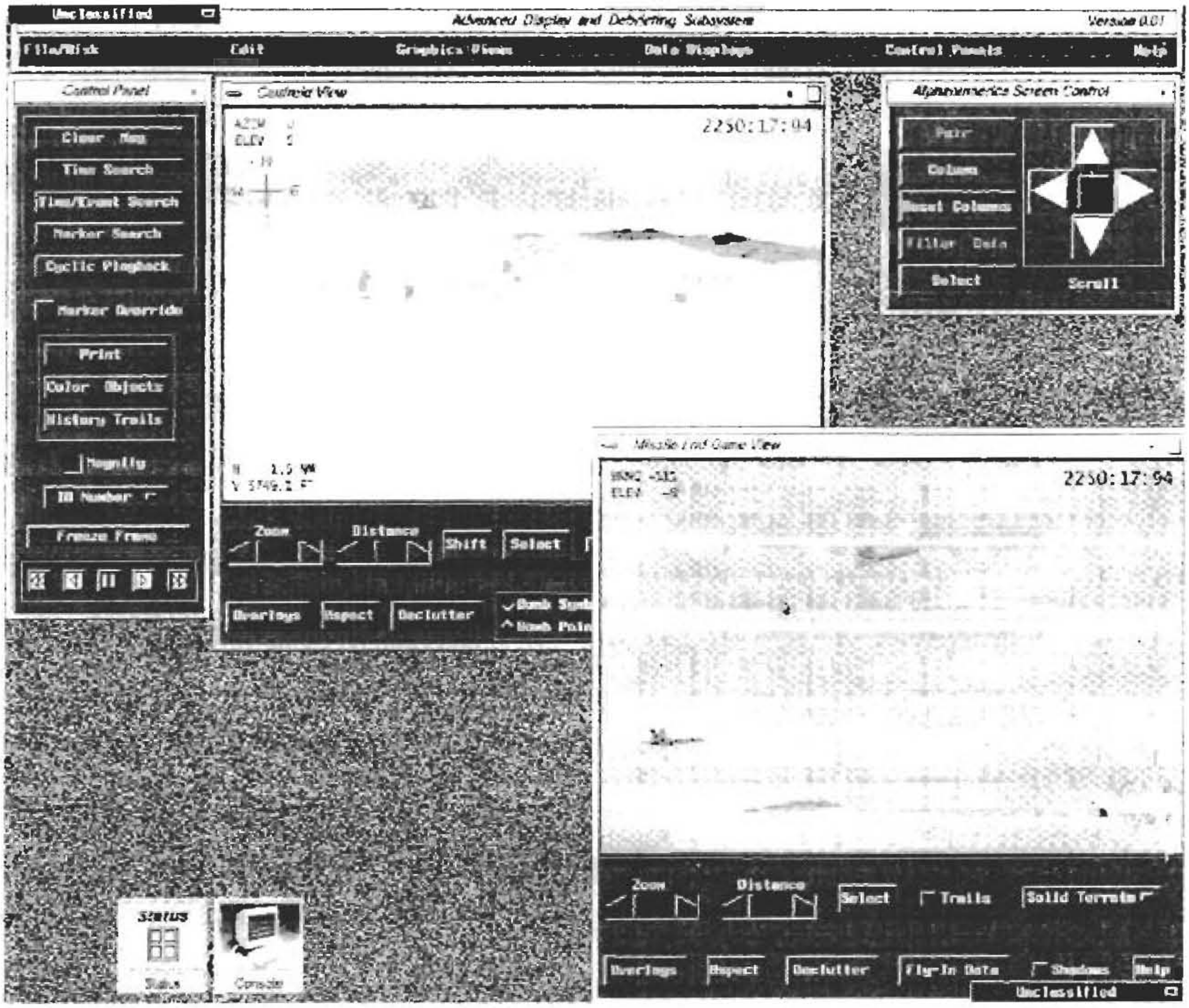


Figure 7-4. Examples of Centroid View and Missile End Game View displays.

Figure 7-5 illustrates a screen layout with examples of Centroid View and Chase View displays. The Chase View display shows that the aircraft symbol can be very visible at appropriate levels of zoom.

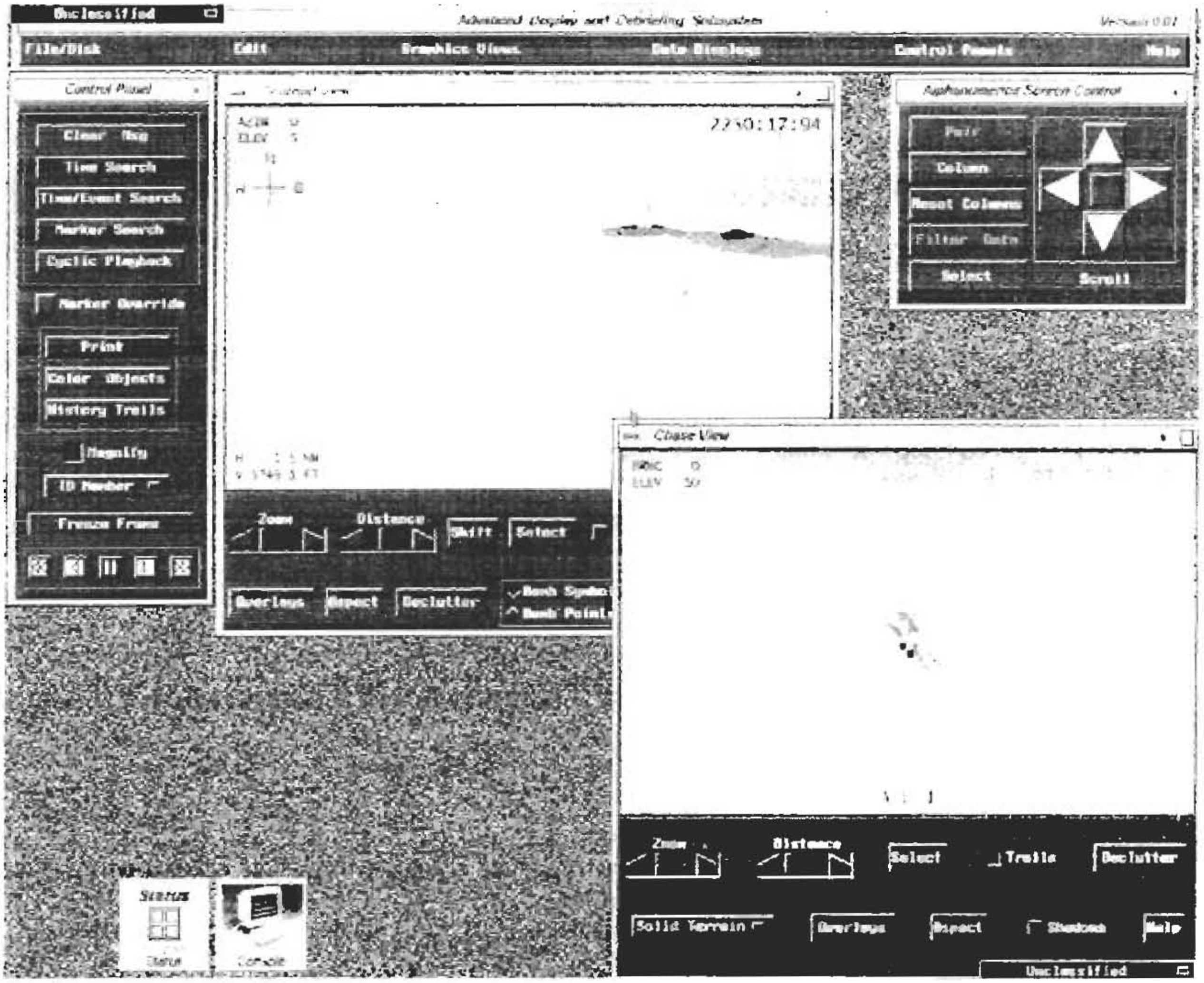


Figure 7-5. Examples of Centroid View and Chase View displays.

Figure 7-6 illustrates a complex screen layout for ADDS. This example includes two graphics displays and several control panels. This example was included to demonstrate that if the user makes the effort to size and tile the ADDS displays and controls panels, it is possible to create a very usable display. It is recommended that in future display and debreifing systems designs that the default sizing and position of displays and controls be carefully evaluated. The system should provide a properly configured screen as the default, rather than relying on the user to configure the screen into an acceptable layout. Requiring the user to perform this task introduces unnecessary workload.

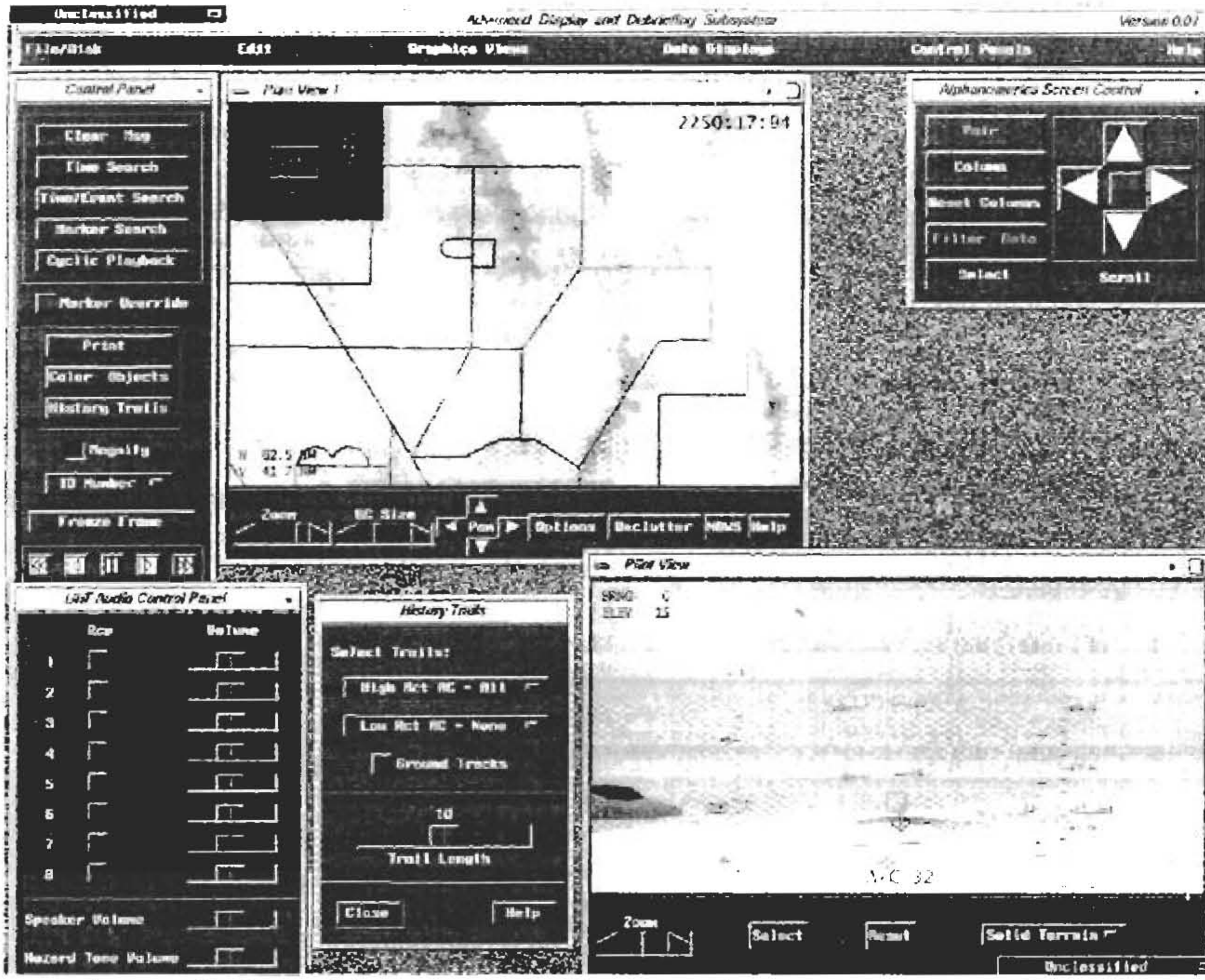


Figure 7-6. Illustration of a complex ADDS screen layout.

Figure 7-7 illustrates a screen layout with examples of a Plan View and No-Drop Weapons Scoring (NDWS) View displays.

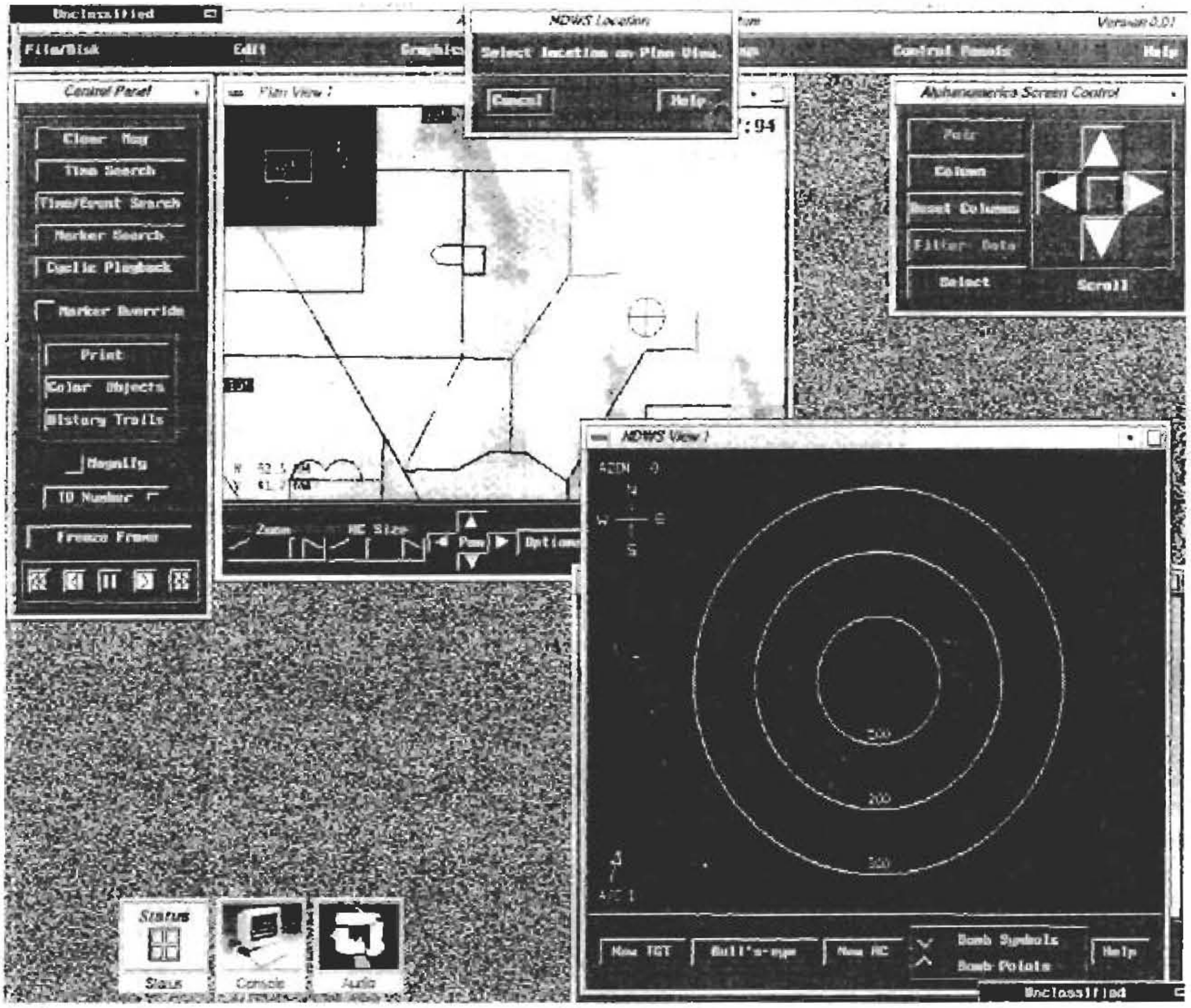


Figure 7-7. Screen layout with examples of a Plan View and NDWS View displays.

Figure 7-8 provides an example of the Ground Target View display.

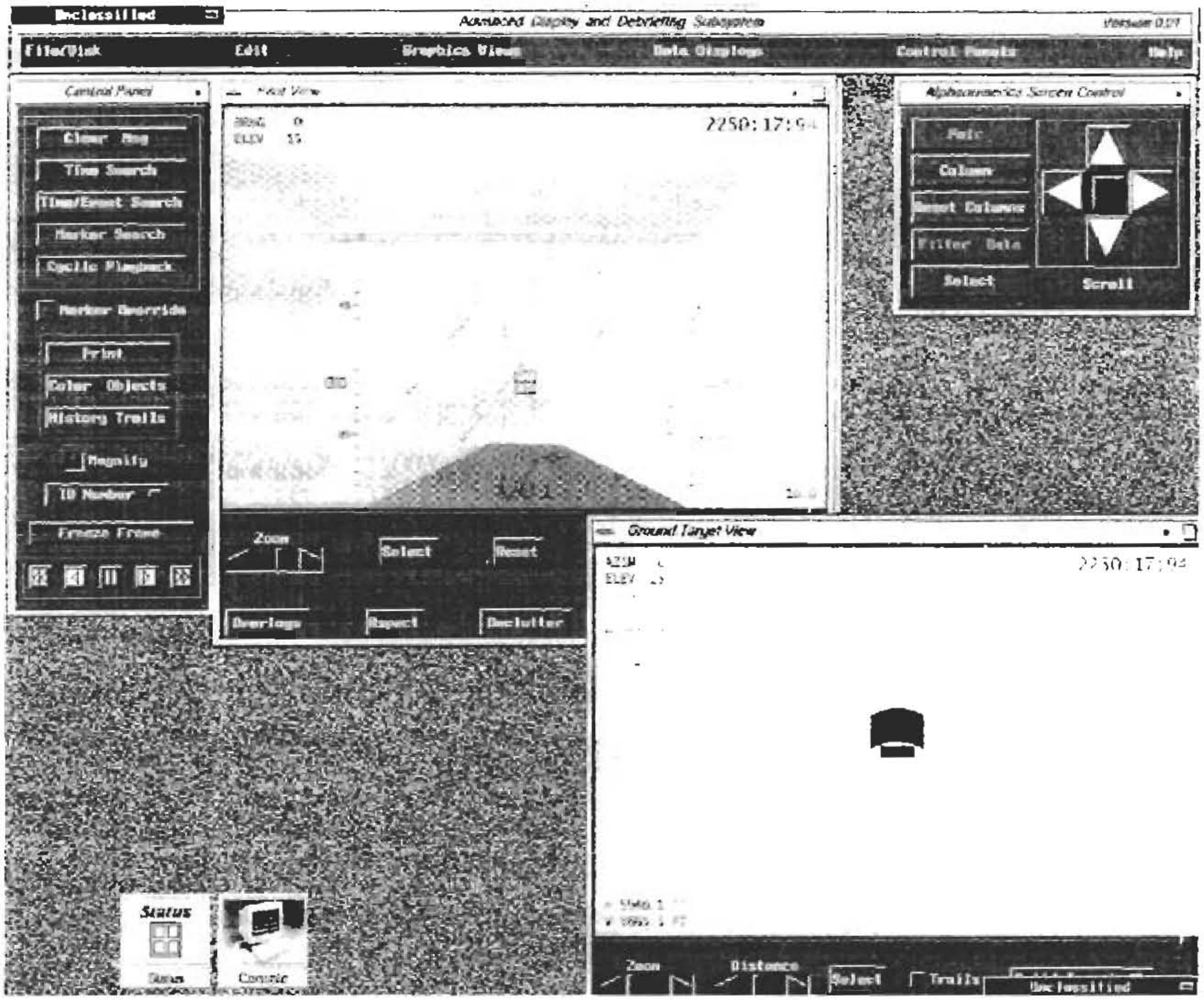


Figure 7-8. Example of the Ground Target View display.

Figure 7-9 provides an example of the Threat Boresight View display.

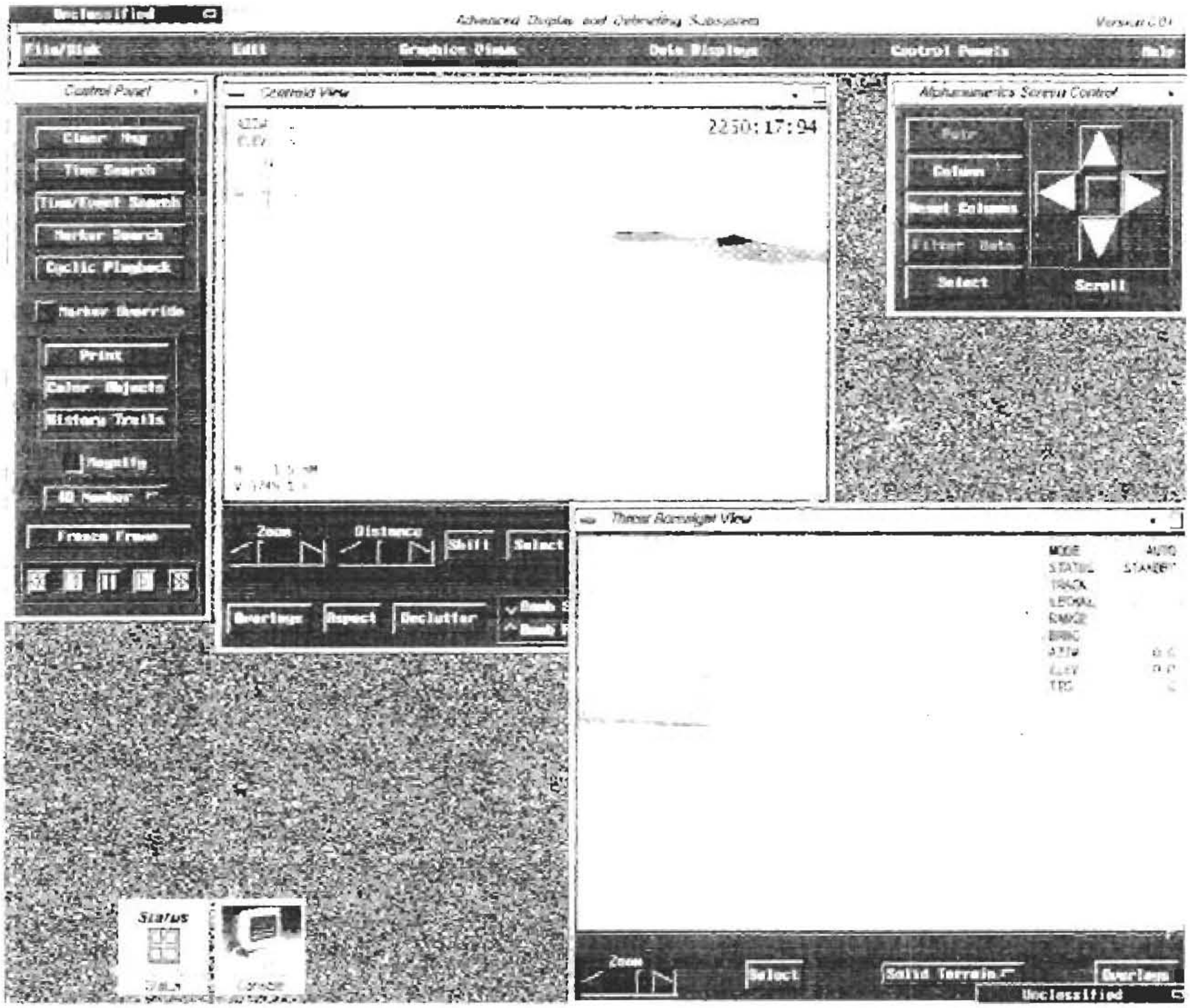


Figure 7-9. Example of the Threat Boresight View display.

Figure 7-10 is included to illustrate two Graphics View features. In the Plan View Display the size of the control panel has been reduced to the point where several control have been lost from view. It is not possible to determine that there are missing controls by looking at the display. This could lead to confusion by the user. It is recommended that the control panels for displays have a minimum size that precludes hiding control functions.

The second feature in this example is the message displayed at the top of the Centroid View display.

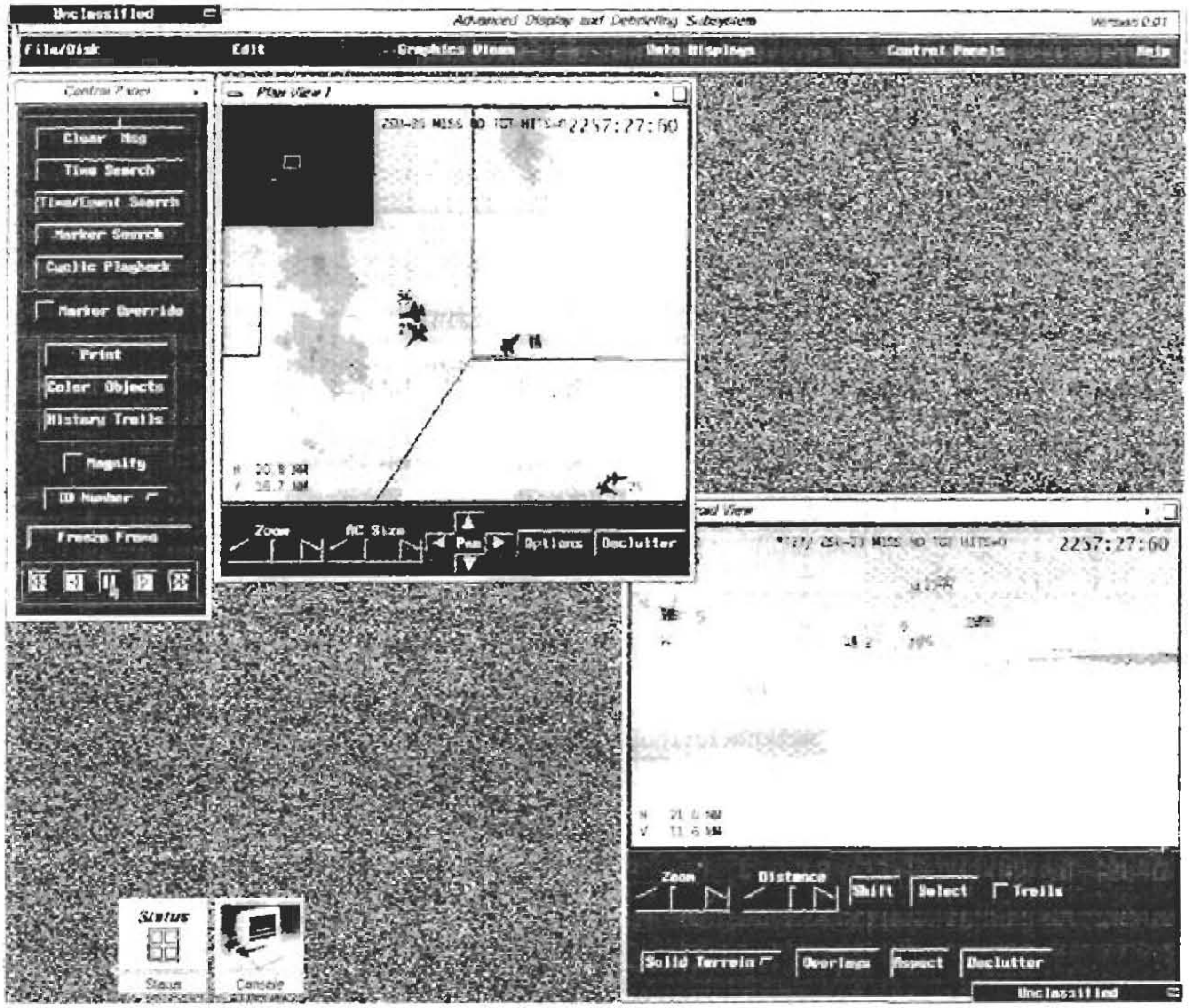


Figure 7-10. Illustration of two Graphics Views features.

Figure 7-11 provides a full screen version of the Centroid View display. Note that on full screen displays, the security classifications at the top of the display occludes the display label, and the security classification at the bottom of the display can occlude functions on the control panel. This implementation does not comply with human engineering guidelines.

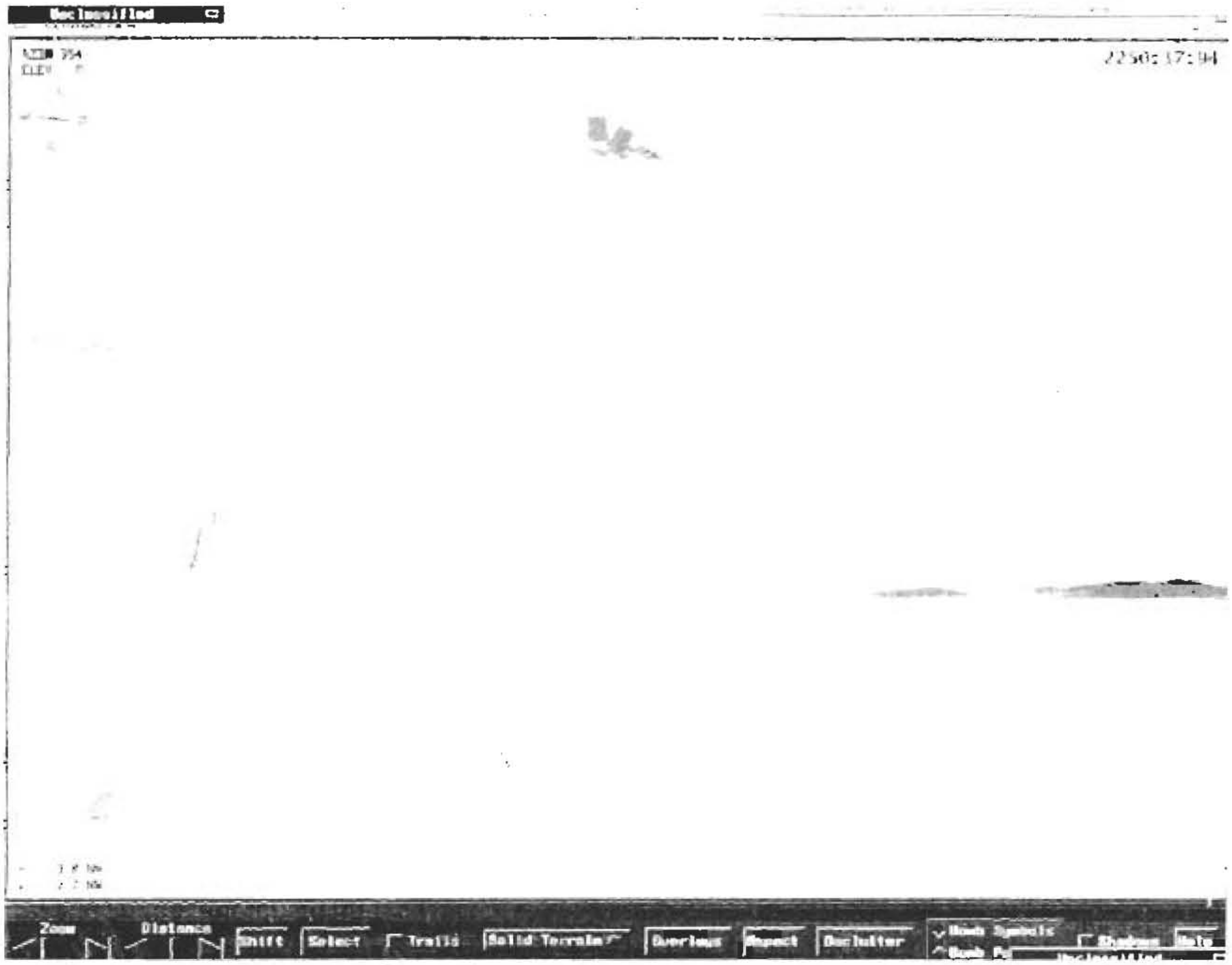


Figure 7-11. Example of a full screen version of the Centroid View display.

Figure 7-12 illustrates an example of a full screen presentation of the Plan View display. Note that when the plan view is presented full screen, the color contrast problem is reduced. The larger symbology provides sufficient area to aid perception. However, this example illustrates two of the other human engineering problems in the ADDS Graphics View display. The aircraft labels are fixed positionally to the aircraft. Hence, when two aircraft are close together, their labels fall on top of each other making them illegible. A related problem is that the labels are a fixed distance from the center of the aircraft symbol. Hence, as the Zoom or Aircraft Size is increased the aircraft symbol occludes its own identifier. Neither of these features represents good human engineering design. While it is complex to have these positional conflicts resolve automatically by the software, it is recommended that some manual capability be implemented in future systems to permit the user to resolve these conflicts.

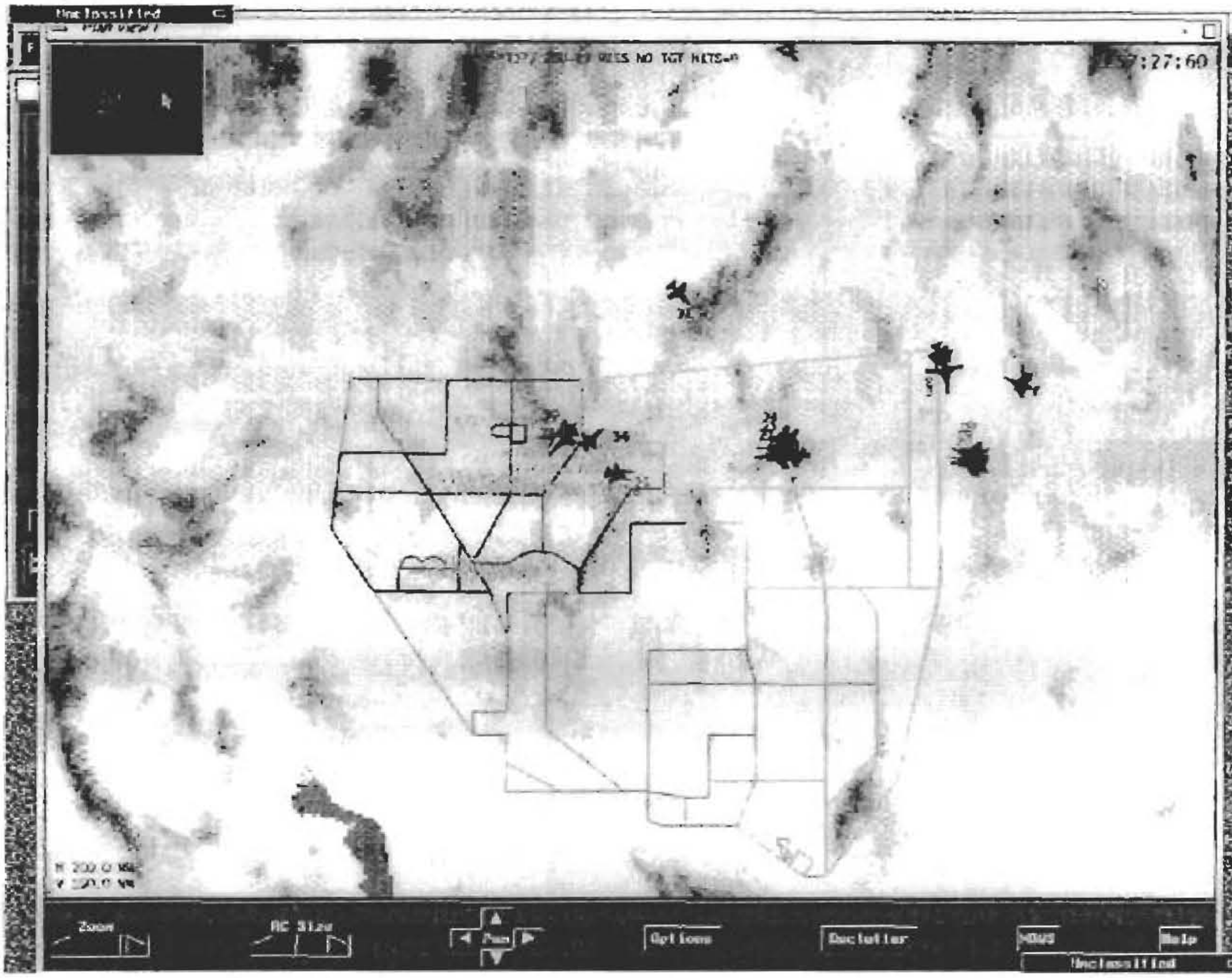


Figure 7-12. Example of a full screen version of the Plan View display.

7.2 ADDS DATA DISPLAYS

The data displays represent a different human engineering problem for ADDS. In most cases these displays were simply a reimplementation of displays from the current display and debriefing system. The ADDS program primarily focused on the CGUI and new or enhanced graphics displays. During the ADDS Factory and Quality Testing it was found that these data displays did not comply with human engineering guidelines in several areas. The following paragraphs illustrate a selected set of these displays and discuss some of the human engineering shortcomings.

7.2.1 Data Display Labels

Figure 7-13 illustrates the major human engineering deficiency in the data displays. This figure shows the data labels from a number of the alphanumeric displays. An examination of these labels reveals a number of inconsistencies in the organization of the labels. The row locations of data for the same parameter vary from display to display, e.g., G and IAS. Human engineering guidelines recommend consistent organization of labels. This deficiency should be corrected in future display and debriefing systems.

In addition, note that units are provided for several parameters in the High Activity Aircraft display, but are absent on all other displays. This inconsistency violates a number of human engineering guidelines. Units should be provided for all appropriate parameters.

Figure 7-13. Illustration of major human engineering deficiency in the data displays.

7.2.2 ACM Flight Data

Figure 7-14 illustrates the ACM Flight Data display. Two common human engineering shortcomings are reflected in this display. As with a number of graphics displays, the display label does not correspond to the menu selection option. The color contrast is somewhat marginal because of the color palette. This is a problem for the projected displays. The projected alphanumeric displays have to be viewed almost head-on to be legible. In addition, in many cases the highlighted data on the display is of lower contrast than the non-highlighted data. This is especially true for the labels. The labels are extremely readable, but the data, which is the important part of the display, has marginal readability. This does not reflect good human engineering design.

The control functions on this display appear to be logical and usable.

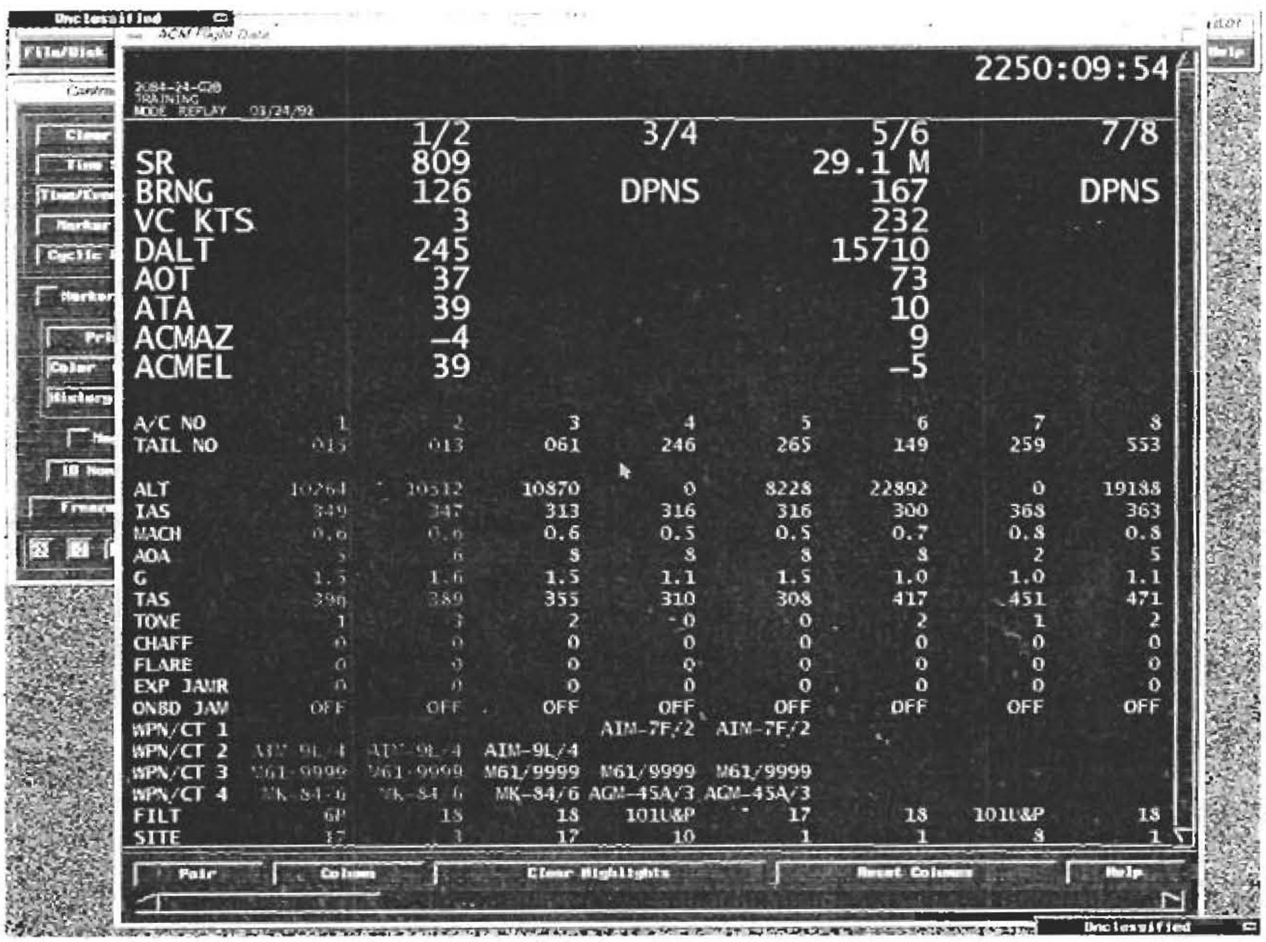


Figure 7-14. ACM Flight Data display.

7.2.3 Joint Munitions Effectiveness Manuals(JMEMS) Target

Figure 7-15 illustrates the Attack Pair-JMEMS Target/AC display. Because of the large character size on this display, it provides good readability.

The control functions on this display appear to be logical and usable.

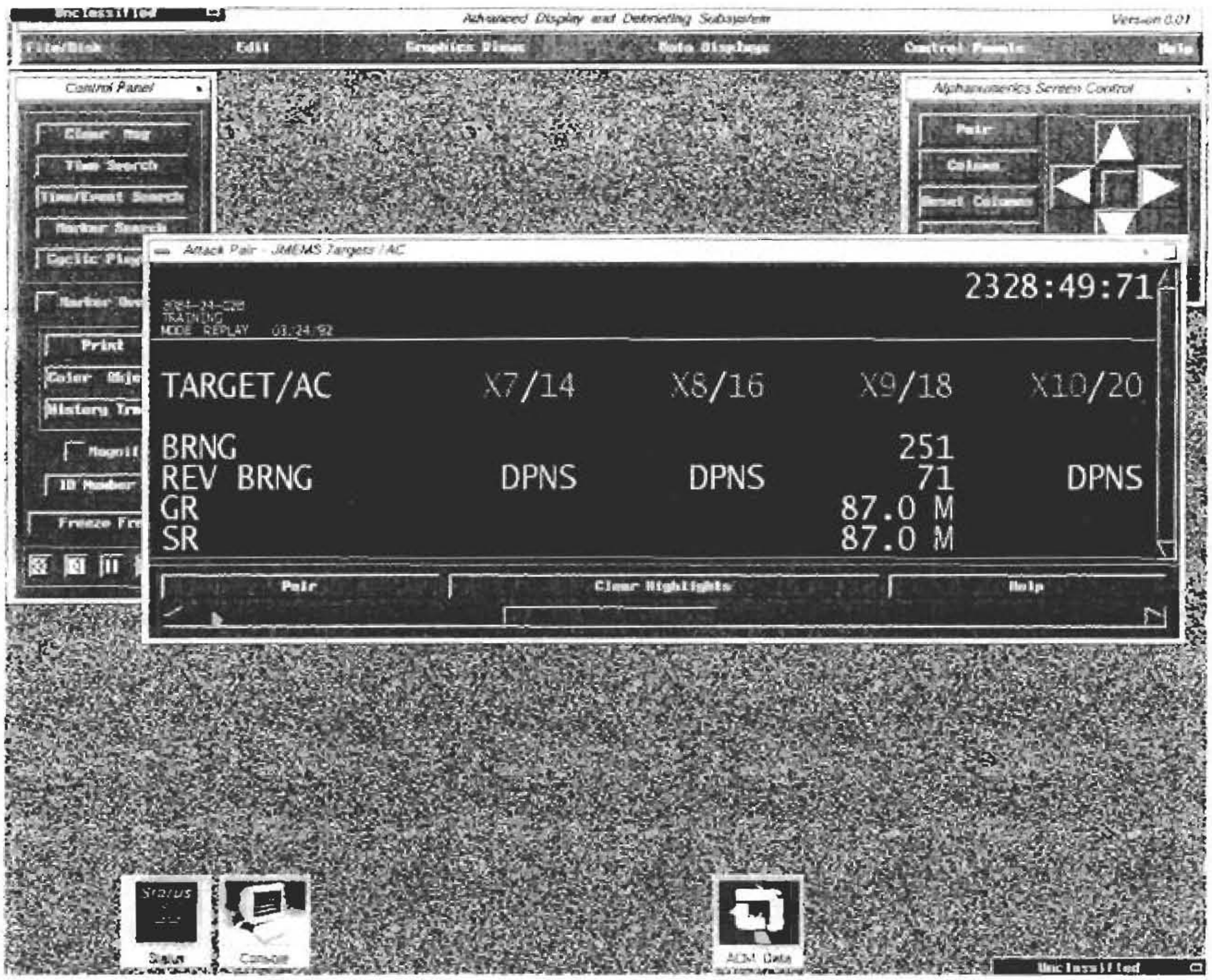


Figure 7-15. Attack Pair-JMEMS Target/AC display.

7.2.4 Exercise Data

Figure 7-16 illustrates the High Activity AC Exercise Data display. This display has the same shortcomings identified for the ACM Flight Data display.

The control functions on this display appear to be logical and usable.

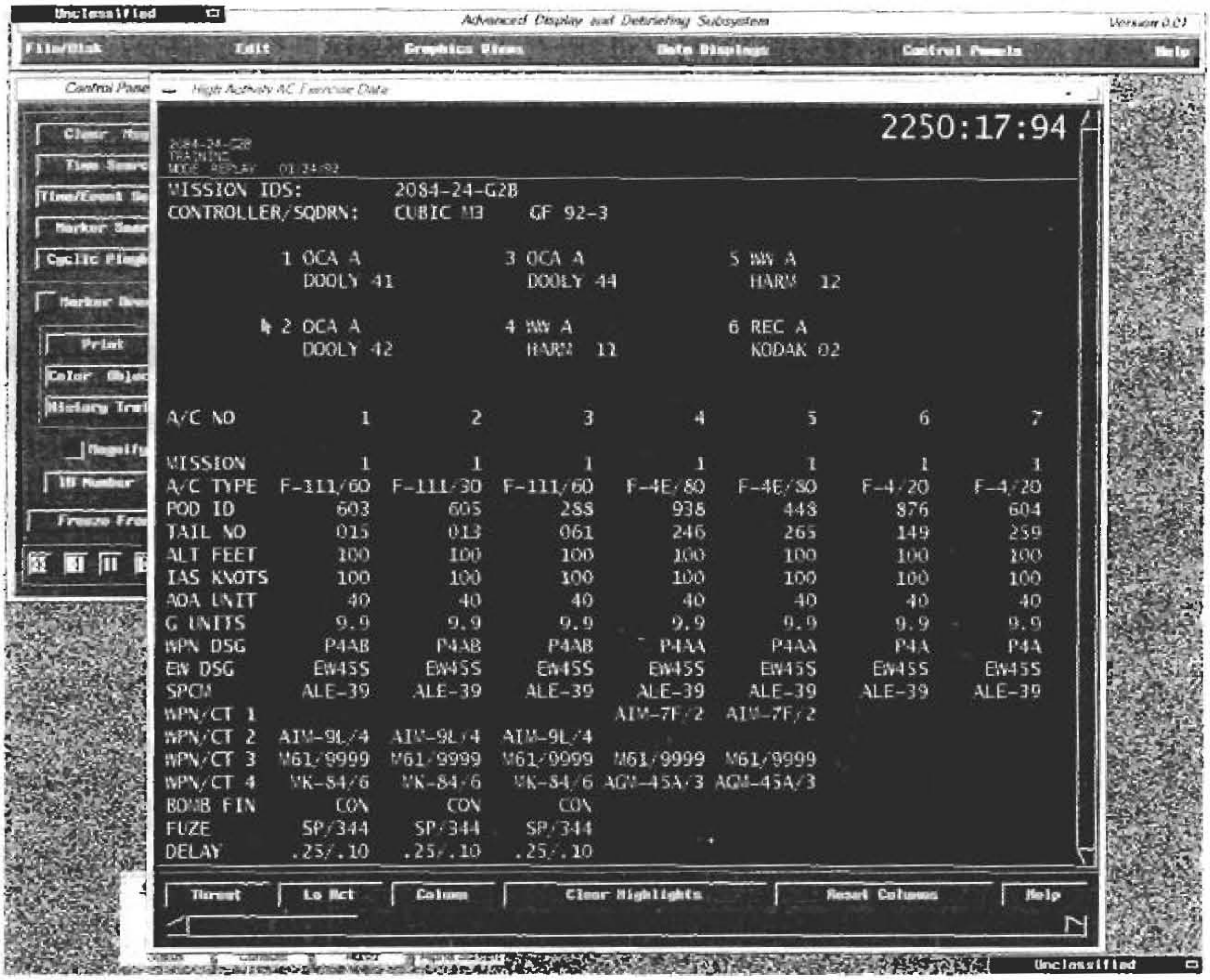


Figure 7-16. High Activity AC Exercise Data display.

7.2.5 Quick Look Display

Figure 7-17 illustrates and example of the Quick Look Display. This display has the same shortcomings identified for the ACM Flight Data display.

The control functions on this display appear to be logical and usable

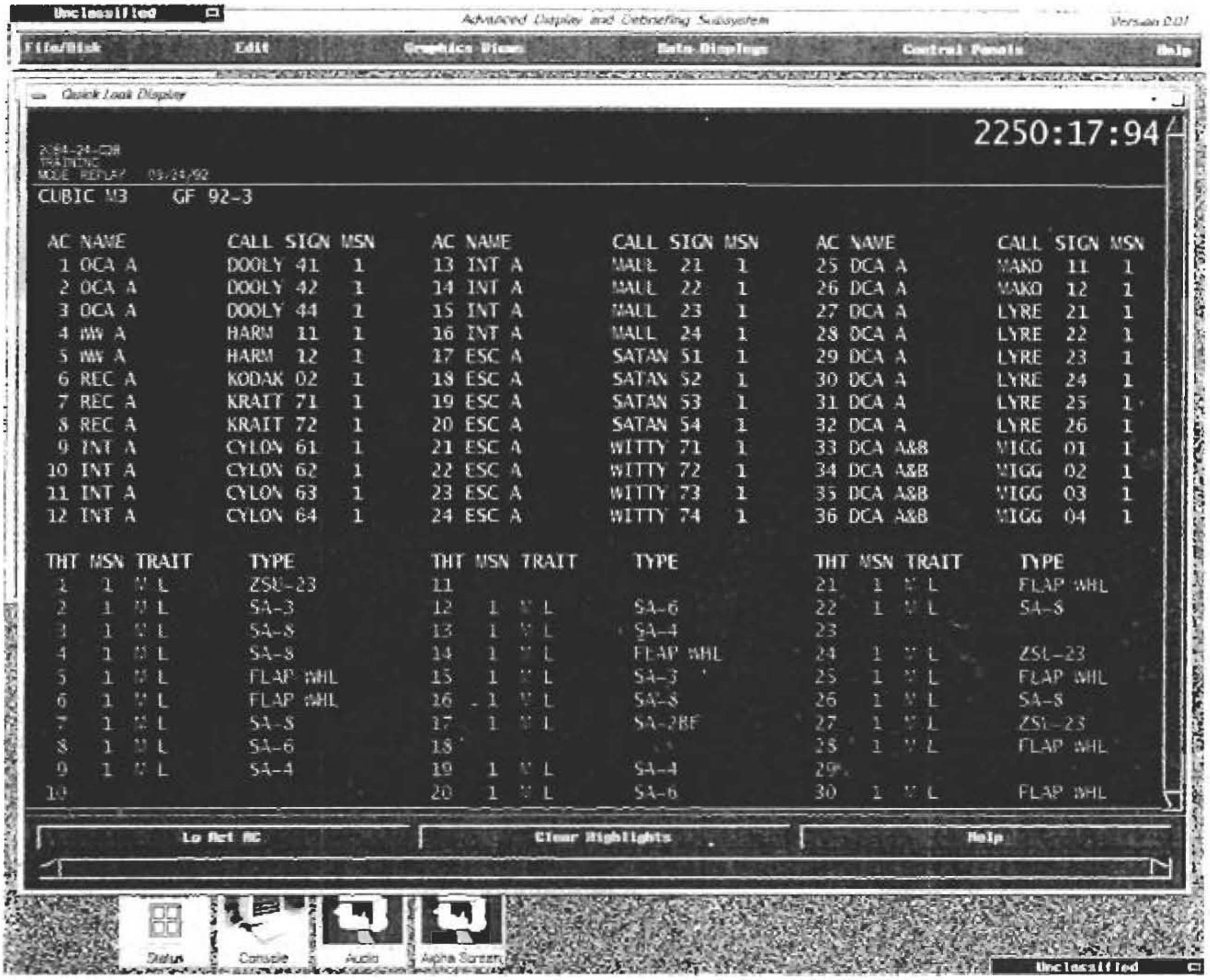


Figure 7-17. Quick Look Display.

7.2.6 Threat Data

Figure 7-18 shows an example of a Threat Data display. This display format has the same problems identified for the other data displays described above.

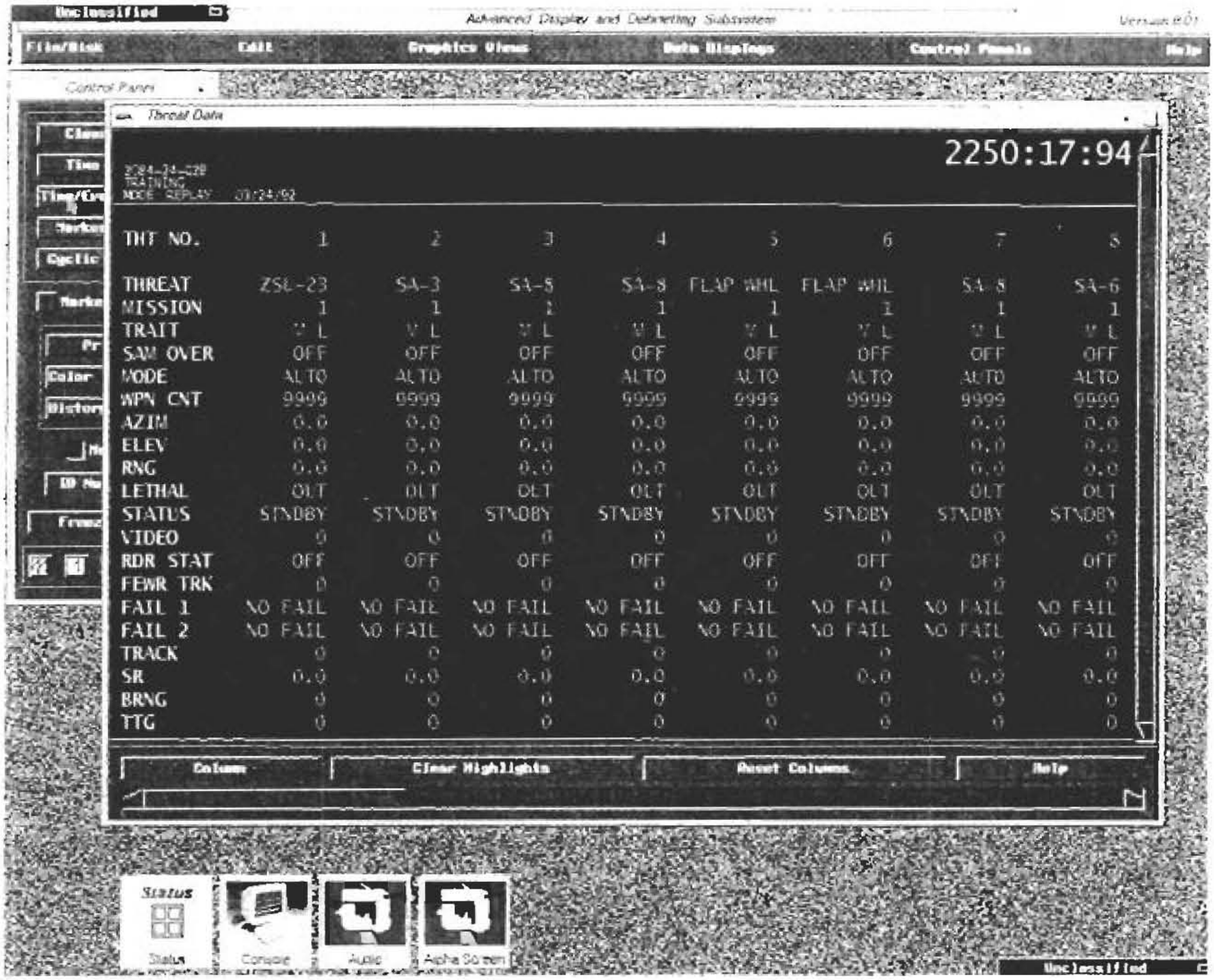


Figure 7-18. Threat Data display.

7.2.7 Range Status

Figure 7-19 shows an example of a Range Status display. This display format has the same color contrast problem identified for the other data displays described above. These deficiencies are less critical for this display since it is not used during ADDS exercises.

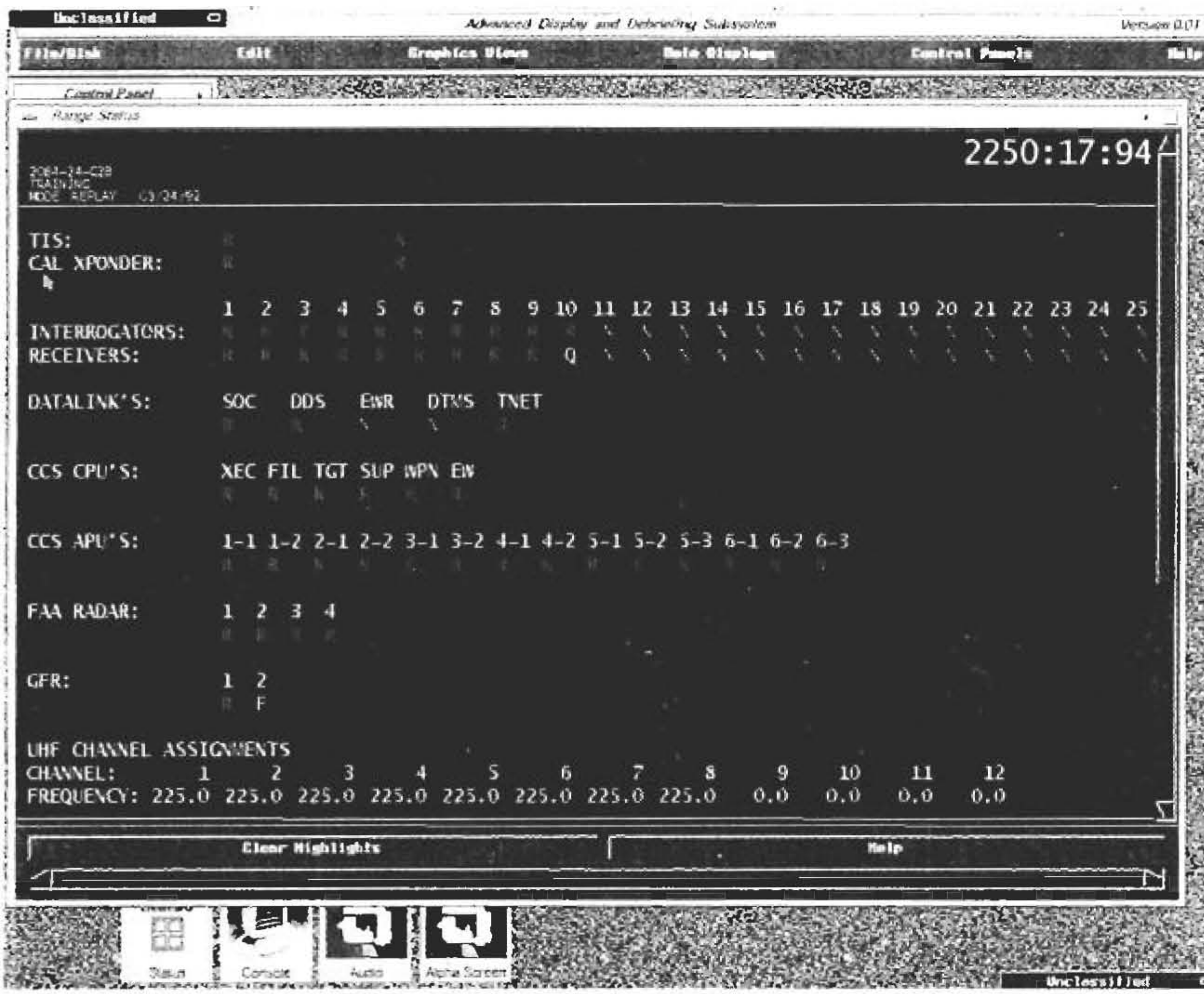


Figure 7-19. Range Status display.

7.2.8 Hazard Summary

Figure 7-20 illustrates an example of a Hazard Summary display. This display format is susceptible to the same color contrast problem identified for the other data displays described above. These deficiencies are less critical for this display since it is not used during ADDS exercises.

Figure 7-20. Hazard Summary display.

7.3 CONTROL/DISPLAY EXAMPLES

Figure 7-21 illustrates an ADDS screen showing a Live Control Panel, the Plan View Display and a pop-down menu. This ensemble of controls and displays is an example of an acceptable screen. However, this is not representative of the majority of ADDS default screen layouts. Figure 7-22 illustrates a common ADDS problem. Pop-up control panels tend to have a default locations which obscure displays that are currently in use. As shown in this figure, there is a large amount of non used screen area, but the pop-up Countermeasure Control panel is located on top of part of the Plan View Display.

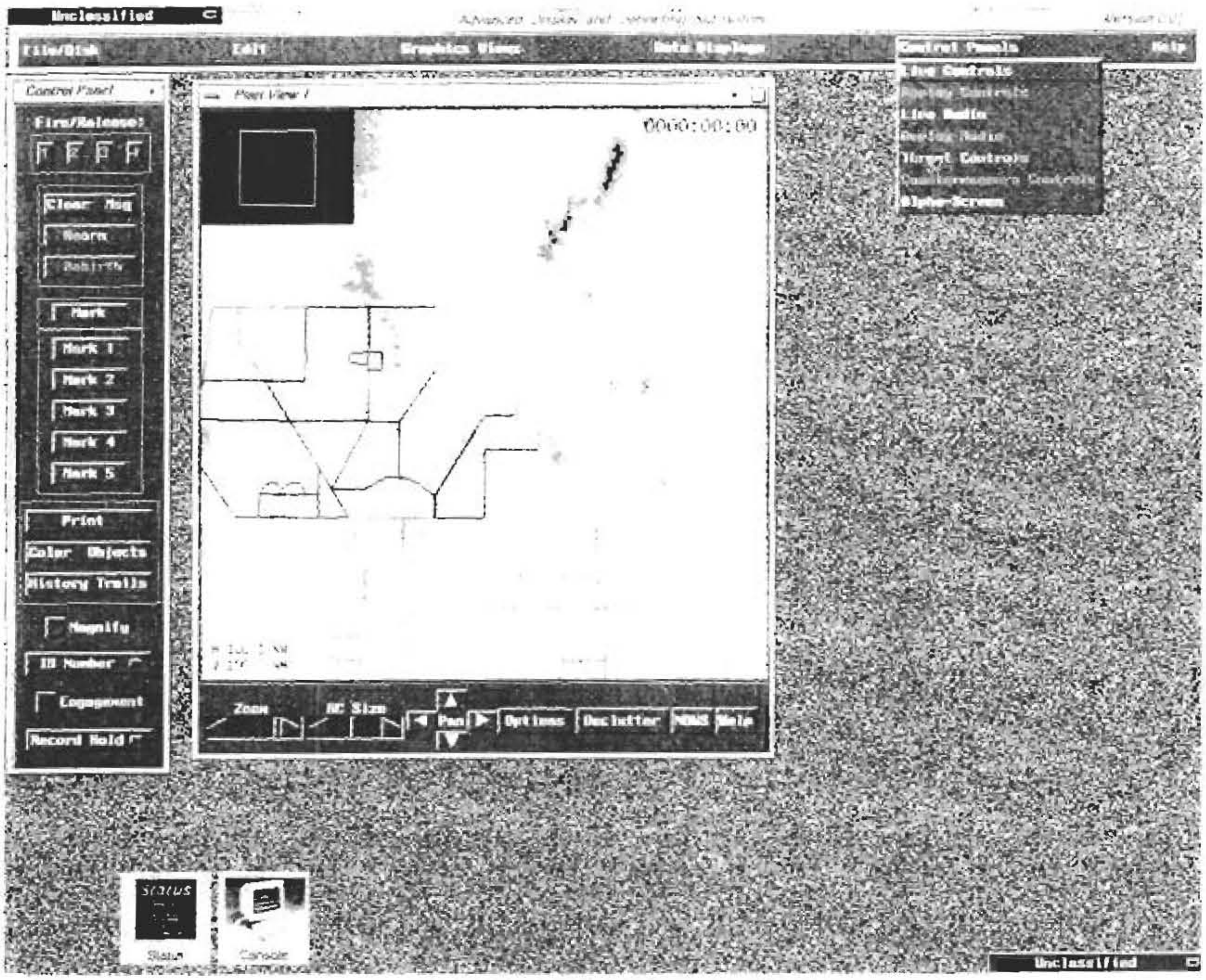


Figure 7-21. ADDS screen showing a Live Control Panel, the Plan View Display and a pull down menu.

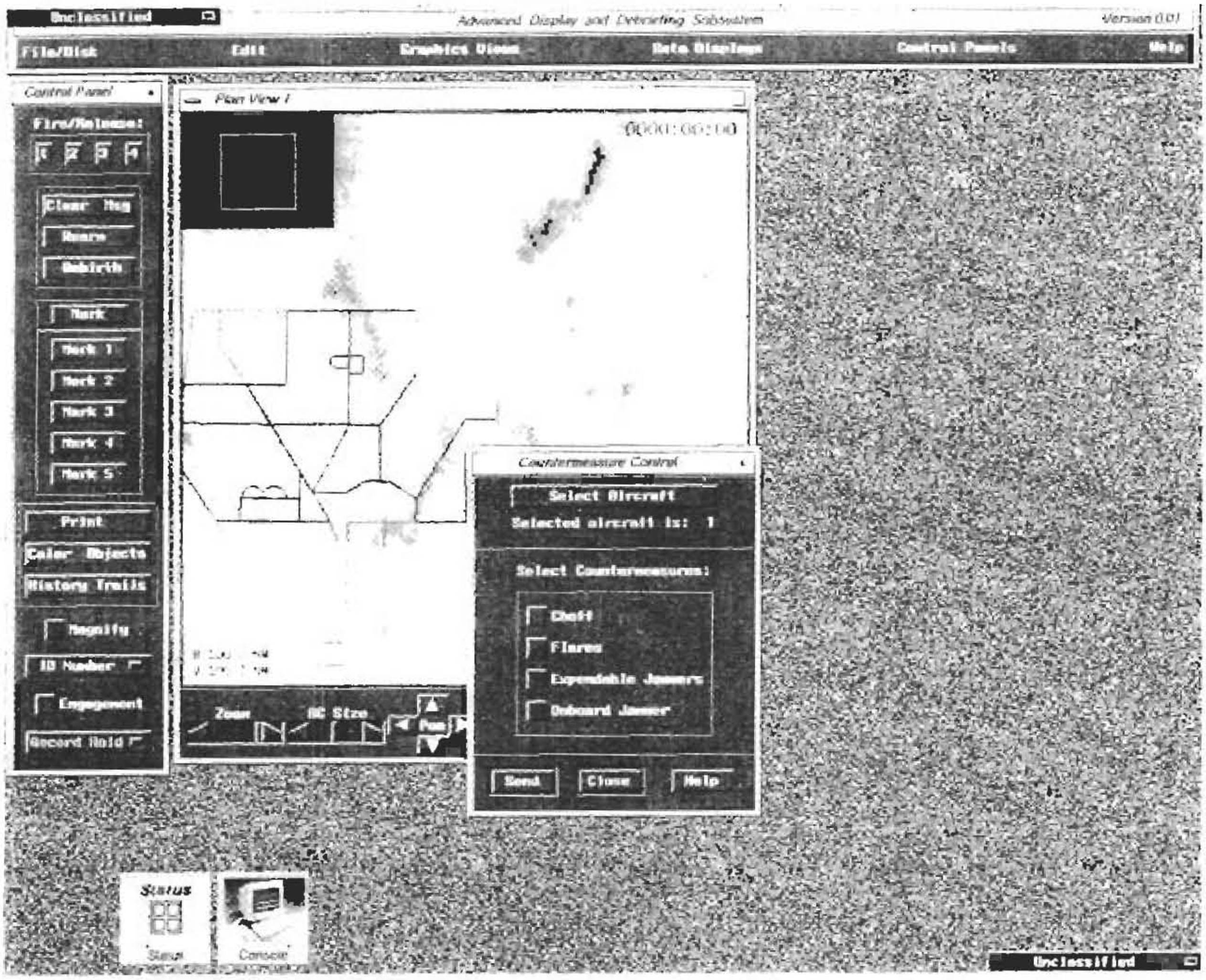


Figure 7-22. Countermeasures Control Panel occluding the Plan View display.

Figure 7-23 provides another example of this problem. The Threat Control and Number Panel are located on top of the Plan View display. As a result, they obscure the user view of the information that they are trying to change. This is poor design. Figure 7-24 shows that it is possible to have the control panels pop up in locations which do not obscure the display the user is modifying. ADDS adopted an overlapping windows design philosophy rather that a tiled window approach. Overlapping windows are acceptable for non critical applications, but they were a poor choice for ADDS.

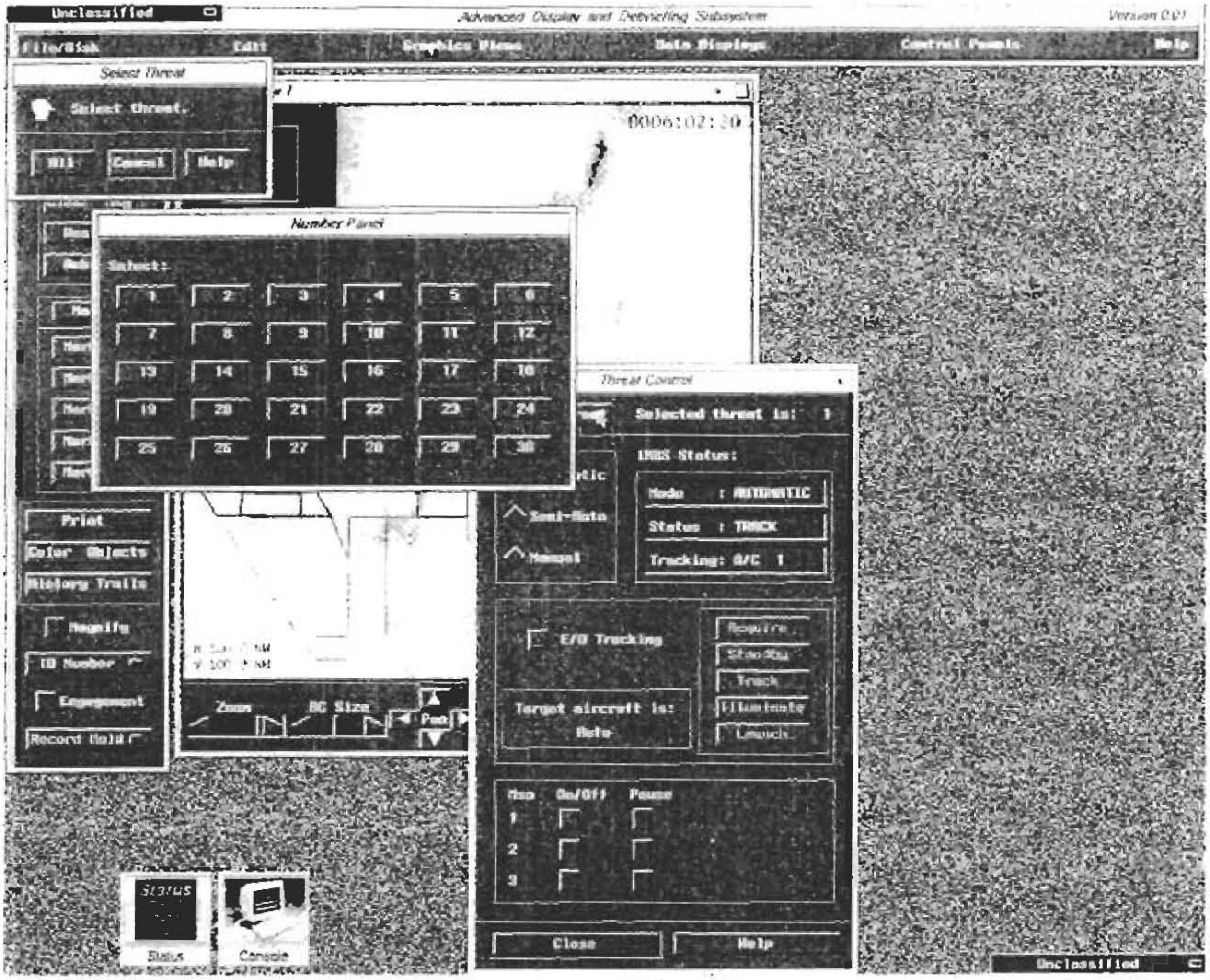


Figure 7-23. Example of a poor default arrangement for control panels.

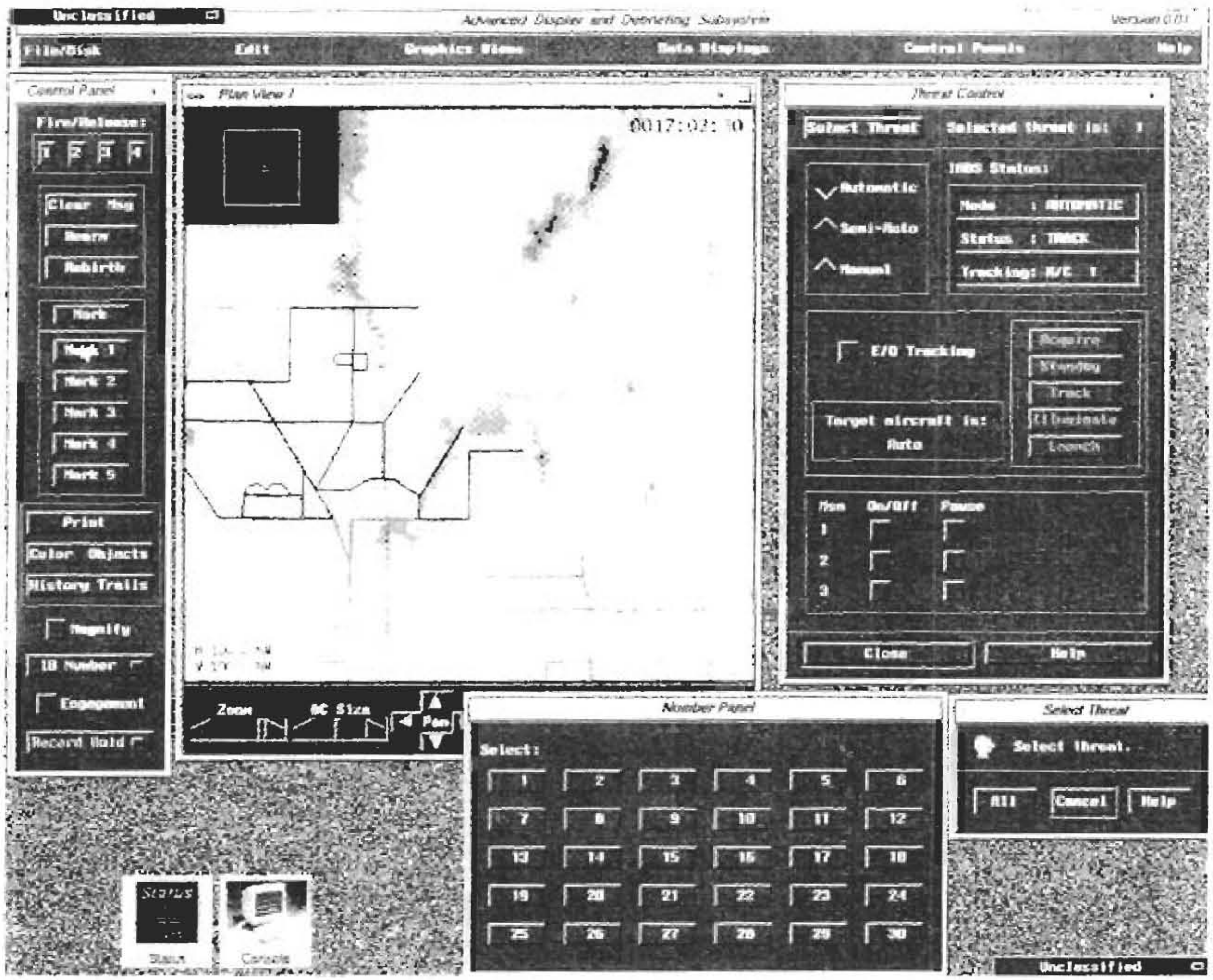


Figure 7-24. Illustration of a good default arrangement for controls panels.

Figure 7-25 provides another example of a poor default arrangement for control panels. In this color changing task, the Number Panel obscures the Plan View display. As a result, the user may not be able to see the color changes until the task is completed. In this example, there is a second problem. The default location of the controls panels requires the user to move the mouse continuously back and forth across the display. This introduces excessive and unnecessary mouse movement, and increases workload. Figure 7-26 illustrates a better default arrangement of controls panels which does not obscure the Plan View display and complies with human engineering guidelines. By following human engineering guidelines for sequential layout of controls and displays, mouse movement and workload is minimized.

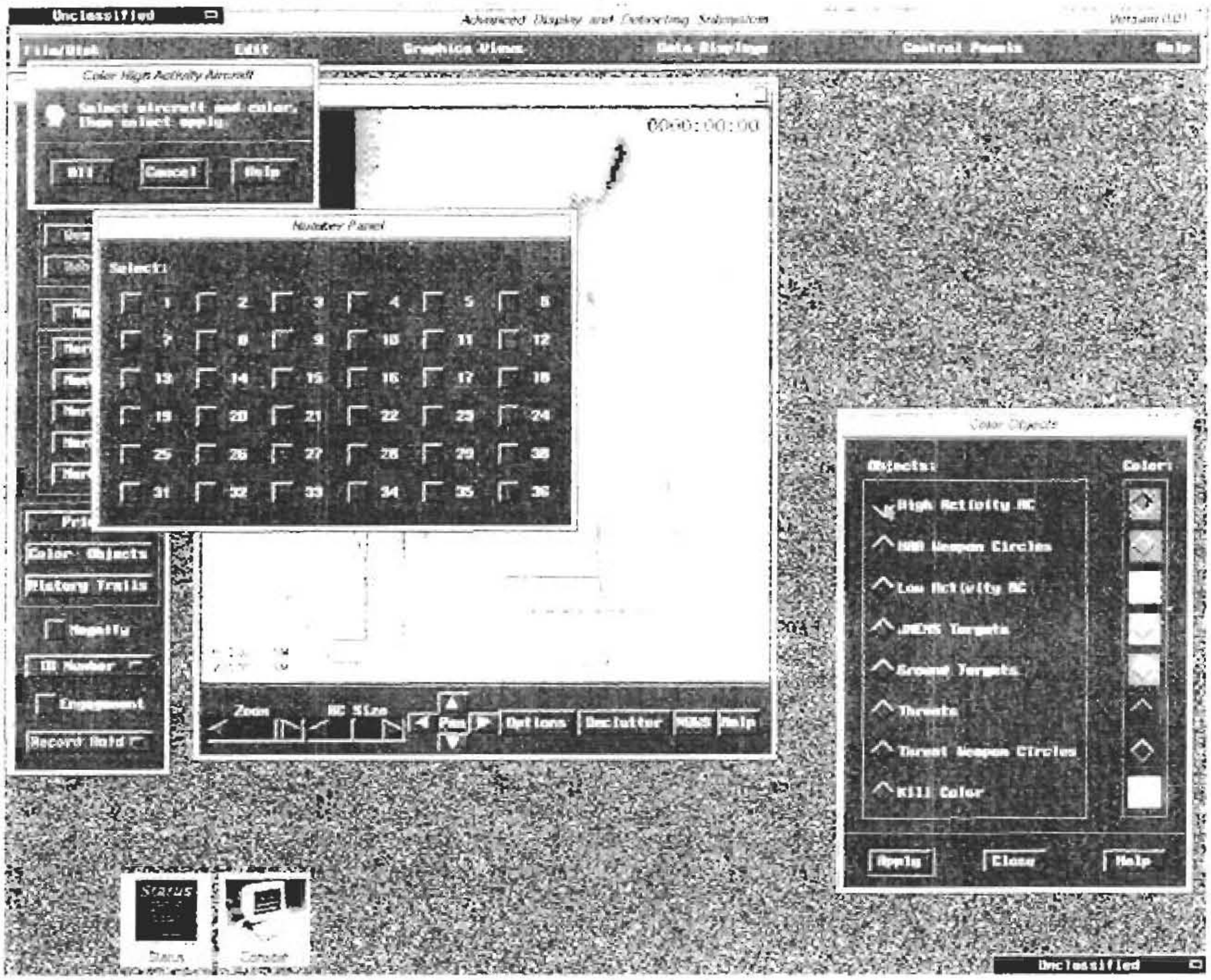


Figure 7-25. Example of a poor default arrangement for control panels.

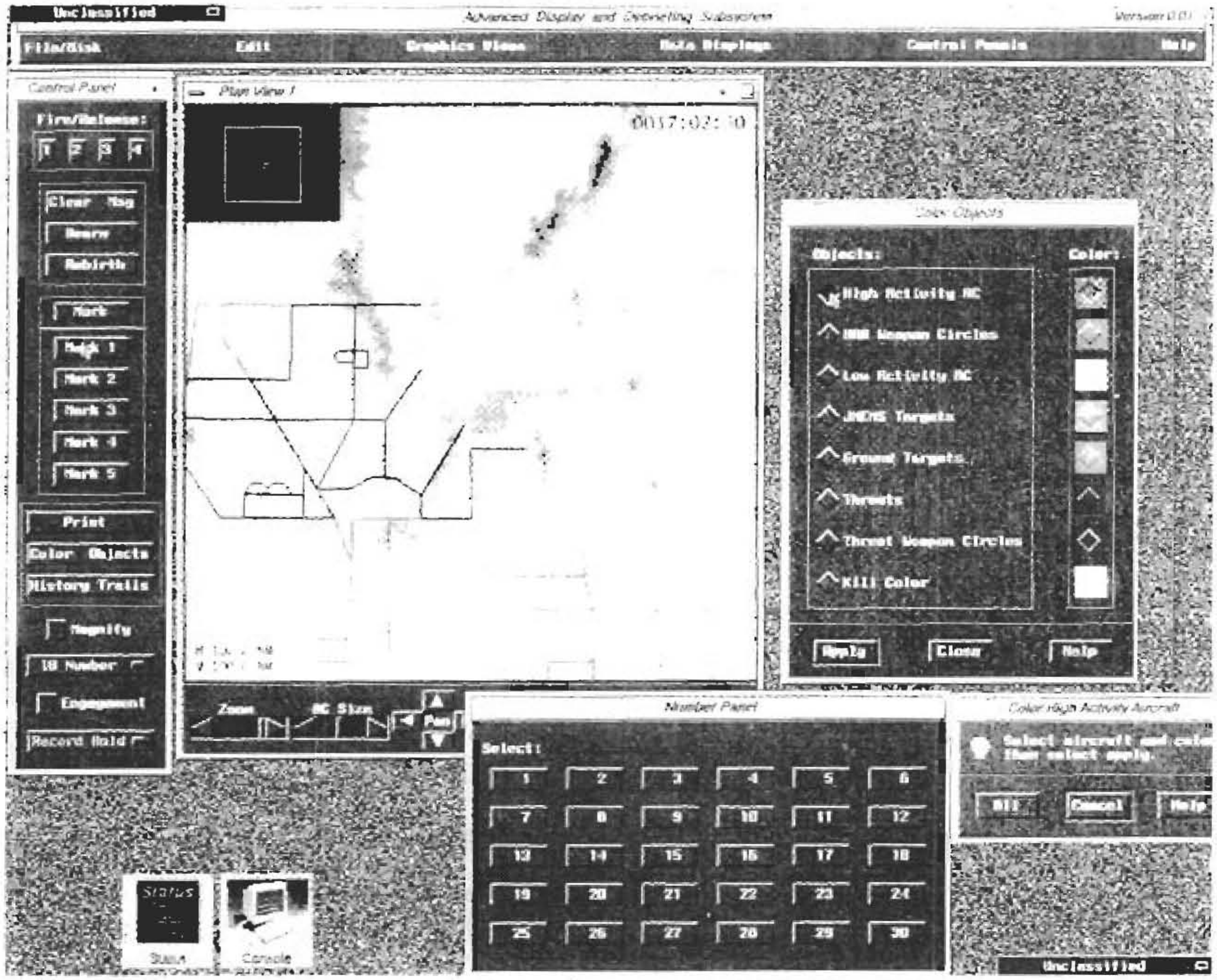


Figure 7-26. Illustration of a good default arrangement for controls panels.

8.0 OTHER ADDS DESIGN FEATURES

8.1 ERROR MESSAGES

Table 8-1 lists the basic ADDS error messages. From a human computer interaction standpoint, the structure and content of the error messages are both good and bad. The error messages provide a clear and unambiguous identification of the problem in concise, clear terminology, in accordance with the human computer interaction guidelines established for ADDS (See Appendix A). However, the error messages are incomplete. A properly developed error message should not only identify the problem, but, in accordance with the human computer interaction guidelines, should also suggest a course of action to correct the problem. The requirement to provide corrective actions in the error message is especially important for systems like ADDS where many users are essentially casual users. The typical user for ADDS does not use the system often enough to become familiar with procedures required to correct errors. Hence, it is necessary to provide appropriate guidance as part of the error message.

TABLE 8-1
ERROR MESSAGES

Message
Archive-8 mm-tape-write error
Archive-read-error
Archive-DTI-tape-write error
Restore-write-error
Restore-8 mm-tape-read error
Restore-DTI-tape-read error
DS-CD-ROM-read error
Terrain-data-base-file-read error
Terrain-data-base-file-write error
Terrain-data-base-selection-data-read error
Terrain-data-base-selection-data-write error
Object-image-file-read error
Object-image-file-write error
DS-configuration-file-read error
DS-configuration-file-write error
DS/LIS Communications Active

TABLE 8-1 (con't)
ERROR MESSAGES

DS/LIS Communications Inactive
CCS/DS Communications Active
CCS/DS Communications Inactive
Unable-to-read-COMS-load-file error
Mission/audio-data-write error
Mission/audio-data-read error
Audit-trail-file-read error
Audit-trail-file-write error
User-profile-data-read error
User-profile-data-write error
Tutorial-data-read error
Unable-to-access-DS-operating-system error
Vertical Parity Error
Message Label Error
Message-Word-Count Error
Vertical Parity Error ratio
Recording Started
CODS Data Error
End of Mission
Hard Disk Error
Hard Disk 25% Full
Hard Disk 50% Full
Hard Disk 75% Full
Hard Disk 95% Full
Hard-copy-disk-write error
Frame-Grabber-I/O error
RGB Printer Busy
Display-overload-graphics-degradation

8.2 ADDS USER MANUALS

The original Software User's Manual did not meet the intent of the document. It was not written for the typical end user, i.e., pilots. It has a lot of information which is of little value to the end user, and it is filled with computer programmer jargon. In addition, the document was highly repetitive across formats which hid the differences. The reader quickly gets bored and assumes that everything operates identically, which is not always the case. The repetitive nature also makes the document unnecessarily long. The manual is fairly complete and probably covers all classes of ADDS users to some extent, but it is not really usable for any. It is not possible to create a one manual fits all. The manual is much more oriented to a system software administrator than a pilot.

There are a lot of references and guidelines on how to write useable user manuals based on human engineering principles. There is probably a need for two user manuals; an overview and frequently asked questions, and a comprehensive guide and reference. The user's manual needs a hierarchical structure. The figures and text need to be same page or facing pages for ease of reference. The Red Flag manual uses this general style of format. Common basic principles should be described up front. Most importantly, it must be written from the user's perspective, not the software engineer's perspective.

8.2.1 On-line Reference

One option that might enhance the utility of the user's manual would be to place the appropriate manual, including procedural illustrations, on disk, i.e., on-line. The user could click on an icon and access the document. The document should be developed using hypertext principles so that related topic areas are linked. This would permit the user to jump to related information by simply clicking a "hot word" with the mouse. A disk-based version of the user's manual also has merit because it is easier to modify and keep updated.

It is not recommended to host an on-line reference directly on the ADDS. The primary reason is that, in a GUI environment, calling up help or an on-line reference usually hides what you have a question about.

8.3 WORKSTATION DESIGN

The previous debrief system console design used a "C" configuration. This configuration allows the operator to view three different displays with minimal movement. However, this configuration may lead to cramped seating arrangements when the system is used by two or three operators. Because the ADDS type B console is designed to be used by three operators at one time, an alternative configuration was sought. The new design employs a single six foot table with the three monitors on swivel bases (Figure 8-1 and Figure 8-2). The monitors can be positioned to form a "C" configuration, or they can be repositioned in a straight line for two or three operators. (See Figure 8-3)

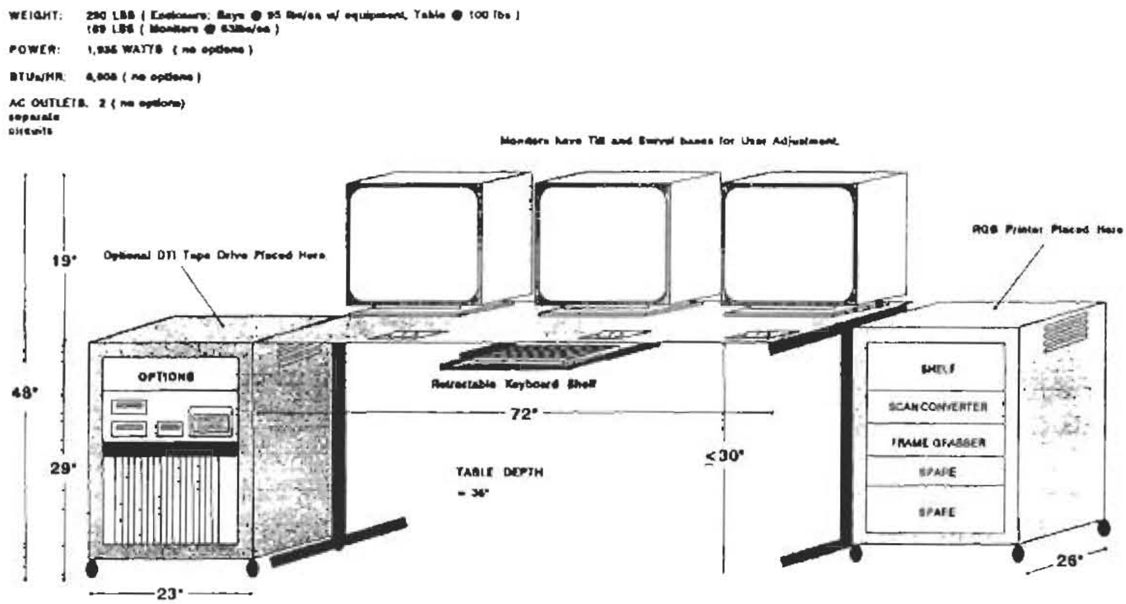


Figure 8-1 Illustration of the basic Type B configuration.

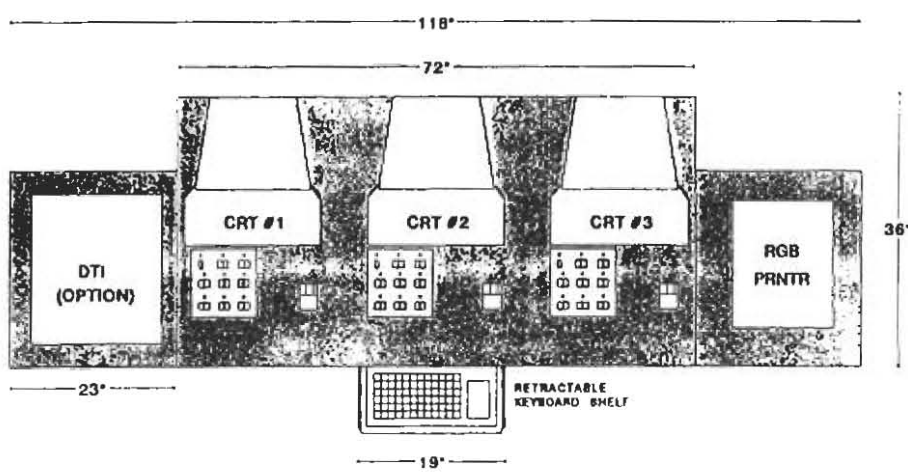
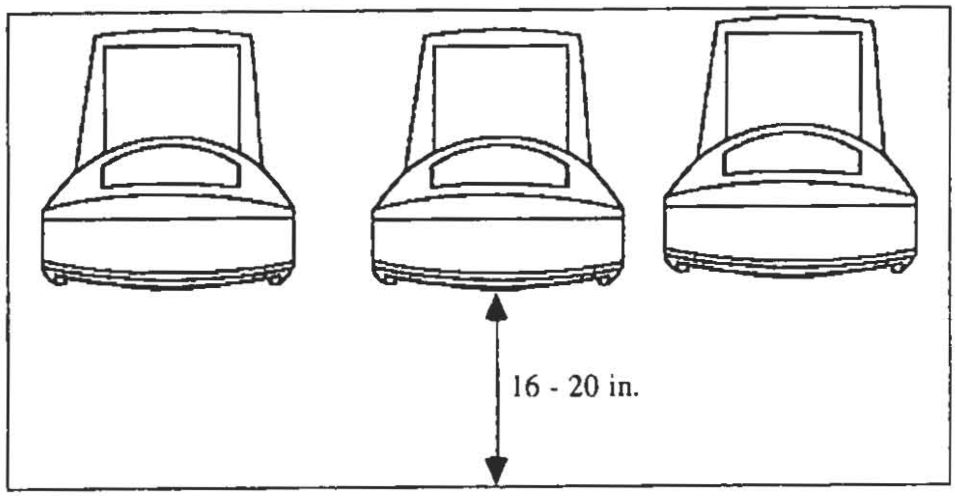


Figure 8-2 Illustration of the Type B layout.

This new table design meets military standards for viewing distances and angles, weight support, comfort and clearance. Specifically, the ADDS console design meets MIL-STD-1472D specifications for workstation design. Because some debriefing tasks require the operator read from hardcopy, an area on the ADDS table top was preserved for place documents and/or manuals.

Positioning for three users.



Optimal positioning for one user

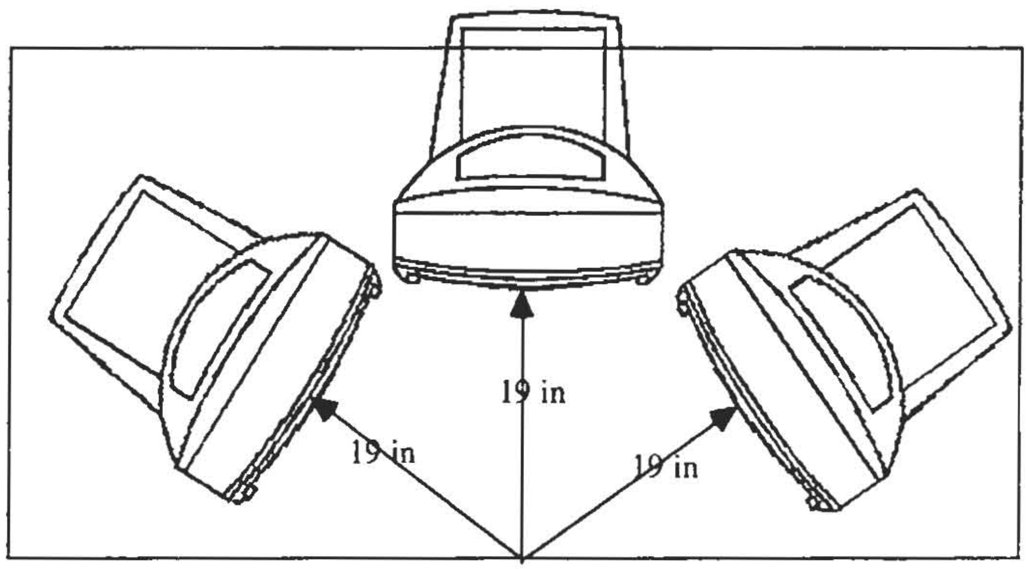


Figure 8-3. Layout options for one versus three operators in the Type B configuration.

9.0 TEST AND EVALUATION SUMMARY

The goal of the human engineering factory qualification test (FQT) was to verify compliance and expected outcomes for each detail of the design. This section provides a summary of the process and conclusions for this test.

9.1 HUMAN FACTORS FACTORY QUALIFICATION TESTING

The human factors Factory Qualification Tests for the Advanced Display and Debriefing System included 9 procedures with between 5 and 32 steps in each procedure. The more complex test procedures were for the menu checklists (32 steps), graphic displays (28 steps) and alphanumeric displays (18 steps). These procedures were applied to Type A configuration, one graphics display and one alphanumeric display, the Type B configuration, three graphics displays, and Low-speed Interface System (LIS).

The primary test platform was the Type A configuration. Only differences were tested on the Type B configuration. In addition, the primary test mode was the replay mode, which minimized conflict with other parallel, ongoing tests. Only menu differences had to be tested for the live mode plus several display elements which are only available in the live mode.

The test procedures are applied to each instance of the test item. For example, the 32 step menu checklist was applied to each and every unique menu in the system, approximately 30-35 different menus. The first instance of each test was verified against relevant MIL-STD-1472D requirements, so that the specific non-compliance requirement could be identified. On the average each test step referenced 6 or 7 paragraphs in MIL-STD-1472D.

9.2 SUMMARY OF TEST RESULTS

Many of the same problems and non-compliance issues observed previously during the evaluation of a prototype ADDS at Miramar Naval Air Station still existed at FQT. There was essentially a small set of recurring non-compliance issues. While there were a large number of identified problems, they probably boiled down to only about a dozen unique problems. Examples of common recurring problems were insufficient contrast and default locations for menus in the GUI.

Probably the most frustrating aspect of the test results was that the cost and time difference between how the contractor implemented the design and a good design is negligible. For example, it requires no more effort to put a pop-up menu in the right place as the wrong place. There were also several instances where selections varied in location from menu to menu and all the zoom controls operated backwards. These non-compliance issues should have been easily avoided. Only two, or at most, three deficiencies were bigger programming issues. These included tying the HUD size to the zoom control and overlapping of aircraft identifiers. A couple of deficiencies were dictated by the system specification because of commonality to the current system. These are issues which will need to be addressed in the next generation ADDS.

Overall, the FQT demonstrated that the ADDS design is not bad, but it just as easily could have been very, very good.

10.0 CONCLUSION

The ADDS project represents the next evolution of debriefing capabilities to enhance aircrew proficiency training. It provides a significant enhancement in functionality, as well as a state-of-the art user interface. While there are a number of human engineering and capability shortcomings yet to be resolved, it is still a major improvement over the current DS design. The human engineering problems in the ADDS design are in part due to general programmatic problems, but also a number of process deficiencies in the human engineering activities that were implemented on the project. This report has tried to provide an objective human engineering evaluation of the ADDS user interface, provide lessons learned, identify process problems and make recommendations to guide future upgrade or development efforts. These findings should help to avoid similar problems on future projects.

As stated earlier, despite its human engineering deficiencies, the ADDS provides a generally good user interface, maybe better than could be expected given the problems that were encountered. However, with an improvement in process and better adherence to human engineering principles, the contractor could have developed an excellent user interface with little increase in effort or cost.

The ADDS function will continue to be improved through upgrades or new programs, and as new technology becomes available. It is expected that it will eventually be integrated into the Distributed Interactive Simulation (DIS) environment. At that point, it will be necessary to address updating the CCS, in addition to the DS. A reevaluation of the entire debriefing system will provide the opportunity to address all enhancements desired by the users. While ADDS is a major element in enhancing tactical aircrew training effectiveness, other elements of the total debriefing system have a significant impact on the relative performance of ADDS.

APPENDIX A

ADVANCED DISPLAY AND DEBRIEFING SUBSYSTEM (ADDS)

HUMAN COMPUTER INTERFACE GUIDELINES

1.0 INTRODUCTION

This appendix is a tailored version of the draft DoD Human Computer Interface Guidelines developed for guidance on the ADDS program. It is provided in this report because it represents a good baseline design guidance for future display and debreifing systems projects using a graphical user interface.

1.1 PURPOSE

The purpose of this style guide is to provide a common framework for Human Computer Interaction (HCI) design and implementation. Through this framework, the long-term functional goals, objectives, and requirements of the HCI will be defined and documented. Interface implementation options will be standardized,, enabling all DoD applications to appear and operate in a reasonable consistent manner.

Specifying the appearance, operation, and behavior of DoD software applications will support the following operational objectives:

- Higher Productivity - People will accept and use what is easy to understand if it aids them in accomplishing their assigned tasks without confusion or frustration.

- Less Training Time - Standard training can be given once for all applications, not once for each application.

- Reduced Development Time - It will no longer be necessary to design a complete HCI for each component. The basic appearance and behavior of the interface will be specified by this style guide.

1.2 SCOPE

This documentation begins by defining frequently used terms pertaining to HCI and windowing systems. The rest of the document addresses functional requirements and operations that should be reasonably consistent across the entire user interface. The emphasis is on HCI considerations for features and functions applicable to DoD applications (e.g., system start-up, security issues, map graphics). General HCI considerations described in commercial style guides are only discussed if there is some value to be added to the commercial style guide presentation.

1.3 INTENDED AUDIENCE

The primary audience for the DoD HCI Style Guide is program managers and designers of systems and applications. The secondary audience is users and software maintainers who are interested in the general design of the interface.

1.4 DESIGN GOALS

DoD application development should achieve the following objectives:

- Applications should be designed to meet the specific requirements of the user. Above all, the functionality to meet those requirements must be provided.

- All applications should be consistent with the interface guidelines specified in this document.

- An application should provide rapid access to all its functions. one way to ensure this is to avoid unnecessary menus and long selection lists that force users to "page" through all entries.

- An application should be flexible. For example, multiple methods (e.g., direct command line entry, menus, tree diagrams, mnemonics and keyboard accelerators) should be provided to access a function.

- Explicit action should be required to perform any act that could result in irreversible negative consequences (e.g., quit without saving).

- The keyboard and pointing device should be virtually interchangeable. As a minimum, users should have a choice of input devices for scrolling, map manipulation, and invoking or terminating an application.

- With a few exceptions (e.g., map graphics applications that are difficult to support without color), an application's interface should not depend on color to communicate with the user. Color should provide additive information content to the interface, not dominate it.

1.5 ASSUMPTIONS

In writing this style guide, the following assumptions were made:

- The user will be interfacing with message handling system, COTS software (e.g., data base management systems, word processing packages and spreadsheets) and Government-off-the-Shelf (GOTS) applications.

- A Motif compliant window manager will be provided as part of the base window environment (which will typically come bundled with the operating system). Applications will not require modifications to the base window manager.

- All new systems developed after 1991 by DoD organizations that participate in the Common Operating Environment (COE) Working Group will use Motif. Existing applications may continue to use Motif, Open Look, or both.

- The application design requirements specified in this style guide will be supported by standard DoD workstations and tactical ADP environments. Applications will be designed to take advantage of today's technologically advanced workstations and the windowing capabilities of X Windows. The DoD HCI will be implemented on a variety of workstations. For example, some workstations will have color displays and others, monochrome. Workstation configurations will include various keyboard layouts, and workstations will be equipped with various amounts of random access memory and central processing unit power.

- Ultimately, all workstations will be equipped with color monitors and a two or three-button mouse (or equivalent pointing device).

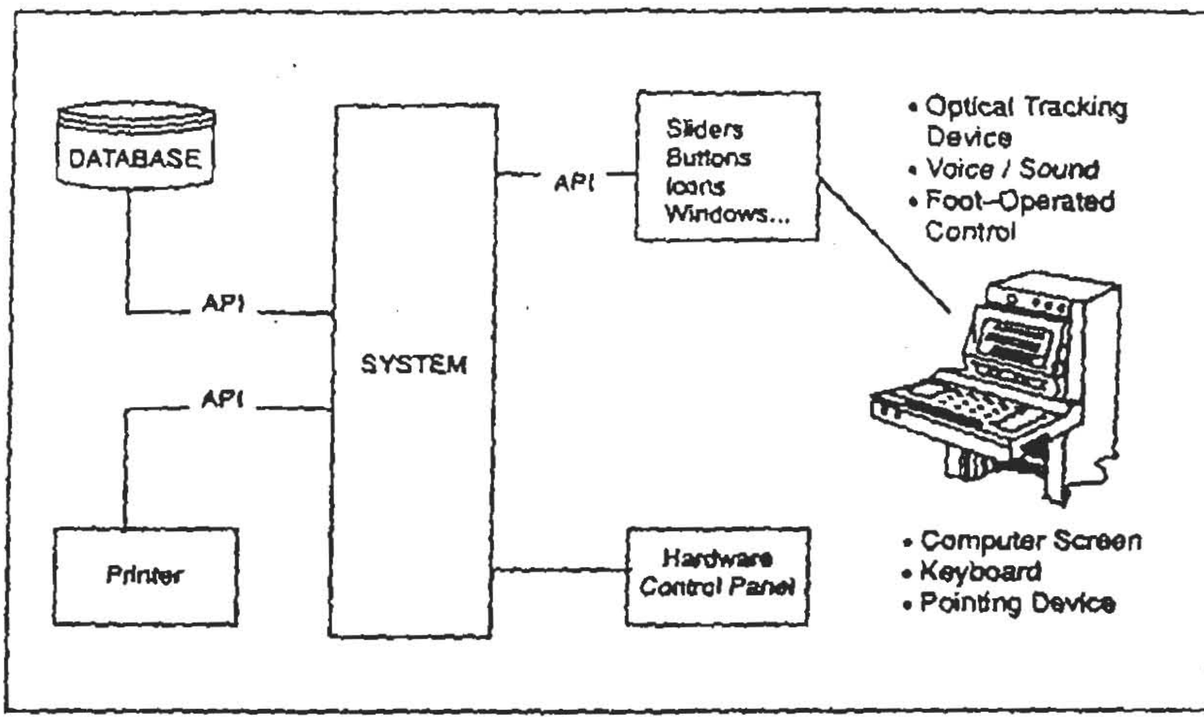
- The standardization of the DoD HCI will occur gradually as new systems are developed. During the transition, users will have to deal with new applications that comply with this document and existing applications that do not. Retrofit of applications to this style guide is not required.

2.0 DEFINITIONS

Before addressing the DoD HCI, it is important to develop a common understanding of essential elements and terms that will be referred to in this document and in discussions pertaining to HCI standardization. This section provides the necessary definitions.

2.1 HUMAN-COMPUTER INTERFACE

The HCI comprises the objects and actions presented to the user as a means of communicating with applications. It pertains to all aspects of system design that affect a user's data handling and decision making processes (See Figure A2-1). HCI includes, but is not limited, to the following items:



A2-1. Example an of HCI System

- The look and feel, or style, which guides the <u>appearance and behavior</u> of the interface. The look of the interface is what the user sees on the computer screen. This includes colors, buttons, menus, and the general appearance of the windows. The feel of an interface involves the interactions of a user with what is seen on the screen to accomplish the desired function.

- Suppose, for example, that a person uses the cut function in a word processing application. The objects, menus, and windows seen on the computer screen make up the look of the interface. The actions required to perform the cut function (mouse buttons and keys pressed, commands entered) and the corresponding reactions of the computer software make up the feel of the interface.

- Physical interaction devices (e. g., displays, keyboards, and pointer devices such as mice and roller balls).

- Graphical interaction objects (e.g., windows, icons, buttons, and scroll bars).

- Other means of interaction between the user and application (e.g., <u>touch screen or voice</u>).

- Environmental factors, such as proper (or improper) illumination, seating, work place management, keyboard layout, display contrast, and symbol size.

- The <u>data handling procedures, data storage method</u> (including paper files and forms), <u>and data processing logic</u>.

- Hardware such as workstations and printers.

- The application program interface (API); that is, the means by which an application designer enters and retrieves information.

The DoD HCI Style Guide will not address all the preceding HCI elements (e.g., hardware and environmental factors), but all are included to present a complete definition. The DoD HCI Style Guide is primarily concerned with standardizing the look and feel of the user interface.

2.2 SYSTEM DEVELOPMENT ENVIRONMENT

The system development environment is the set of industry and DoD standards, guidelines, and products specified for use in applications development. it includes software development tools, common libraries, and standard interfaces for use in developing DoD software applications, and it provides guidance on various phases of software development.

2.3 APPLICATION PROGRAMMING INTERFACE

The API is a collection of. library routines used by an application designer to create, manipulate and delete objects (e.g., scroll bars, menu panes, and buttons. APIs are usually designed to implement a particular GUI and can therefore affect application portability between GUIs.

2.4 FUNCTION

A function is part of an application that provides a specific action or effect (e. g. , cut, paste, save). Functions are often represented on the screen as menu options or buttons.

2.5 GRAPHICAL USER INTERFACE

A GUI is the specification for the look and feel, or appearance and behavior, of an application. This includes the types of basic objects the user sees and the basic ways in which the user interacts with those objects. More specific aspects of appearance (e.g., size, color, and placement of a window) may be left to the application developer, but the DoD HCI Style Guide will offer guidance in some of these areas. Several examples of GUI specifications follow:

- The basic appearance of application windows
- The types of objects the user can expect to see (e.g., buttons, scroll bars, and sliders)
- How to move through data using scroll bars
- What menus look like and how to use them

- How to select and operate on text and icons.

2.6 LOG-ON

Log-on is the process by which a user enters an identification and/or password for authentication at the user terminal. once this step is successfully completed, a session is initiated. There are several approaches to log-on:

1) Unitary log-on, where the user enters an initial identification and password and only those resources that the user is allowed to access are made available. No additional identification or passwords are needed during the session.

2) Password-unique log-on, where a new password is needed for each application or set of applications the user tries to access during the session.

3) Password/ID-unique log-on, where the user is required to enter an identification. and a password for each application or set of applications accessed during the session.

2.7 SCREEN

A screen (also called a computer screen or display) is the physical surface of a workstation upon which information is shown to users. The screen is considered the entire display surface on which the windows of a user's environment are seen and is sometimes referred to as the desktop workspace. Through the screen, tools can be accessed and work is placed in view.

2.8 SESSION

A session is the interaction between the user and the computer from the initial workstation log-on to log-off.

2.9 SYSTEM/COMPONENTS/PRODUCTS

A system is the entire suite of hardware, network components, and software. The system is made up of one or more components, which may be a combination of COTS and/or

GOTS products and developed applications software.

2.10 WINDOW

A window is normally a rectangular area on the computer screen within which an application displays information or receives data from the user; within which options are displayed; or through which messages are displayed to, and acknowledged by, the user. An application may divide a window into horizontal or vertical subareas, called panes. Windows may appear side by side (often called tiled or mosaicked) or overlaid. overlaid windows are referred to as stacked windows. The window stack consists of the windows that are overlaid on the screen, like sheets of paper stacked one on top of another. The ADDS is a stacked window system.

3.0 INPUT DEVICES AND PROCEDURES

This section will highlight the procedures used to communicate with system applications using a pointing device or the keyboard. For a more detailed explanation of the input procedures, consult the OSF/Motif style guide.

3.1 POINTING DEVICES

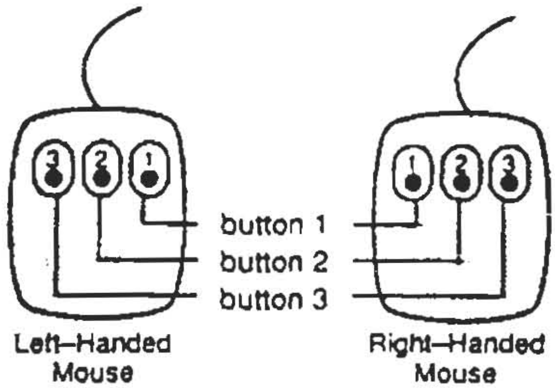
A pointing device (e.g., mouse, trackball, tablet, or lightpen) allows a user to navigate rapidly around the screen and to specify and select objects for manipulation and action.

3.1.1 Mouse Button Definitions

The mouse button operations are defined as follows (Figure A3-1):

- Press - Pushing the mouse button and holding it.
- Release - Letting up on the mouse button.
- Click - Quickly pushing and releasing a mouse button before moving the pointer.
- Double-click - Pushing and releasing the mouse button twice quick succession.
- Move - Sliding the pointer without pushing any mouse buttons.
- Drag - Pushing the mouse button and holding it while moving the pointer.

The phrase "dragging an object with the mouse" means moving the pointer; over the object, pressing the SELECT button on the mouse, moving the mouse until the object is in the desired location, and then releasing the SELECT button.



Motif

3-Button Mouse	Name	Function
button 1	Select	Select objects: display pull-down menus
button 2	Drag	Manipulate objects (e.g., moving, dragging)
button 3	Custom	Display pop-up menus; application-specific functions

Figure A3-1 Mouse Button Assignments.

3.1.2 The Pointer

A key element of the workspace is the pointer. Objects on the screen can be manipulated by positioning the pointer over the object and pressing the mouse buttons appropriately. The user moves the pointer by moving the mouse.

Mouse pointer shapes provide visual clues to the activity within a window. For example, an hourglass or watch shaped pointer could be used to indicate that an application is busy, and a crosschair could be used when sighting on a graphics display. The pointer should remain where it is placed until it is moved by the user.

3.2 THE KEYBOARD

The keyboard is interchangeable with the mouse to allow a user to interact with the application by using a pointing device, the keyboard, or both. Although keyboards vary greatly in the number and arrangement of keys, most keyboards include the following:

- Alphanumeric Keys - Letters of the alphabet, numbers, punctuation symbols, and text-formatting functions (e.g. Tab, Return, Spacebar).

- Modifier Keys - Keys (typically Shift, Control and Alt) that modify or qualify the effect of other keys (or pointing device inputs) for as long as they are held down).

- Navigation Keys - Keys that are used to move the cursor (arrow keys, home, page up/down).

- Function Keys - Keys (typically F1 through F10) provided for extra or general functions.

- Special-Purpose Keys - Keys that have a special function, such as Help, Delete, Escape, Backspace, Insert, and Enter.

Because a keyboards differ and function keys vary according to application and GUI, a function should not be solely available through a function key.

3.3 INPUT FOCUS

Usually, several application windows are ready to accept input, but only one window, the one with "input focus", actually receives the user input. The window with input focus is known as the active window and is the window where keyboard input appears and pointer device inputs apply.

Most interfaces provide explicit input focus; that is, the user (or application) performs an action (e.g., typing appropriate keyboard accelerators, clicking pointer inside a window, or moving a window to foreground through menu selection) to assign input focus. Implicit focus (the focus is automatically assigned to the window containing the location cursor) is often provided as an option.

A window with input focus should be identified in a consistent manner. The default behavior should be to move the window to the front of the workspace and highlight the window in some fashion, such as highlighting the window frame or title bar.

4.0 BASIC SCREEN GUIDELINES

This section provides guidelines for log-in, log-off, the initial screen display, and the management of workstation resources.

4.1 WORKSTATION LOG-ON

A standard workstation log-on screen should be developed for each application (See Figure A4-1). Rather than continually displaying the log-on screen or any other display on an idle workstation, it is suggested that all workstations implement a screen saver, which is activated when the workstation has been idle for three minutes and is deactivated whenever any new activity is detected.

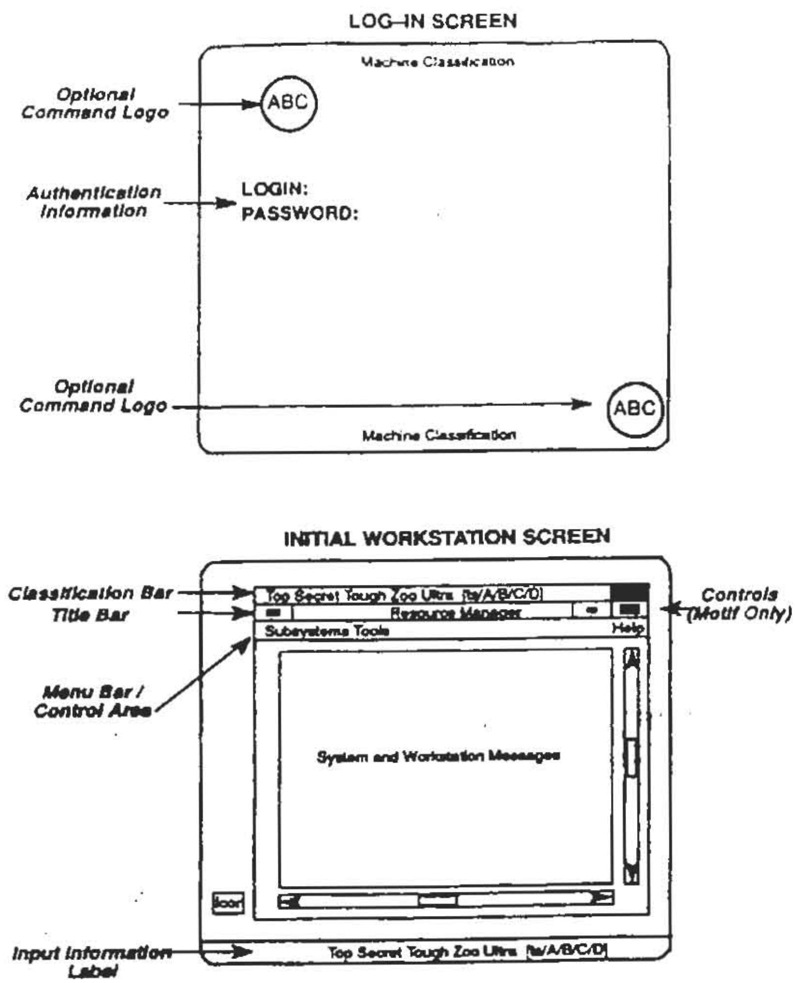


Figure A4-1. Example of a log-in screen.

Guidelines for developing a log-on procedure are as follows:

- The authentication information should be a combination of name, password, and/or other identification information required before a user can access system resources.

- Each prompt for the user's name, password, etc. should be clearly labeled and displayed on a separate line.

- Error messages should be clearly displayed at the bottom of the computer screen along with guidance on how to correct the error. Error messages or help generated during the log-on sequence should not convey information that could assist someone in breaking into the system.

When displaying a machine classification on a workstation accredited for compartmented mode operations, the lowest classification applicable to all possible users of the workstation should be displayed. When displaying a machine classification on a workstation accredited for system high operations, the system high banner should be displayed.

4.2 ADDS LOG-ON

The workstation log-on will automatically load the ADDS application software.

4.3 APPLICATION LOG-OFF

Application log-off exits an application and closes all windows associated with the application. Application log-off is accomplished by selecting the Exit function in Motif applications such as ADDS. In the event that changes haven't been saved, the user should be asked to confirm the quit, save modified data or cancel the request.

4.4 ICONS

An icon is a graphic representing a window that has been closed while its supporting software is still active. The default location of icons is the lower left hand corner of the display; however, users may be able to change the icon display location through a user preference facility.

5.0 GENERAL WINDOW FUNCTIONALITY

This section provides general guidelines for windows. Refer to the OSF/Motif style guide for a more detailed explanation of GUI attributes and the terms used to describe the actions, warnings, and information presented to the user.

5.1 BASIC WINDOW APPEARANCE

A basic compartmented mode window (CMW) is shown in Figure A5-1. The bottom line of the desktop is the message area in Motif implementations, the line under the title bar is called the menu bar.

The classification bar displayed as the top line of the basic window and the optional input information label displayed at bottom of the screen are value added features supported by the CMS operating system rather than OF Motif. However, from the CMW application designers, viewpoint, the classification bar and input information label are displayed in the same manner as other window controls (e.g., the title bar).

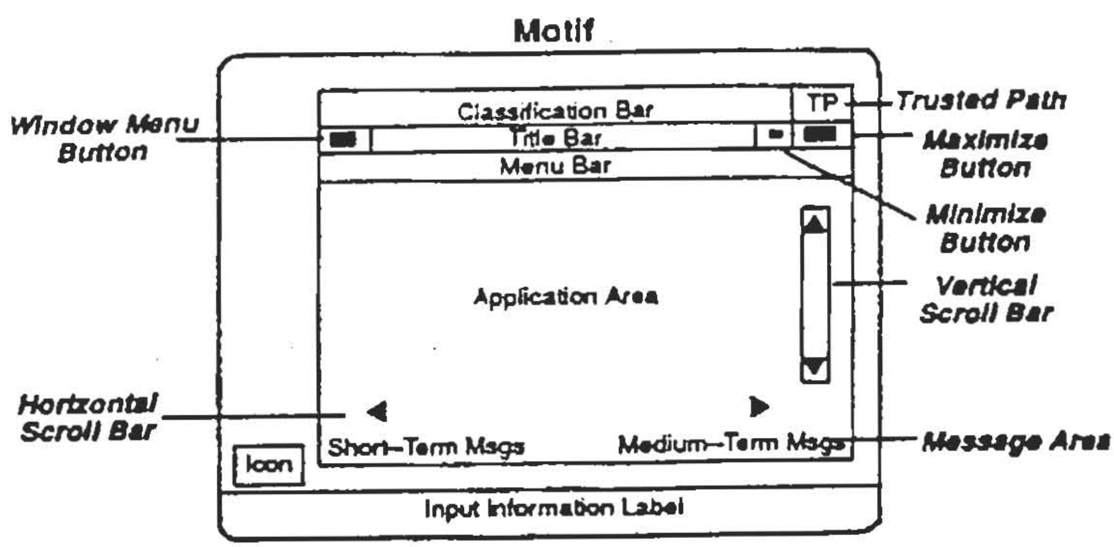


Figure A5-1. Example of a compartmented window.

5.1.1 Title Bar

The Motif title bar displays the window and three control buttons: the window menu button, the minimize button, and the maximize button.

5.1.1.1 Title

The title clearly identifies the view to the user. Some general considerations that apply to the generation of titles are as follows:

- The title should be centered.
- The title should be distinguished by a visual attribute (e.g., boldface type).
- A window's title should not display any messages.

5.1.1.2 The Window Menu Button

The window menu bottom is located in the upper left-hand corner of the title bar (See Figure A5-1). This button provides a standard location for window management functions (e.g., close, move, and window resizing functions). A Motif window menu is illustrated in Figure A5-2.

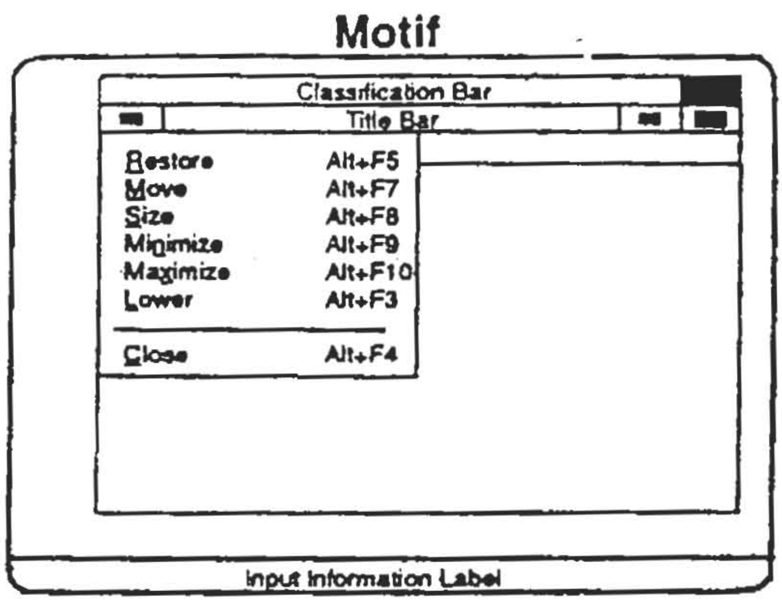


Figure A5-2. Example of a Motif window menu.

5.1.1.3 Reducing The Window To An Icon

A window that a user wishes to keep available but is not using actively for extended periods, can be reduced to an icon. When a window is reduced to an icon, the window is removed from the screen and the software controlling the window is represented as an icon. Application processing continues in the background, as if the window were still displayed on the screen. In OSF/Motif applications, windows can be reduced to icons by selecting the minimize button from the title bar, selecting the minimize function from the window menu bar, or depressing the minimize accelerator keys with the window focus appropriately selected. Icons should be opened by positioning the pointer over the icon and double-clicking the Select button on the mouse.

5.1.1.4 Expanding A Window To Its Full Size

Expanding a window to its full size (maximizing) increases the size of the window to the maximum specified by the application. In OSF/Motif applications, windows can be maximized by either selecting the maximize button from the title bar, selecting the maximize function from the window menu button, or depressing the maximize accelerator keys with the window focus appropriately selected. Windows can also be expanded to full size by dragging the resize borders or resize corners.

5.1.2 Dragging The Window

Dragging a window moves it to a different position. A Motif window can be dragged using the mouse by positioning the mouse pointer over the title area of the title bar, pressing the Select button on the mouse, moving the mouse pointer to the desired location, and releasing the button. (A window can be also be moved using the appropriate keyboard function key, or using the move option from the window menu button.) As the window is dragged (or moved), a "ghost" outline of the window should move with the pointer. The window should move to the position of the outline when the mouse button is released.

5.1.3 Scroll Bars

The scroll bar is a special type of control that makes it easy for the user to view or page through objects (such as documents, drawings, and spreadsheets that are too long or wide to be displayed in the application area or pane) and pan graphic map displays in the north/south and east/west directions. Scroll bars actually give users the capability to navigate through documents without paging one window at a time.

The vertical scroll bar supports movement backward and forward (north/south) through the document or graphics display, while the horizontal scroll bar supports left and right (east/west) movement. Horizontal scroll bars should be located at the bottom edge of the window area; vertical scroll bars should be at the right edge. The Motif style guide should be consulted for a detailed explanation of the document paging and window movement features that are supported by the scroll bar.

5.1.4 Message Area

The message area (or footer) is reserved for non-critical application messages that should not suspend processing. The left side of the message area should be used for short-term messages such as "Incorrect format - field requires numeric data. Please reenter." The right side of the message area should be used for medium-term messages such as "Page 4 of 29."

5.1.5 Resizing The Window

Resizing a window normally increases or decreases the size of the window frame, not the scale of the data within the window. For example, if a window containing a text document is enlarged, more lines of data may be seen, but the test itself does not enlarge.

Some guidelines to follow when resizing windows are:

- The minimum height of a window should allow enough room for at least the classification bar, title bar, and menu bar (control area).
- The view should be logically designed to accommodate the resizing function. Pertinent information should be contained in the upper left-hand corner of the window.
- When a user resizes a window, only the size of the window's borders should change, not the size or relative position of the data or the controls within

the borders. An exception might occur in imagery manipulation where the user may require the image to rescale (magnify) with the window frame.

- OSF/Motif windows normally have a wide frame border, made up of corner handles and edge handles. Users can drag the resize corner when they want to change the window's size.

5.2 WINDOW MENU BAR/CONTROL AREA

A menu is a window that consists of a list of choices (menu items) and optionally, a name. Menu selections serve several purposes: to display action or command items; to display submenus or windows; or to select and set parameters. The window menu bar (or control area) contains a list of the titles of available pull-down menus. The titles chosen by each application should clearly indicate the purpose of the menu. Figure A5-3 shows sample pull-down menus. Some general guidelines for implementing menus are:

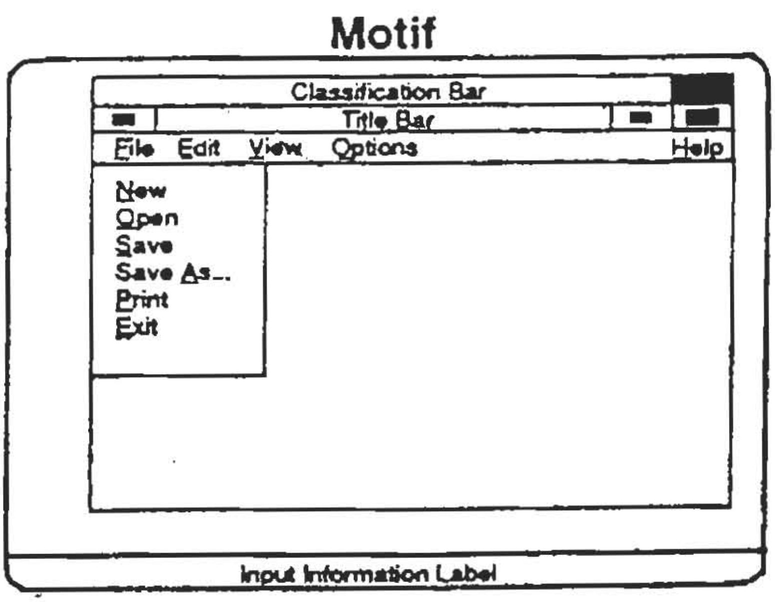


Figure A5-3. Example of a pull-down menu.

- To accommodate short term memory and visual search procedures, the number - of menus and the number of items(or groups of items) should never exceed seven plus or minus two.

- The user should be able to browse the menu bar by positioning the pointer over a menu name (title) and pressing the select button. As the pointer is dragged over the menu name, the name should highlight and a menu with a list of menu items should appear directly beneath it. Each active menu item should also highlight as the pointer is dragged over it.

- The application may disable menu items. For example, an application may disable the "Paste option if no data is present in the clipboard for insertion in the document. Disabled menu items should be dimmed or grayed and should not highlight as the pointer is dragged over it.

- A pull-down menu should contain related functions.

- Mnemonics and accelerators should be available for keyboard access to menu options, and their existence should be visually represented on the menu.

- Two actions should be required to select a menu item: 1) identify the item to be selected, and 2) select the item. An item should be deselected by moving the pointer to another item or outside the menu.

5.2.1 Menu Entries

In Motif applications, a menu entry can be one of three primary types: an action item, a routing, or a setting. A general description of each type of menu entry follows; a more detailed description can be found in the OSF/Motif style guide.

5.2.1.1 Action And Command Menu Entries

An action type menu item executes the function named in the menu item. For example, in Figure A5-4, the selection of "Graphics Editor" in the menu will activate the Graphics Editor application.

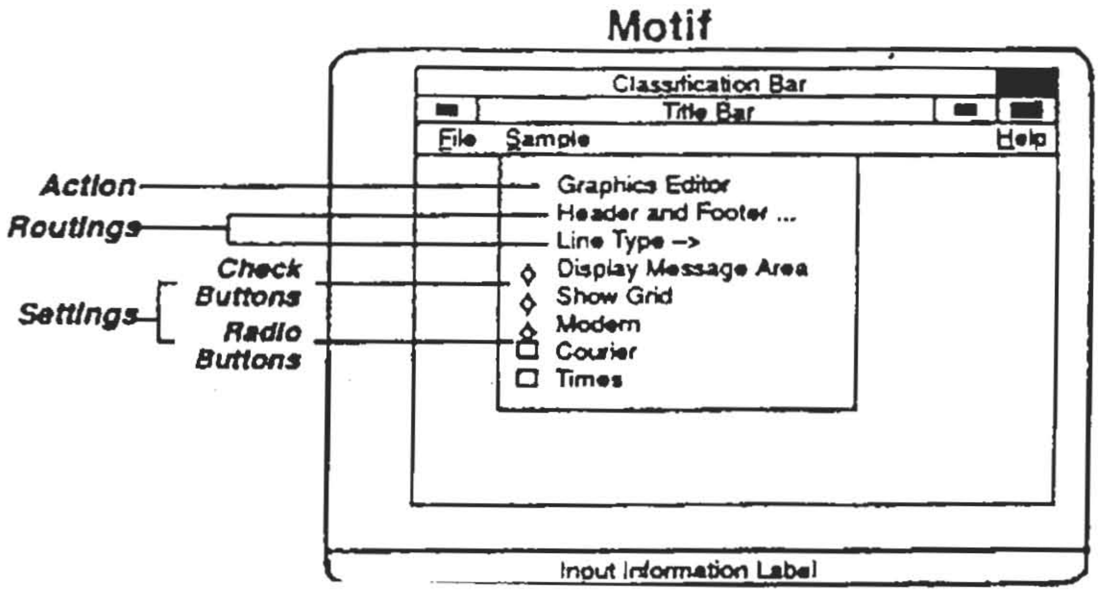


Figure A5-4. Example of an action menu entry.

5.2.1.2 Routings

Routing entries display other windows or menus. Those that display windows are designated by displaying continuation characters (11... ") after the menu entry, and those that display sub-menus (also referred to as cascading menus) are designated by displaying a pointer (e.g., "->") after the menu entry. In Figure A5-4, the menu item "Header and Footer... " will display a selection window if selected; the menu item "Line Type will display a cascading menu.

5.2.1.3 Settings

Settings are displayed as check buttons (for non-exclusive settings) or radio buttons (for mutually exclusive settings). These buttons are used to set a view state. Figure A5-5 illustrates the method Motif applications use to present settings. Section 5.3 explains the functional use of settings in more detail.

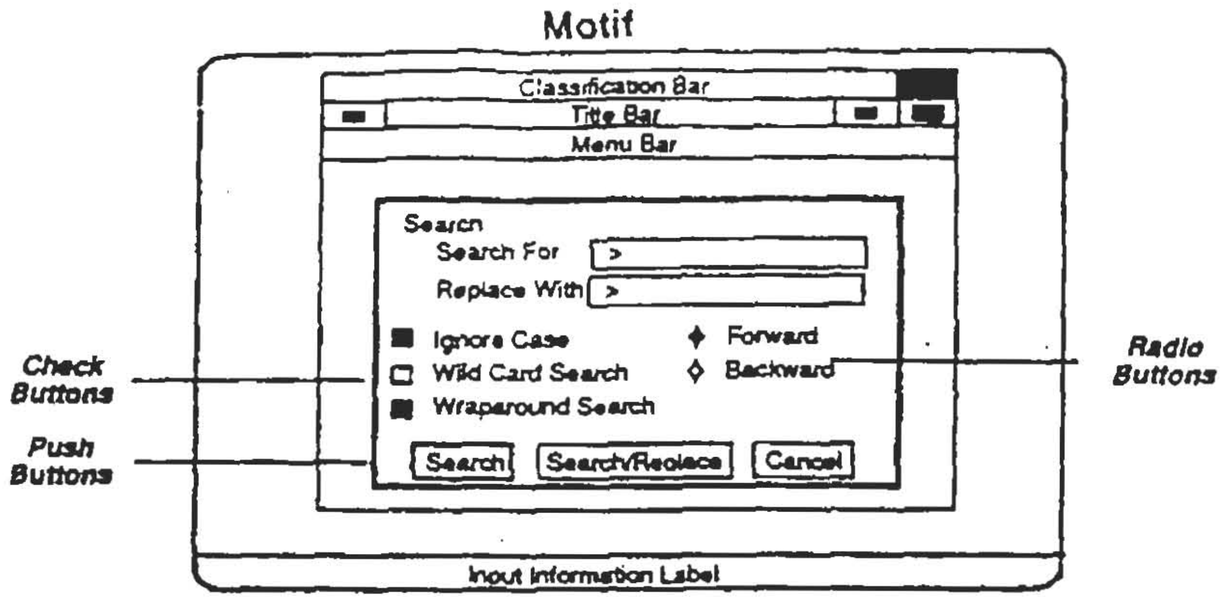


Figure A5-5. Example of Motif settings.

5.2.2 Mnemonics And Accelerators

A mnemonic is a single character that provides a shortcut for making a menu selection from the keyboard. Rather than pointing to the menu item, the mnemonic is entered via the keyboard. Mnemonics are usually the first letter of a menu item, unless that letter is already in use (in which case a subsequent letter should be chosen). Mnemonics must. be unique within the window with input focus. Different window may use the same mnemonics, but an effort should be made to provide consistency of mnemonics whenever possible.

A keyboard accelerator is a multiple key sequence that invokes a menu item without having to display the menu. Keyboard accelerators are typically used for frequently used functions (e.g., save, cut, copy) and should be consistent for all settings.

Figure A5-6 illustrates how mnemonics and accelerators can be displayed within menus. In the figure, the Edit menu can be displayed by pressing "E" (upper or lower case) . To select the Undo menu item, the application should allow the user to press "U". The Undo menu item could also be selected by simultaneously pressing the "Alt" and "Backspace" keys on the keyboard.

Motif

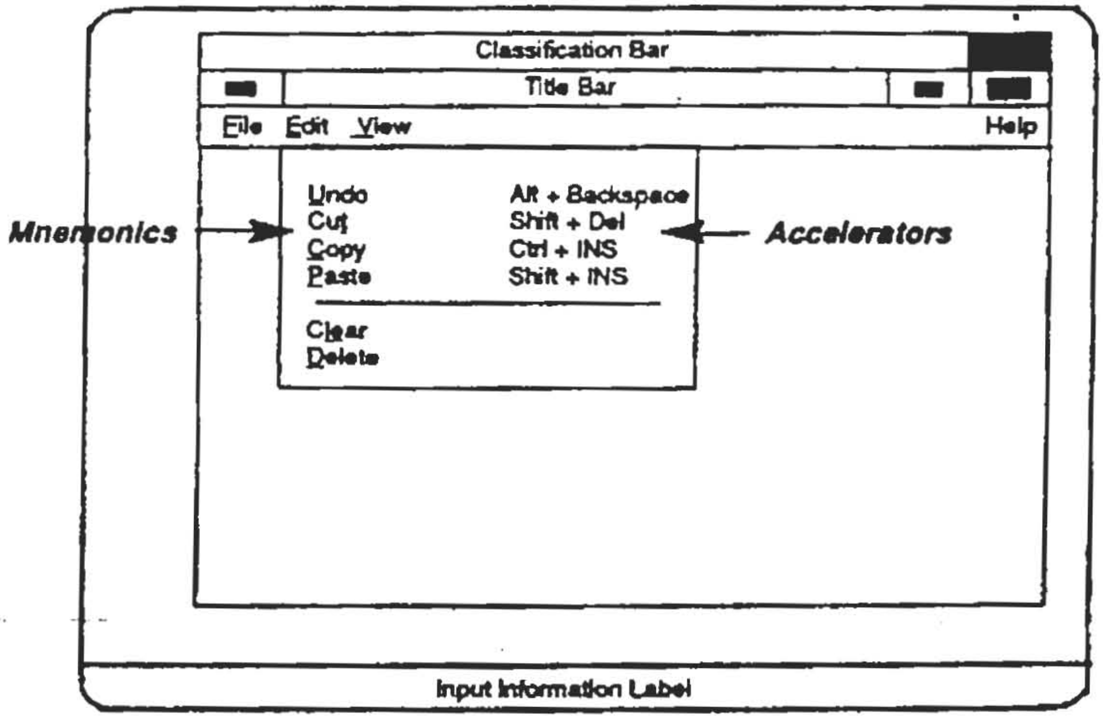


Figure A5-6. Example of the use of mnemonics and accelerators.

The following guidelines apply to mnemonics and keyboard accelerators:

- Mnemonics and accelerators should not be case sensitive. The user should be able to access the menu item by typing in either upper or lower case.

- Mnemonics should be underlined and/or designated in bold or contrasting color.

- Mnemonics should only be accessible when the menu containing them is displayed.

- If a keyboard accelerator exists for a menu item, it should appear right justified on the same line as the menu item.

5.2.3 Menu Item Selection With Mouse

Menu item selection can be done in either of the following ways. The user can select the preferred option. They include:

- The first method is to position the pointer on the menu option, press the select button, and drag the pointer to the desired option (each option along the way is highlighted). To execute the option, the user releases the mouse button when the highlight passes over it. To avoid making a selection, the mouse button is released outside the menu.

- The second method is to move the pointer to the menu option and click the appropriate mouse button (same as in first method). The menu window will display its options. To execute, the user moves the pointer to the desired option and clicks the mouse button again. To dismiss the menu without making a selection, the mouse button is clicked outside the menu.

5.2.4 Menu Item Selection Without Mouse

Users should be able to use the arrow keys to position the pointer on a menu item and then-press the Return/Enter key to select the item. To cancel the menu without choosing an option, the Esc key should be pressed.

5.3 WINDOW CONTROLS

Controls and their labels represent application functions in windows and dialog boxes. Controls should mimic the physical items they represent (e.g., switches or buttons) by providing feedback before, during, and after selection by a user. For example, a button that the user has chosen should appear to be pushed in.

Window controls are generally selected using the Select button on the mouse. However, users who interact with the application using only the keyboard should have equivalent functionality. Arrow keys should allow the user to move between controls, and pressing the Return/Enter key should invoke the indicated control. In addition, mnemonics should be provided for each control.

5.3.1 Check Buttons/Non-Exclusive Settings

A check button, or non-exclusive setting, provides an analogue of a physical toggle switch. Activating the control toggles the value of the state, but need not invoke any further action. These controls can be arranged in related groups or stand alone. The user should be able to toggle them off and on by positioning the pointer over the control and clicking the Select button. An empty or raised box indicates the control is off; a filled or depressed box indicates it is on.

5.3.2 Radio Buttons/Exclusive Settings

Radio buttons, or exclusive settings, are used when selecting from multiple options where only one can be selected. These controls are referred to as mutually exclusive settings because only one setting in a group can be chosen at a time. In Motif applications, a set of radio buttons consists of at least two buttons and a label that describes the function of the set. The user should be able to select a radio button by positioning the pointer over the button and clicking the Select button. When one of these controls is selected, the previously selected control is deselected. An empty or raised button indicates the control is off; a filled or depressed button indicates it is on.

5.3.3 Push Buttons/Command Buttons

A push button or command button, which is used to initiate an action, consists of a name or icon within a rectangular or oval frame. The user should be able to select the control by positioning the pointer over it and pressing the Select button on the menu. Releasing the Select button should execute the action. Before the Select button is released, users should be able to cancel a selection by dragging the pointer away from the control and releasing the Select button. A default push button or command button, which can be readily distinguished from the other buttons, should always be provided. The action associated with the default button should be invoked if the user fails to move the pointer before pressing the select button (Return/Enter key if the mouse is not being used.).

5.3.4 Text Fields

A text field is an area in which text is entered. A title or label is normally appended to the field to identify or describe the data that is to be entered. The text display should scroll horizontally if the text entered is longer than the input area. If the text entered is more than one line high, the entry area should scroll vertically. The title should describe what is to be entered and should appear to the left or above the entry area.

5.4 BUTTON DEFINITIONS

The OSF/Motif style guide defines terms often used in applications to perform a certain function, either through a menu item or window control. In addition, each DoD organization should define a standard vocabulary to be used in its application.

5.5 WINDOW COLORS/PATTERNS/AUDIO SIGNALS

The proper use of color, background patterns, and sound has the potential to significantly aid the user. This section provided recommendations for using these features.

- on both color and monochrome displays, background patterns can be used to highlight, group, or clarify relationships, and to add extra meaning.

- <u>Color should always be redundant with some other visual attribute; color should not be provided as the only means of visual distinction</u>.

- For quick and accurate interpretation, colors should be used sparingly and match user expectations.

- Colors should not be "hard coded" into applications. Users should have the option to select their own color schemes (See also Section 7.4).

- Some colors have strongly associated meanings. For example, a user may assume a red control button has critical or irreversible consequences. Red should thus be avoided for non-critical buttons as it may inhibit the user from exploring them. Some common color meanings are as follows:

- Red - Stop, alarms, errors, danger, critical consequences
- Yellow - Warning, caution, approaching critical
- Green - Normal, safe, within normal range, proceed
- Blue - Cold, water, non-critical items
- Gray - Inactive, unavailable options or actions

- Both color and sound should be used for messages that require user acknowledgment. Critical messages should be displayed in red, and the audio alarm should continue until the user responds. Non-critical messages (e.g., "Printer error. Please check printer and retry or cancel") should be displayed in yellow and should be accompanied by a short audio alert.
- Spectral extremes (e.g., red and green) should not be used together. Colors at considerably different wavelengths appear to vibrate when placed together.
- When data is color coded, a legend (e.g., "Orange Required Field") should be provided at the bottom of the window. Color codes should be limited to four per window and no more than seven per application.
- The same color scheme (window background, foreground, etc.) should be used for all windows of an application. Repeated use of the same color for similar user interface components or data types allows elements to be associated quickly.
- White text on a black background produces halation, or the spreading of light, making the text less readable. Text should only be displayed in multiple colors if the other colors provide additional meaning. Due to the

inherent focusing problems with blue, it should never be used As a text color or for any critical item.

- The workspace, or computer screen, background should be a neutral color (preferable gray).

- The application window background should be in enough contrast to stand out in the workspace foreground. At the same time, it should provide a neutral background for the application data to ensure readability. Muted pastels are recommended.

- In general, the larger the object, the less saturated or deep its color should be to avoid eye fatigue.

- CMW Classification Bar colors are listed below. The use of background colors that match these colors should be restricted.

  - Green - Unclassified
  - Blue - Confidential
  - Red - Secret
  - Orange - Top Secret
  - Yellow - Sensitive Compartmented Information

6.0 DIALOG BOXES

Dialog boxes contain graphical controls for interacting with applications. Examples of dialog boxes include message, question, warning, action, and command windows. These windows are used to:

- Display important messages or warnings
- Collect or solicit data from the user
- Modify and set properties of objects
- Notify the user of the progress of a lengthy process

Dialog boxes are invoked by applications in response to 1) user actions and requests, 2) unexpected or unplanned events (e.g., printer running out of paper), or 3) initiation of a time-consuming activity. The application decides where and when they are displayed, but all dialog boxes should include at least one button that solicits a response from the user. they - should be noticeable but kept small, and if possible, they should be moveable. Only one dialog box should be displayed at a time within any application.

Dialog boxes should automatically receive input focus. Users should not be able to change the input focus to any other window in any application until they have responded to critical dialog boxes.

6.1 MESSAGE WORDING GUIDELINES

The following guidelines, which are designed to maximize user performance and accuracy, should be applied to dialog boxes, and message areas (See Section 5.1.5), and any other communications between the application and user.

- An abbreviation should only be used when it is significantly shorter than the full word.
- Abbreviations should be meaningful and recognizable and should be used consistently.
- Words not commonly abbreviated should not be abbreviated. For example, use "Restricted Acct No",

not "Restr Account Number".

- Message lines should end in full words rather than hyphenations.

- Messages should be directly usable, requiring no further documentation or translation.

- Avoid overly technical wording and use short simple sentences that begin with the main topic.

- Abrupt wording such as INVALID, ILLEGAL and FATAL should be avoided.

- Error messages should focus on the procedure for correcting the error, not the action that caused the error.

- Error messages that require immediate response from the user should be contained in caution/warning windows. Non-critical messages should be displayed in the Message Area at the bottom of the application window, as previously described.

6.2 WORK IN PROGRESS WINDOW

When a user's request is simple and does not require processing time in excess of a few seconds (five or less), the feedback can be in the form of a changed pointer shape or a brief message within the window. When the request exceeds a short delay of five seconds, the application should provide a work in progress window to indicate that a time-consuming operation is taking place and, if appropriate, provide a means by which the operation can be canceled or aborted. The application removes the box when the operation has been completed.

Figure A6-1 shows examples of two types of work in progress windows. The application should show the status of the operation by a dynamically changing process indicator (e.g., "10% Sorted", "4 out of 10 files copied". or a scale showing status).

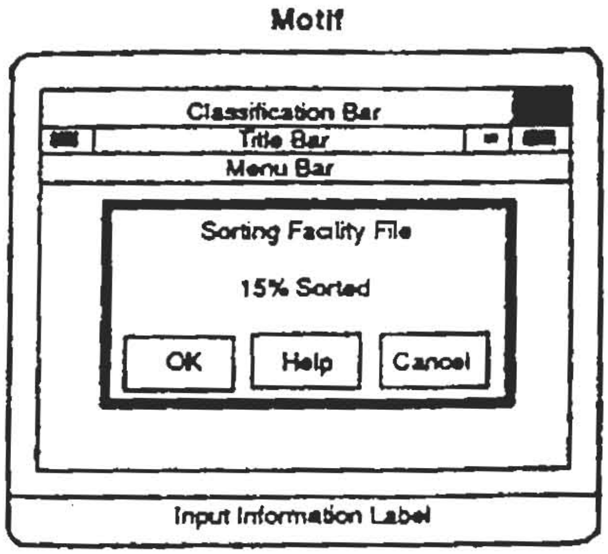


Figure A6-1. Example of work in progress window.

6.3 INFORMATION BOX

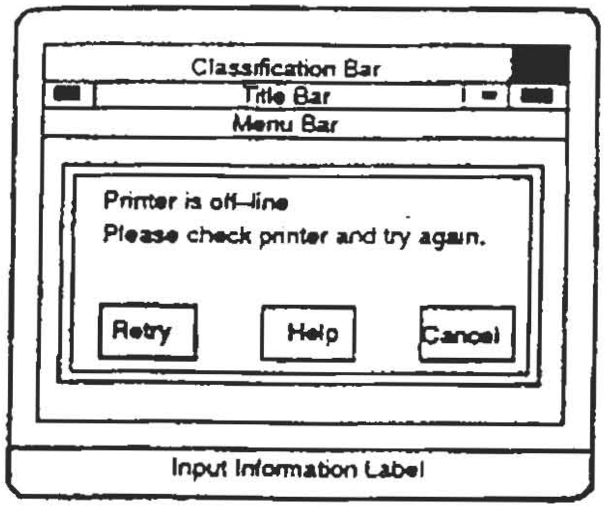
An application should generate a message box when the application needs to display an informational message (Figure A11). This window should be reserved for non-critical messages requiring acknowledgment by the user. An application's frequent informational messages should be displayed in the window's message area (See Section 5.1.5).

An information box can freeze the application and require the user to explicitly dismiss the window before proceeding. If the halted operation can be retried, a "Retry" button should be included within the message window. If a default push button is designated, it should be the assumed desired action.

6.4 CAUTION/WARNING BOX

A caution/warning box contains critical messages that warn the user of the consequences of carrying out an action and usually contains "Yes" "No" and "Cancel" buttons (Figure A6-2). The message should be an unambiguous question or statement. When this box is displayed, the application is suspended until the user provides instructions on how to proceed. The default push button should always be the least destructive operation.

Information Box



Caution/Warning Box

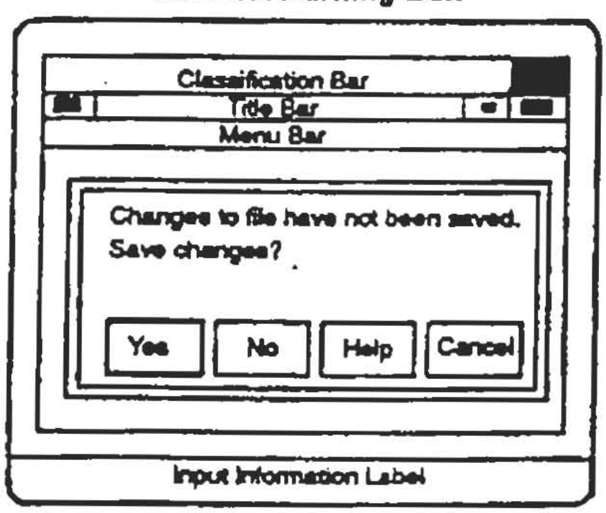


Figure A6-2. Examples of information and caution/warning boxes.

6.5 MENU BOX

A menu box is the result of the user's selecting a routing or window menu item. Menu boxes solicit data from users through a combination of controls (e.g., entry boxes and settings) . The menu box should be named in accordance with the menu item that created it. For example, the "Search..." menu item should generate a menu box with the title

"Search... ". A "Cancel" push button should be included in the window to allow users to dismiss the menu box. If a default push button is designated, it should be the assumed desired action.

7.0 COMMON FEATURES

This section describes features, functions, and field display formats that should be handled consistently by all DoD applications.

7.1 DATE/TIME DISPLAY

When date and time information is displayed in digital form, the format should be as follows:

- Date - YYMMDD, where YY is the last two digits of the year, MM is the month, and DD is the date (e.g., 910104 specified 4 January 1991), or

  DD MMM YY, where DD is the day, MMM is the month, and YY is the year (e.g., 04 JAN 91).

- Time - HHMM(SS)Z, where HH is the hour of a 24-hour day, MM is the minute, SS (optional) is the second, and Z is the time zone, Zulu (Z) time is the system standard and the-default DoD display standard (e.g., 113024Z) . Colons or spaces may be used on the display or output format to make the format more readable (e.g., 113024Z). To simplify data entry and avoid extraneous characters, the colons or spaces should be generated as part of the form and not left to the user's discretion.

  Users should generally be allowed to specify local time on hardcopy output and softcopy displays, as desired (e.g., 113024L). However, this option should not be provided to users in operational systems where input and coordination are based on Zulu time.

- Date/Time Group should be displayed as DDHHMMZ, MMM YY, where DD is the day, HH is the hour of a 24-hour day, MM is the minute, Z is the time zone (defaults to Zulu), MMM is the month, and YY is the year (e.g., 041130Z JAN 91).

7.2 LATITUDE/LONGITUDE DISPLAY

Latitude and longitude displays will always be given as two fields. The labels may be given as Lat and Long. The formats are as follows:

- Latitude - D (D) H, where D (one or two characters) is the degrees of latitude and H is the hemisphere (optional, but can only be given if minutes of latitude is given), and H is the hemisphere (N for North, S for South).

- Longitude - D(D)(D)H where D (one, two, or three characters) is the degrees of longitude and H is the hemisphere (E for East, W for West), or

  DD(MM(SS)H, where DD is the degrees of latitude, MM is the minutes of latitude (optional), SS is the seconds of -latitude (optional, but can only be given if minutes of latitude is given), and H is the hemisphere (N for North, S for South).

- Longitude- - D(D(D))H where D (one, two, or three characters) is the degrees of longitude and H is the hemisphere (E for East, W for West), or

  DDD(MM(SS))H where DDD is the degrees of longitude, MM is the minutes of longitude (optional), *SS* is the seconds of longitude (optional, but can only be given if minutes of longitude is given), and H is the hemisphere (E for East, W for West).

7.3 HELP FEATURES

The purpose of help is to provide on-line assistance at the user's request. Help information is not meant to tutor users but to assist them in recalling how to use an application. Help should provide optional assistance for the new user which can be bypassed by the expert. The OSF/Motif style guide defines several types of help and should be consulted for details on how to implement the help features.

Guidelines for the implementation of on-line help follow:

- Context-sensitive help should describe the purpose of the item and how users interact with the item.

- For labeled entry fields that are abbreviated or are acronyms, the help window should include, at a minimum, the long unabbreviated name and a definition.

- Help should be included as a menu title in the basic Window Menu Bar.

- DoD applications should use the keyboard "Help" key (if available) and the F1 function key to access help.

- The title of a help window should reflect its contents.

- Users should not need help to get help. A help window should be both easily accessed and exited. A single response should be all that is required to exit the help window.

- At initial display, a help window should be placed in the position that covers the least amount of information in the active application window.

7.4 USER-DEFINABLE PARAMETERS

All users should be able to configure their computer screens to meet individual preferences. User-definable parameters include, but are not limited to, the following:

- Display colors

- Printer Default - In networked environments, users should be able to specify the printer destination.

- Mouse button function mappings - Users should be able to specify either left-handed or right-handed button configurations.

- Mouse sensitivity - User selectable preference option.

8.0 TEXTUAL WINDOWS

This section addresses topics unique to textual windows (i.e., data entry/update screens) that were not covered in Section 5.0 General Window Functionality.

8.1 DATA FIELD LABELING

In general, the appearance of the data should be pleasing to the eye; the arrangement uncluttered and functionally efficient. The following list of guidelines should help to achieve these objectives:

- Field - ordering should be in the logical sequence of a user's thought.

- The data field labels should be easily distinguishable from the data itself. This distinction could be accomplished using different fonts for labels and data, or using special characters as separators. For example, each label should be followed by a colon (:) and be separated from the actual data by at least two spaces.

- Columnar data should be distinctly separated (at least three spaces between columns) with column headings displayed above the data and at least one row of separation between the column heading and the data.

- Labels should be consistent throughout an application or set of applications.

- When a dimensional unit (e.g., nm) is always associated with a field, it should be displayed as part of the label.

8.2 UPDATABLE FIELDS

Guidelines for data field updates follow:

- Updatable fields should be distinguished by underscores below the data field. If highlights or colors are also used, they should be the same throughout an application or set of applications.

- Cues should distinguish required from optional fields and should be consistent throughout an application or set of applications.

- When the length of a field is variable the user should not have to right or left justify or remove blanks from the entered data.

- The user should be able to enter data in familiar units. The application should perform any required conversions (e.g., between geographic, geodetic and military Grid Reference System coordinates).

- Authorized personnel should be able to selectively inhibit updatable fields in a multi-field display. Such a feature would allow trainees to take on increasing database maintenance responsibilities as they learn. It also supports efficient on-line accomplishments of "mass changes" when batch updates are not available.

8.3 TEXT CURSOR

The purpose of the text cursor is to indicate to the user where entered data will be placed. The text cursor can be in any updatable input field. Guidelines for the text cursor follow:

- If the user clicks on a non-updatable field or anywhere on the form, the text cursor should not move.

- The text cursor should move between and within fields with the mouse or by using the Return/Enter key, the Tab key, or the arrow keys.

- With the exception of password and other non-display fields, the cursor should not obscure the character displayed in the position it designates.

- When in insert mode, the text cursor should appear between the characters where the inserted text will be placed.

- When in overwrite mode the text cursor should highlight the character that will be replaced.

9.0 GRAPHICS WINDOWS

This section addresses topics unique to graphics windows that were not covered in Section 5.0, General Window Functionality. The following paragraphs contain general guidelines, recommendations, and definitions of some important graphics functions.

9.1 DATA DISPLAY

All maps should be north oriented, or the north direction should be annotated.

9.2 ITEM SELECTION

Guidelines for item selection on a map graphics screen (the portion of the window in which a map is displayed) follow:

- Because fine accuracy is often required in positioning the cursor, the cursor should include a point designation feature (e.g., cross hairs or a v-shaped symbol).
- The user should be able to select a single item within a densely packed group. When a graphics item is selected, it should be highlighted.

9.3 INTERACTION WITH DATA/ITEMS

Functions should be made available to the user of a map graphics application through menus to permit the user to make measurements, perform analysis, and to control the appearance of the display. The following sections define some recommended functions.

9.3.1 Zoom-In

The zoom-in function, similar to the zoom lens on a camera, should permit the user to magnify a portion of the graphics canvas. Graphic displays that provide a zoom-in capability should include a small, reference display that indicates the relative position of the area viewed within the original canvas.

9.3.2 Zoom-Out

Zoom-out is the inverse of the zoom-in function in that it rescales the display by permitting the user to return to the previous zoom level and position.

9.3.3 Full Zoom-Out

Full zoom-out displays the lowest scale map.

9.3.4 Distance/Azimuth

A distance/azimuth function calculates the distance (range) and azimuth (bearing) between any two selectable points or symbols. Distance should be presented in selectable units (feet, meters, miles, or kilometers). Azimuth should be displayed in degrees from true north.

9.3.5 Determine Position

The determine position function calculates the position of the point that is identified by a starting latitude and longitude, distance (in nautical miles), and an azimuth. The answer is provided textually. Coordinates should be presented in a selectable coordinate system (e.g., Universal Transverse Mercator or latitude/longitude).

9.3.6 Clear Selection

The clear selection function deselects a selected graphics item.

9.3.7 Current Selection Location

The current selection location function returns the geographic coordinates of the selected graphics item.

9.3.8 Legend

The legend function opens/closes a panel that displays the symbols and corresponding textual titles that are available for an application.

9.3.9 Map Overlay Editor

The map overlay editor function activates/deactivates a map overlay editor application.

9.3.10 Overlay Options

An overlay is a layer of information (e. g. , grids, boundaries, or control measures) that has been drawn on a graphics canvas. Various overlays should be made available to the user to display (make visible) , hide from display (make invisible), or delete. The capability to display a list of available overlays, distinguishing between visible and invisible overlays, should be icluded in the graphic package. Some possible overlays include boundary lines, oceans, rivers, grids, land masses, railways, and user-generated overlays (created through the graphics editor).

9.3.11 Graphics Symbols, Line Types, And Colors

Colors, symbols, line size/quality, and fonts should be consistent throughout a given system. Whenever possible, display symbology should conform with published standards (e.g., Army Field Manual 101-5-1, North Atlantic Treaty organization Standardization Agreement 2019, or the DIA Standard Military Graphics Symbols Manual), but each system should also be able to use a. commercial graphics editor to accommodate the creation and display of system-unique features and symbols.

9.3.12 Area Bounding Boxes

Area bounding boxes are pairs of coordinates defining a rectangular area in terms on latitude and longitude. Bounding boxes, which should be used when displaying maps in the main graphics drawing area, should display the bounding coordinates for the geographic area being shown.

APPENDIX B

ADVANCED DISPLAY AND DEBRIEFING SYSTEM (ADDS)

TASK ANALYSIS

1.0 MISSION

The TACTS/ACMI system, directly and indirectly, supports training in air-to-air (AA) combat, air-to-surface (AS) combat, electronic warfare (EW) and integrated operations (IO) in a simulated hostile air and surface air defense environment. The ADDS will provide the capability for aircrews to debrief at a location different from the CCS and the local or remote DDS. The ADDS CGUI provides the user the capability to select, navigate and manipulate the displays for debriefing purposes.

2.0 FUNCTION

The function of the ADDS is to display the TACTS/ACMI mission data in real-time or replay conditions using all of the current displays and the enhanced displays listed in the ADDS System Specification.

3.0 JOB(S)

Aircrew Training Users (Users)
Air-to-Air Combat User (AA User)
Air-to-Surface Combat User (AS User)
Electronic Warfare User (EW User)
Integrated Operations (IO User)
Diagnostic Operator
CEBS Operator
Installation and Range Terrain Data Base Operator
Software Developer
Utility Operator
System Administrator
Security Administrator
System Hardware Maintainer

4.0 AIRCREW TRAINING USER TASKS

Tasks are listed under each display view.

5.0 GENERAL TASKS INDEPENDENT OF SELECTED DISPLAY

Print screen

Control screen windowing and horizontal/vertical view window aspect

6.0 GRAPHICS DISPLAY VIEWS

6.1 PLAN VIEW

Select display
Change scale/zoom
Hard deck on/off
Declutter high-activity aircraft
Declutter low-activity aircraft
Flight history trails on/off
Flight history trails adjust length
Call signs name/AC #/off
Select participant color
Ground threats on/off
Ground targets on/off
Declutter ground participants
Select dead AC color
Pan

6.1.1 Range Plan Overlay

Map and terrain
Map only
Terrain only

6.1.2 Lat/Long Overlay

Lat/long and terrain
Lat/long only
Terrain only

6.1.3 Battle Management Overlay

Battle management overlay and terrain
Battle management overlay only
Terrain only

6.1.4 NDWS Overlay

NDWS on with concentric rings
NDWS on with concentric rectangles

6.2 CENTROID VIEW

Select display

Change FOV
Terrain on/off (small scales)
Change scale/zoom
    Horizontal
    Vertical
Centroid
    Default
    Change
    Reset to default
AZ & El manipulation
Hard deck on/off (PPPI)
Declutter high-activity aircraft
Declutter low-activity aircraft (PPPI)
Flight history trails on/off
Flight history trails adjust length
Ground history trails on/off
Ground history trails adjust length
Weapon seeker and lock-on on/off (PPPI)
"Whiskers and Frowns" on/off
Call signs name/AC #/off
Select participant color
Pairing
Ground threats on/off
Select dead A/C color
Predicted bomb impact points symbols/craters only

6.3 GROUND TARGET VIEW

Select display
FOV and view direction default for each target
Terrain on/off (small scales)
Change scale/zoom
Horizontal
Vertical
Centroid
Default
Change
Reset to default
AZ & El manipulation
Hard deck on/off (PPPI)
Declutter high-activity aircraft
Declutter low-activity aircraft (PPPI)
Flight history trails on/off
Flight history trails adjust length
Ground history trails on/off

Ground history trails adjust length
Weapon seeker and lock-on on/off (PPPI)
"Whiskers and Frowns" on/off
Callsigns name/AC #/off
Select participant color
Pairing
Ground threats on/off
Select dead A/C color
Predicted bomb impact points symbols/craters only

6.4 MISSILE ENDGAME VIEW

Select display - replay only
Change FOV
Terrain on/off (small scales)
Change scale/zoom
Horizontal
Vertical
Centroid
Default
Change
Reset to default
AZ & El manipulation
Hard deck on/off (PPPI)
Declutter high-activity aircraft
Declutter low-activity aircraft (PPPI)
Flight history trails on/off
Flight history trails adjust length
Ground history trails on/off
Ground history trails adjust length
Weapon seeker and lock-on on/off (PPPI)
"Whiskers and Frowns" on/off
Call signs name/AC #/off
Select participant color
Pairing
Ground threats on/off
Select dead A/C color
Predicted bomb impact points symbols/craters only

6.4.1 Fly-in Data Analysis

Alphanumeric data accompanying missile endgame on/off

6.5 PILOT VIEW

Select display
Change FOV
Terrain on/off (small scales)
Change scale/zoom
AZ & El manipulation
    AZ = 0 - 90 degrees
    EL = -180 - + 180 degrees
    reset to 0,0
Hard deck on/off (PPPI)
Declutter high-activity aircraft
Flight history trails on/off
Flight history trails adjust length
Ground history trails on/off
Ground history trails adjust length
Weapon seeker and lock-on on/off (PPPI)
"Whiskers and Frowns" on/off
Call signs name/AC #/off
Select participant color
Pairing
Ground threats on/off
Select dead A/C color
Predicted bomb impact points symbols/craters only
Radar & caged IR & uncaged IR on/off

6.5.1 HUD

Select as overlay on pilot view
AZ = 0 degrees only

6.6 THREAT BORESIGHT VIEW

Select display
Change FOV
Terrain on/off (small scales)
Change scale/zoom
Hard deck on/off (PPPI)
Declutter high-activity aircraft
Declutter low-activity aircraft (PPPI)
Flight history trails on/off
Flight history trails adjust length
Ground history trails on/off
Ground history trails adjust length
Weapon seeker and lock-on on/off (PPPI)

"Whiskers and Frowns" on/off
Call signs name/AC #/off
Select participant color
Pairing
Ground threats on/off
Select dead A/C color
Predicted bomb impact points symbols/craters only

6.7 CHASE VIEW

Select display
Terrain on/off (small scales)
Change scale/zoom
Hard deck on/off (PPPI)
Declutter high-activity aircraft
Declutter low-activity aircraft (PPPI)
Flight history trails on/off
Flight history trails adjust length
Ground history trails on/off
Ground history trails adjust length
Weapon seeker and lock-on on/off (PPPI)
"Maskers and Frowns" on/off
Call signs name/AC #/off
Select participant color
Pairing
Ground threats on/off
Select dead A/C color
Predicted bomb impact points symbols/craters only
Adjust lag time/distance

7.0 ALPHANUMERIC DISPLAYS

7.1 EXERCISE DATA: HIGH-ACTIVITY AIRCRAFT

Select
Scroll

7.2 FLIGHT DATA: AIRCRAFT-AIRCRAFT DATA PAIRING

Select
Scroll
Set AC/AC Pairs
Select column

7.3 FLIGHT DATA: THREAT-AIRCRAFT DATA PAIRING

Select
Scroll
Set Threat/AC Pairs
Select column

7.4 FLIGHT DATA: AIRCRAFT-GROUND TARGET DATA PAIRING

Select
Scroll
Set AC/ground target pair
Select column

7.5 TIME EVENT SUMMARY DATA

Select all
Select subset of AC, threats and weapons
Scroll

7.6 HAZARD SUMMARY DATA

Select
Scroll

7.7 EXERCISE DATA: LOW-ACTIVITY AIRCRAFT

Select
Scroll

7.8 EXERCISE DATA: THREATS

Select
Scroll

7.9 QUICK-LOOK DATA

Select high-activity -A/C and threats
Select low-activity threats
Scroll

7.10 THREAT DATA

Select
Scroll

7.11 PILOT DATA

Select
Scroll

7.12 ENGINEERING DATA

Select display
Scroll display

7.13 RANGE STATUS

Select
Scroll

7.14 JMEMS BOMB-SCORE DATA

Select
Scroll

7.15 MISSION EFFECTIVENESS

Select
Scroll

7.16 STRIKE SUMMARY

Select
Scroll

7.17 ATTACK PAIR DATA

Select
Scroll
Select AC/ground target
Select column