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Proposed Design For EA-6B ICAP III Weapon-system Alert Display

Andre Laurence Mercier
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Andre Laurence Mercier entitled "Proposed Design For EA-6B ICAP III Weapon-system Alert Display." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Aviation Systems.

Robert Richards, Major Professor

We have read this thesis and recommend its acceptance:

Alfonso Pujol, Jr., Ted Paludan

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Dr. Anne Mayhew
Vice Chancellor and
Dean of Graduate Studies

(Original signatures on file with official student records.)

PROPOSED DESIGN FOR EA-6B ICAP III WEAPON-SYSTEM ALERT DISPLAY

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Andre Laurence Mercier

May 2004

DEDICATION

This thesis is dedicated to my wife

Christina Mercier

who has inspired me to persevere.

ACKNOWLEDGMENTS

I would like to thank everyone who helped contribute to this thesis. I would also like to thank all the professors who helped craft my education. Especially Dr. Richards whose patient instruction at the U.S. Naval Test Pilot School and University of Tennessee Space Institute helped make this a fantastic experience.

Thank you.

ABSTRACT

The EA-6B Prowler electronic warfare aircraft is undergoing a major weapon system improvement referred to as Improved Capabilities Three (ICAP III). The ICAP III upgrade presents an opportunity to improve the existing aircraft system for alerting the crew of potential weapon system problems.

This thesis provides a recommended design for display of weapon-system alerts in production Lot 1 configured EA-6B ICAP III aircraft. Human factors engineering methods, the ICAP III system performance specification and the author's experience employing electronic warfare weapon systems were used to define required alerts. These tools along with human factors engineering research and software best practice research were used by the author to recommend consolidation, format, prioritization, location and mode of alert presentation. Conclusions will be presented to the EA-6B ICAP III and E/A-18G design teams for consideration.

PREFACE

A portion of the information contained within this thesis was obtained from Department of Defense test reports, FAA documents, and product literature on the design features of avionics systems from the Northrop Grumman Corporation. The research, discussion, and conclusions presented are the opinion of the author and should not be construed as an official position or an endorsement of these products by the United States Naval service, the United States Government or the University of Tennessee, Space Institute, Tullahoma, Tennessee.

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LIST OF ABBREVIATIONS

AA	Alarm Assignment
AKPD	Airborne Keyboard Pointing Device
ALQ-99	ICAP II and III Tactical Jamming System
AN/ALQ-218	ICAP III Tactical Jamming System Receiver
APS-130	EA-6B Ground Mapping Radar
BIT	Built-In Test
CIU/E	Computer Interface Unit / Encoder
CMC	Central Mission Computer
CRT	Cathode Ray Tube
CTF	Central Track File
DA	HARM Direct Attack (number)
DDI	Digital Display Indicator
DSMU	Data Storage Memory Unit
DVRI	Direct View Radar Indicator
ECMO	Electronic Countermeasures Officer
FAA	Federal Aviation Administration
FWS	Functional Weapon System
HARM	High-speed Anti-radiation Missile
HCP	HARM Control Panel
ICAP	Improved Capability
ICAP II	Improved Capability (version two)
ICAP III	Improved Capability (version three)
ICS	Inter-cockpit Communication System
ICU	Interface Control Unit
IDM	Improved Data Modem
ILS	Instrument Landing System
IM	Information Management Computer
IOC	Initial Operational Capability
IPL	Initial Program Load
JAS	Jammer Assignment Status (page)
LCD	Liquid Crystal Display
MATT	Multi-mission Advanced Tactical Terminal
MDB	Mission Database
MIDS	Multifunction Information Distribution System
MM	Mission Management Computer

MRU	Mission Recorder Unit
NATOPS	Naval Air Training and Operating Procedures
OFP	Operational Flight Program
PA	Preemptive Assignment
PE RA	Protected Entity Reactive Assignment
PHD	Pilots Horizontal Display
PRI	Pulse Repetition Interval
RAT	Ram Air Turbine
SEAD	Suppression of Enemy Air Defense
TDS	Tactical Display System
TDSIU	Tactical Display System Interface Unit
TJSR	Tactical Jamming System Receiver (ALQ-218)
TT RA	Target Track Reactive Assignment
UE	Universal Exciter
UEU	Universal Exciter Upgrade
USQ-113	EA-6B Communication Countermeasures System
WRA	Weapon Replaceable Assembly
XMTR	Transmitter

CHAPTER 1: INTRODUCTION

BACKGROUND

The EA-6B electronic warfare aircraft first saw Navy service in 1971 and was referred to as the Standard version. In 1973 the Standard was upgraded to the Extended Capabilities version or EXCAP. In 1976 the EA-6B was further upgraded to the Improved Capabilities or ICAP configuration. In 1985 ICAP was followed by the more sophisticated Improved Capabilities Two version dubbed ICAP II. The ICAP II version of the EA-6B saw action in Desert Storm, Kosovo and Iraqi Freedom and is the version of the aircraft currently fielded. Most of these upgrades included changes to both the aircraft and weapon systems. There are currently two “Blocks” of ICAP II configured EA-6B aircraft referred to as Block 89 and Block 89A. Block 89A is an avionics upgrade to Block 89 fielded in 1993. Block 89A did not include any upgrades to the tactical jamming or receiving (AN/ALQ-99) system.

In 1998 a contract was awarded to Northrop Grumman for the engineering and manufacturing development of the EA-6B Improved Capabilities Three (ICAP III) upgrade to the EA-6B aircraft. The ICAP III modification only includes changes to the weapon system, not to the basic aircraft or non-weapon system avionics. In order to reduce program risk and shorten the acquisition timeline a decision was made to retain much of the ICAP II functionality. Germane to this thesis was the decision to retain the “Zone” structure of the ICAP II display interface (discussed in detail at the end of this chapter).

EA-6B aircraft avionics (with the exception of the weapons system) have changed little since the aircraft was introduced over 30 years ago. The first significant avionics upgrade was Block 89A which added a first generation glass cockpit characterized by an electronic flight information system (EFIS) and flight management system (FMS) but did not address the system of aircraft alerts. The aircraft alert system is better described as the "classic" cockpit which is characterized by a simple caution and warning system that covers only the most critical system failures (Arbuckle, Abbott, & Schutte, 1998). There is virtually no integration between weapon system and aircraft alerts.

DESCRIPTION OF THE EA-6B AIRCRAFT

The EA-6B aircraft is a four-place, twin-engine, mid-wing monoplane manufactured by the Grumman Aerospace Corporation (now Northrop Grumman), Bethpage, Long Island, New York. The aircraft, designed for carrier and advanced base operation, is a modification of the basic two-place A-6 airframe. The aircraft is an integrated electronic warfare weapon system that combines long-range, night vision and all weather capabilities with an advanced electronic countermeasures system. A forward equipment bay and a pod shaped fairing on the vertical fin house the additional avionics equipment. The side-by-side cockpit arrangement is designed for maximum efficiency, visibility, and comfort. The aircraft is characterized by a large nose radome and swept back wings (EA-6B NATOPS).

The aircraft is separated into two cockpits, forward and aft. Each cockpit seats two crewmembers. The front cockpit accommodates the pilot and an electronic countermeasures officer (ECMO). Aircrew in the forward cockpit have historically been responsible for flying the aircraft, navigation, communications, and communications countermeasures. The aft cockpit seats two ECMOs who have historically been responsible for electronic surveillance and electronic attack. This historical division-of-labor developed because the ICAP II version of the aircraft only has controls and displays for the ALQ-99 receiver and jamming system in the aft cockpit. The ICAP III version of the EA-6B adds controls and displays to both cockpits (discussed in more detail later in this chapter).

MISSION OF THE EA-6B AIRCRAFT

The mission of the EA-6B aircraft is to provide electronic warfare support for joint and coalition forces. Electronic warfare support includes electronic attack, and electronic support. In the case of the EA-6B, "electronic attack" refers to radar and communications jamming and employment of High-speed Anti Radiation Missiles (HARM). Electronic support refers to collection, recording and dissemination of electronic signals of interest. The EA-6B performs these mission areas in several mission scenarios which include Suppression of Enemy Air Defense (SEAD), offensive counter air, deep strike, war at sea, electronic warfare in support of close air support, surface search coordination, force protection of the battle group, and intelligence preparation of the battle field.

DESCRIPTION OF THE ICAP III EA-6B AIRCRAFT

The EA-6B ICAP III aircraft is a weapon system upgrade from the ICAP II version of the EA-6B aircraft. The ICAP III upgrade consists of a "kit" which is used to modify an existing ICAP II Block 89A EA-6B aircraft. Figure 1 depicts the ICAP III system block diagram.

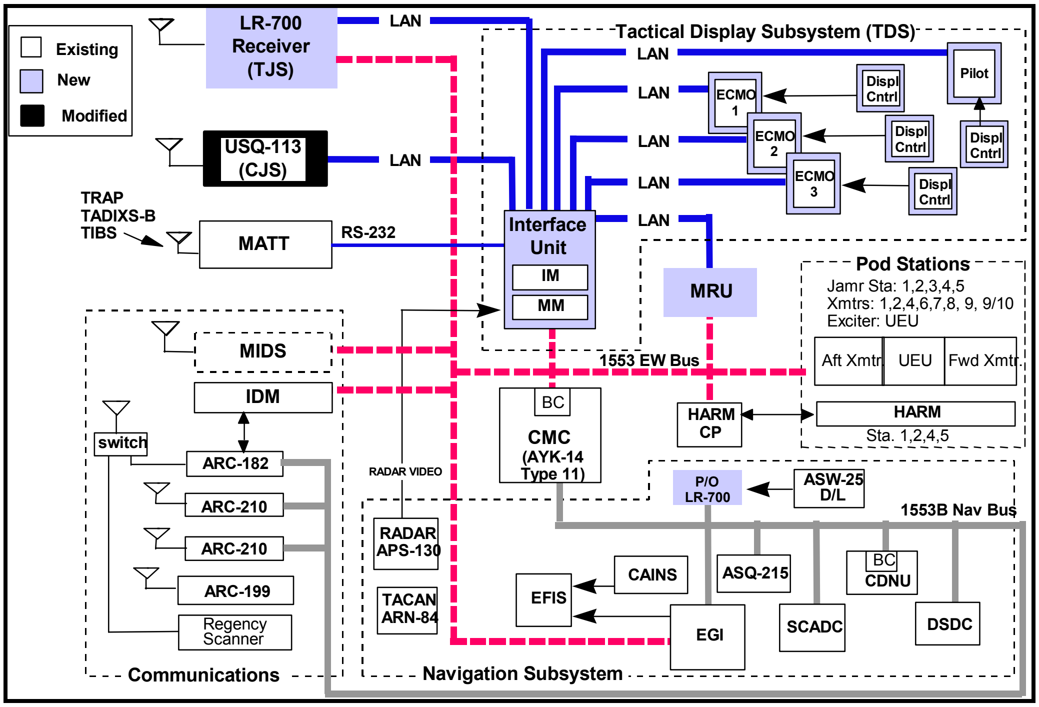

Figure 1. ICAP III SYSTEM BLOCK DIAGRAM (EA-6B NATOPS).

The aircraft is modified to the ICAP III configuration by:

1. Removal of the ICAP II receiver system and installation of the AN/ALQ-218 receiver system along with associated upgrades to the processing equipment.

2. Removal of the ICAP II Digital Display Indicators, the APS-130 radar Pilot's Horizontal Display (PHD) and ECMO 1 Direct View Radar Indicator (DVRI), and installation of color displays at each crew station. The new color displays along with the associated interface equipment are referred to as the Tactical Display System

(TDS). The APS-130 radar display is presented on the new color displays at each crew station.

3. Removal of the current data loader/recorder and installation of the Mission Reprogramming Unit (MRU), also known as the Data Storage Memory Unit (DSMU).
4. Integration of the USQ-113 V(3) Radio Countermeasures Set (RCS) into the display and control system.
5. Integration of the Improved Data Modem (IDM) into the display and control system.
6. Integration of the Multi-Mission Advanced Tactical Terminal (MATT) into the display and control system.
7. Provisions (wiring, installation, space, power, and cooling) for the Multifunctional Information Distribution System (MIDS).
8. Relocation of the ARA-63 Instrument Landing System (ILS) antenna by less than two inches.
9. Removal of the Interface Control Unit (ICU). The functions previously performed by the ICU will be performed by a portion of the AN/ALQ-218 tactical jamming system receiver (TJSR). (EA-6B NATOPS)

In addition to the changes mentioned above, several Weapon Replaceable Assemblies (WRAs) have been removed and their functions replaced within components of the systems listed above. The removed WRAs include the A/D converter, junction box A, forward and aft power supplies, and the computer interface unit/encoder CIU/E.

From the crew interface perspective the largest change between the ICAP II and ICAP III systems is the addition of controls and displays for the ALQ-218 tactical jamming system receiver (TJSR) and ALQ-99 jammers to the forward cockpit. All four ICAP III displays are color liquid crystal displays (LCDs). ICAP III has a display located at each crew station in the front and aft cockpits. By comparison the two ICAP II displays are monochrome green cathode ray tubes (CRT) located at the crew stations in the aft cockpit only.

DESCRIPTION OF EA-6B DISPLAY FORMATS

The ICAP III displays are formatted in "Zones" which serve to separate the larger display area into discrete regions by general function. The Zones are depicted in Figure 2 below. While there are no hard rules for functions or information contained in the Zones, some generalizations do apply. Zone 1 is primarily software buttons that change the display or activate other functions. Zone 2 is display of frequency bands or target track information. Zone 3 is the display of primary information. Zone 4 is display of ALQ-99 jammer pod information. Zone 5 is display of secondary information and where text or numerical values are entered. Zone 6 is for display of textural alerts, aircraft position information, and other ancillary information. The bottom left corner of Zone 6 is the primary location for weapon-system text alerts. Some form of alert information is presented in every zone of the displays except Zone 5.

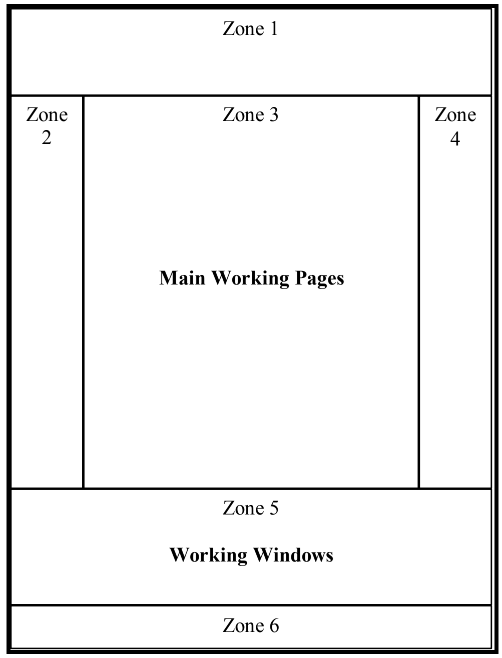

Figure 2. ICAP III DISPLAY ZONES (EA-6B NATOPS).

CURRENT ICAP III DISPLAY COLOR CONVENTION

The current ICAP III color convention uses display color to differentiate detected emitter function. Detected emitters are displayed in red, yellow or green based on the relative threat of the function they perform. For example, engagement radars such as missile guidance or target illumination radars would be displayed in red. Target acquisition radars would be displayed in yellow, and long-range search or height finding radars would be displayed in green.

CHAPTER 2: PROBLEM DEFINITION

DEFINITION OF ALERT

For the purposes of this thesis "alert" will be defined as the attempt to notify the crew of a condition requiring their attention and possible intervention. It naturally follows that conditions requiring alert will be those conditions, which if unrecognized by the crew, could have a negative impact on the safety or success of the mission.

DESCRIPTION OF CONDITIONS REQUIRING ALERT

AIRCRAFT-SYSTEM ALERTS

To aid further discussion, aircraft-system alerts will be differentiated from weapon-system alerts. Simply put, aircraft-system alerts will refer to those alerts which do not involve the weapon system. Examples of such alerts include the fire lights panel, caution lights panel, and forward-cockpit ladder lights panel. These alert locations indicate fire, failure of critical systems such as hydraulics or generators, low fuel or oil quantity, or fuel pressure problems. They also indicate condition of systems. The ladder light panel for example indicates the status of the automatic carrier landing system.

Thirty years of iterative design have provided the current aircraft-system alert design. Over time alerts have been added in response to lessons learned from operational use. Because the ICAP III upgrade only changes the weapon system and does not include any changes to the basic aircraft systems there is no need (or opportunity) to modify the existing aircraft-system alerts. It is important however, to understand the basic aircraft-system alerts because the weapon-system alerts generated by ICAP III (and the focus of this thesis) must make sense in the context of the overall aircraft alert scheme.

WEAPON-SYSTEM ALERTS

Within the ICAP III weapon system there are many conditions which require crew attention. Many of these conditions are carried-over from the ICAP II system although the complexity of the AN/ALQ-218 has increased the number of alerts required. Examples of conditions requiring alert include jammer failure, other system failures, changes in jammer status not involving failures, failure to execute crew instructions due to error checking, or any other state requiring crew attention.

CURRENT ALERTS

AIRCRAFT-SYSTEM ALERTS

Aircraft-system visually displayed alerts are presented in the forward cockpit only. Warnings are displayed as red lights and consist of the fire and wheels warning lights. Aircraft-system cautions are centered around a caution lights panel with individual lights for various aircraft systems. These lights advise of aircraft system malfunctions or indicate a particular condition of the applicable system (EA-6B NATOPS). Caution lights are yellow. There are also “master caution” lights on the upper instrument panel on both sides of the front cockpit. The master caution lights flash whenever one of the lights on the caution lights panel is illuminated. The master caution lights can be extinguished once recognized by the crew, but the light on the caution lights panel will remain on until the condition is corrected. Advisory lights are presented on the “ladder lights panel” and provide advisory information on the status of the automatic carrier landing system. The advisory lights on the ladder lights panel are green. Figure 3 shows the location of all alert lights in the EA-6B front cockpit.

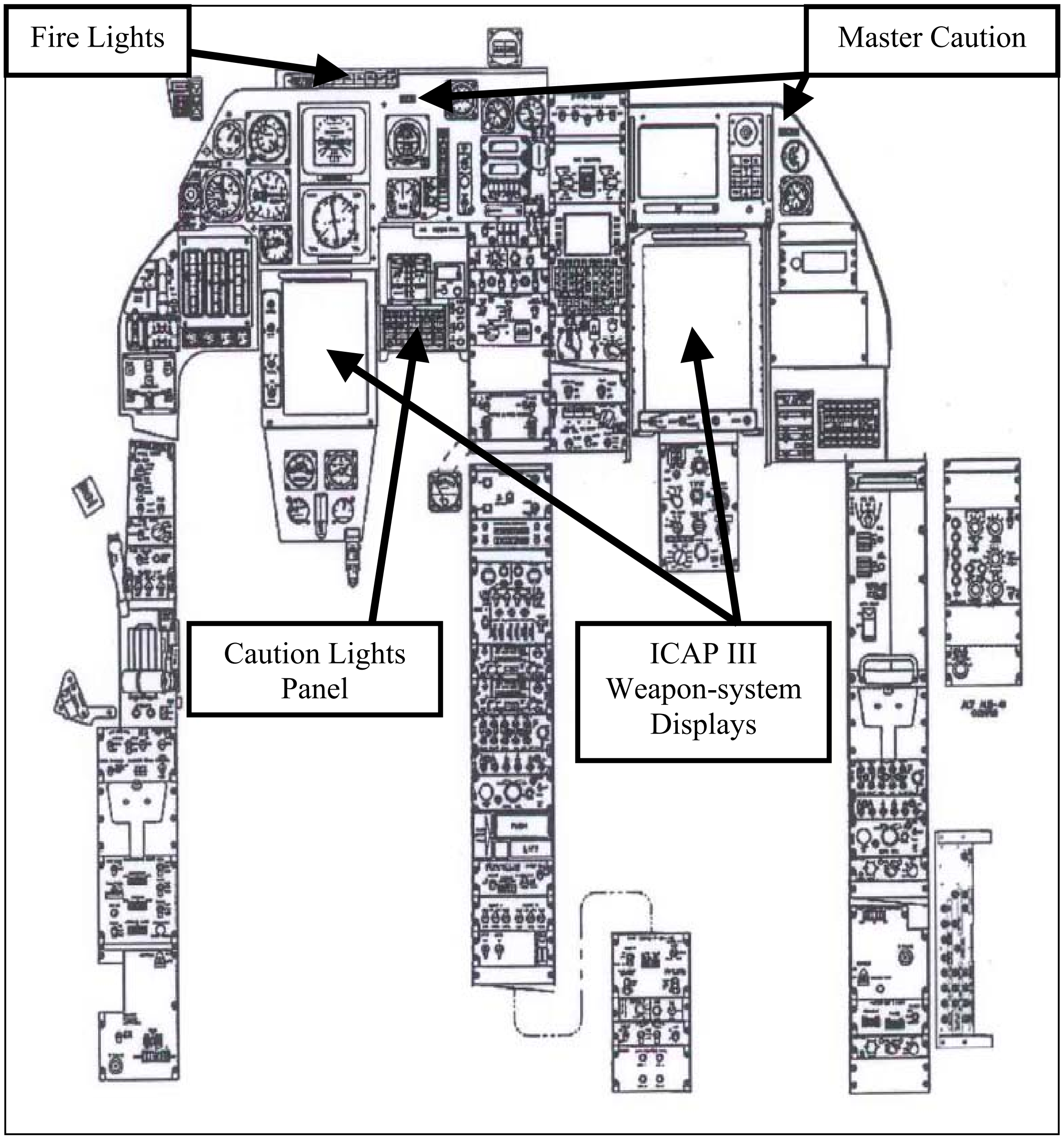

Figure 3. ICAP III FRONT COCKPIT ALERT DISPLAY LOCATIONS (ICAP III Weapon System Operator's Manual, 2003).

The only auditory alert displays are a low altitude warning tone (when the aircraft descends below the altitude set on the radar altimeter) and a stall warning horn (when angle of attack exceeds 21 units). Auditory warnings are displayed to all four crew positions.

WEAPON-SYSTEM ALERTS

All current ICAP III alerts are shown in Appendix A. The alerts are currently grouped by the display-zone in which they are displayed. They are further subcategorized by hardware or mission-area affected (listed as "function" in the appendix). Other than limited color-coding, no effort has been made to group alerts by severity (advisory, caution or warning).

The original design only incorporated Zone 6 text alerts and Zone 4 jammer alerts. Throughout the test-analyze-fix development process other alerts were added to Zones 1 and 6. These additions were to address initial omissions or to provide enhanced visibility into system health. Because of the tight schedule, little human factors analysis, prototyping or design iteration was completed as these alerts were added.

Because the alerts list in Appendix A is largely a carry-over from ICAP II, with additions for the AN/ALQ-218 system, it is very comprehensive for a new weapon system. Opportunity for both consolidation and reduction exists since the list has only been through one iteration since it was originally generated. The greater number of alerts, and the addition of color displays, present both a need and opportunity to improve alert presentation.

PROBLEM STATEMENT

The aircraft system and its related alerts are more mature than the weapon-system alert scheme. There is also no opportunity to change the existing aircraft system alerts because the ICAP III upgrade only affects the weapon system, not the basic aircraft systems. Discussion of the existing aircraft-system alerts is germane since they form the background context in which the weapon-system alerts must be interpreted (both from a design perspective and as encoded by the crew). In human factors terms, alerts presented anywhere in the aircraft (aircraft or weapon system related) should be consistent and compatible. Since the aircraft-system alerts are not likely to change they become a driving factor for the weapon-system alert design.

The primary challenge addressed by this work will be improvements to the weapon-system alert displays to correct potential deficiencies identified during developmental testing of the ICAP III aircraft. The weapon-system alerts described in the previous paragraphs are not prioritized relative to each other. Resulting in the last alert generated being displayed on top of previous alerts regardless of severity. There is no differentiation between severity of alerts by display location or display mode. Alerts are presented in different locations of the display. Some alerts, which are advisory in nature, are displayed at the top level while more critical alerts require several button actuations to view. Color is not always used to display alert severity consistent with sound human factors engineering practices or the ICAP III color convention. Finally, there has been little consideration given to integrating aircraft and weapon-system alerts.

CHAPTER 3: REVIEW OF THE LITERATURE

ICAP III SYSTEM PERFORMANCE SPECIFICATION

The Electronics Performance Requirements For EA-6B ICAP III Aircraft Systems Performance Specification (SPS) dated 14 August 2003, under the heading of SPS-2131 states the requirements quite simply as, “(U) Operator alerts”. This obviously gives wide latitude to satisfy the requirement.

F/A-18 DOCUMENTS

The F/A-18E/F aircraft provides four levels of cuing for the purpose of alerting the crew to critical aircraft status situations. These are defined as follows from lowest to highest priority: advisories, cautions with master caution tone and master caution light, cautions with voice alert and master caution light, warnings with voice alert (H2E System Configuration Set, 2003). The F/A-18E/F alert strategy would be described as a “first generation” glass cockpit. The primary characteristic of a first generation glass cockpit alert system is a “strict hierarchy of warnings (immediate crew action required), cautions (immediate crew awareness and future action required) and advisories (crew awareness and possible action required)” (Arbuckle, Abbott & Schutte, 1998).

WARNINGS

Warnings indicate system malfunctions requiring immediate action. The F/A-18E/F convention is to display warnings as red warning lights with voice alert (F/A-18E/F NATOPS).

CAUTIONS

Cautions indicate malfunctions requiring attention but not immediate action. The F/A-18E/F convention is to display cautions in larger characters than the advisory displays and immediately above the advisory displays (F/A-18E/F NATOPS). For certain critical aircraft functions, voice alerting is provided to enhance the level of aircrew cuing. For cautions in this category, a voice alert message is provided in lieu of the Master Caution tone (H2E System Configuration Set, 2003). Caution lights are yellow in the F/A-18 aircraft.

ADVISORIES

Advisories indicate safe or normal conditions and supply information for routine purposes. The F/A-18E/F convention is to display advisories at the bottom of the display preceded by "ADV". Advisory lights are green in the F/A-18 aircraft (F/A-18E/F NATOPS).

FAA DOCUMENTS

Because of the proliferation of complex integrated avionics the FAA has issued guidance to "facilitate the identification and resolution of human factors/pilot interface issues" (FAA N8110.98, 2002). One of the areas covered is warnings, cautions and advisories of such systems. Even though military aircraft are not generally subject to FAA certification, there are valuable lessons to be learned from civil experience and guidance.

The FAA addresses four primary areas. The first area addressed is determination of which system generated the alert. This is particularly important as the complexity of modern systems increases. This is addressed in Advisory Circular 25.1309-1A which requires “systems, controls and associated monitoring and warning means must be designed to minimize crew errors”. To this end warning, caution and advisory messages should be clear, concise and easily interpreted (FAA N8110.98, 2002). The second area discusses the limited space available on modern displays and the need to prioritize which alerts occupy the limited space when multiple alerts are generated by the system. The third area discussed is use of color. FAA advice with respect to color states, “a warning should be generated when immediate recognition and corrective or compensatory action is required; the associated color is red. A caution should be generated when immediate crew awareness and subsequent crew action is required and subsequent crew action will be required, the associated color is amber/yellow” (Advisory Circular (AC) 25-11). The final area addressed is differentiation. The FAA advises alert messages should be differentiated from normal indications. Specifically, “ abnormal indications should use techniques like shape, size, color, flashing, boxing, outlining, etc. to make them stand out from normal indications” (Advisory Circular (AC) 23.2311-1A).

HOFFER THESIS

In his thesis titled “Implementing operator-centric cockpit design in the EA-6B ICAP III aircraft” Thomas Hoffer identified a subset of the problem addressed by this work. He wrote, " critical weapons system failure alerts can go unnoticed by the ECMOs." He further defined the critical alerts as, “power degrades to an unacceptable level on any jammer transmitter, antenna steering of a jammer transmitter varies by more than 5 degrees from the commanded steering, electrical power from the pod RAT is interrupted, or antenna beam width limitations are exceeded." The identified failures were only deemed critical when the MASTER RADIATE switch was in the RADIATE position, allowing the jammers to transmit. He went on to recommend these alerts be presented to the crew by "a voice warning system using synthesized speech technology to present a non-gender, distinctive, mature voice that will present the messages in a formal and impersonal manner". His research suggested a message consisting of a "0.5 second non-voice aural alerting tone followed by a voice message consisting of three to four syllables with a duration of not less than 1 second or more than 3 seconds" would be the optimal format. His design recommendations were based on EA-6B Block 89A configuration with the AN/AIC-14A analog Inter-cockpit Communications System (ICS). The Initial Operating Capability (IOC) of the ICAP III aircraft will be Lot I configuration with the AN/AIC-45 digital ICS which has an enhanced ability to generate the types of auditory displays recommended (Hoffer, 2000).

HUMAN FACTORS TEXTS

HUMAN FACTORS IN THE S/W DESIGN PROCESS

The primary human factors consideration in software design is the interface. The interface is also one of the last functional stages of design (Meister & Enderwick, 2002) and often occurs (at least in part) during the test phase. This is largely due to the dependant and iterative nature of interface design.

The importance of this iterative cycle has been described as, "a critical component of the user testing and prototyping development cycle" (C. Marlin Brown, 1998). It's important to note the design presented by this thesis will not be the final stage of this iteration. "Problems discovered in a test cycle must be addressed in a revised design (the purpose of this work) then the revised design must be tested. Otherwise, there is no guarantee that the revised design is better than the original" (Brown, 1998). Prototyping and usability testing of a proposed design is beyond the scope of this work. However, "the effect of redesigns can be enhanced if, as criteria, they are buttressed by quantitative design relevant human factors research" (Meister & Enderwick, 2002). This chapter clearly seeks to provide such buttressing.

DESIGN GUIDELINES

Display

The term display can be used to describe almost any indirect form of presenting information. Examples include visual, auditory, tactile and olfactory, often referred to as display modalities (Sanders & McCormick, 1993).

Display Format

For our purposes "format" will be used to describe where information is displayed. This is in contrast to "method" (discussed next) which will be used to describe how information is displayed. An important principal when discussing display format is the principal of consistency. Consistency refers to maintaining the same style of interaction throughout operations (Meister & Enderwick, 2002). For visual displays there are several methods available to help achieve consistency. These include reserved display areas which use fixed display locations or screen areas for the same information. These can be broken down into two types, invariant fields and functional category fields (Brown, 1988). An invariant field stays the same on every screen or page (Engel & Granda, 1997). A functional category field is reserved for certain types of data (Engel & Granda, 1997). Another important factor is "data order" which refers to arranging items in some recognizable or useful order. The data order strategy of "Importance grouping" makes the most sense for alert displays. Importance grouping refers to the arrangement of the most significant information, or that requiring immediate response, at the top of a list (Brown, 1988).

Display Method

As previously stated, "method" will be used to describe how information is displayed. Because the ICAP III aircraft has no capability to generate tactile or olfactory displays only visual and auditory display methods will be discussed. Within the visual and auditory categories, only display methods available consistent with operation aboard tactical aircraft will be discussed. In general this means displays which can be generated by cathode ray tube (CRT) or liquid crystal display (LCD) type technologies, or digital inter cockpit communications (ICS) systems.

Visual Display Methods

Many techniques are available to differentiate alerts from other information presented on the visual displays. The presence or absence of a display window or field may be used to indicate the presence or absence of any type of alert. For example if the alert window is displayed there is an alert present. If the window is absent there are no alerts.

Within the alert window various strategies may be employed to help quickly determine the relative severity of alerts. These include color, text size, text font and text effects like blinking, highlighting, and reverse video. These techniques can be employed separately or used in combination. Caution must be exercised to avoid over use of attention getting techniques to avoid visual discomfort. This is especially true for blinking and highlighting (Brown, 1988).

Auditory Display Methods

"In selecting or designing displays for transmission of information in some situations, the selection of the sensory modality is virtually a forgone conclusion. Specifically, the unique features of the auditory system make auditory displays especially useful for warnings and alarms" (Sanders & McCormick, 1993). This isn't to say auditory alerts should be used without regard to the system in which they will be integrated. In particular, the following rules-of-thumb apply to presentation of auditory displays: "avoid extremes of auditory dimensions; establish intensity relative to ambient noise level; use interrupted or variable signals; do not overload the auditory channel" (Sanders & McCormick, 1993). These rules are particularly important in an EA-6B cockpit where the crew's auditory channel is heavily loaded listening to three radios and four crewmembers on the ICS.

WEB PAGE USABILITY

The ICAP III displays are modified commercial hardware with interface designs based on (and limited by) a commercial software architecture. Multiple pages (breadth) and layers (depth) of information are also displayed. This format is similar to commercial web site design where related pages of information are linked together and must be navigated. As such the design challenges for the ICAP III displays are similar to commercial web page design. It follows that factors important to effective design of web sites should be useful in optimizing the ICAP III interface. The following information was taken from the web site http://www.humanfactors.com.

> One conclusion drawn from studies of web page navigation is that color similarity has a stronger perceptual influence than common region, proximity, or grouping (Beck and Palmer, 2002). A similar but more generalized conclusion was that effective sub-grouping reduces perceived breadth and grouping navigation elements by theme improves performance for even the broadest structures. Creating clear and distinct labels for navigation elements enhances performance. Lastly, users only perceive / encode (change in) elements of the display that they are directly focused on (Simon & Chabris, 1999).

CHAPTER 4: METHODOLOGY

This work seeks to utilize a design approach described as, "*Hill climbing* from a predecessor artifact." This is defined as, "Design decisions motivated by an analysis of the strengths and weaknesses of an existing system in terms of functionality, interface techniques, or tasks implied by these. A perceived problem may be fixed or a new feature added" (Meister & Enderwick, 2002). Tools to complete this analysis include the authors experience in more than 150 hours of ICAP III flight test and interviews with other experienced aircrew to define the conditions requiring alert. Once defined, the same methodology was used to separate alerts by severity into the categories of warnings, cautions and advisories as defined earlier. Finally, a review of military standards, F/A-18 design standards, FAA documents, a related thesis by Thomas Hoffer, human factors texts, web page usability texts and the author's extensive experience in EA-6B ICAP III and F/A-18G design was used to make recommendations for design improvement of the ICAP III alert system.

CHAPTER 5: RESULTS AND DISCUSSION

Like many modern weapon-system interfaces, the ICAP III crew vehicle interface is a complex, software controlled fusion of a tremendous amount of information. Containing a great amount of information both on the primary display pages (breadth) and nearly an equal amount of information available by selecting sub-displays (depth). As such the display interface has usability challenges similar to an internet web page. The tools available to meet these challenges are also similar because the ICAP III display hardware, and much of the underlying software, are commercial-off-the-shelf and therefore similar to that used in commercial internet applications.

INTEGRATION

This modern, commercial-based interface must also be integrated into the reality of the existing EA-6B cockpit. Weapon-system alerts have to make sense in relation to the existing aircraft-system alerts. For example, it doesn't make sense to have weapon system related warnings, sounding sirens and flashing lights, while the existing engine fire indication is simply a steady red light. While minor modifications to the existing aircraft alert scheme may be possible, to help harmonize weapon-system and aircraft-system alerts, changes to existing aircraft-system alerts will not be addressed in this work.

Prior to the ICAP III upgrade, weapon-system alerts were only presented to the aft cockpit crew, and aircraft system alerts (except for auditory warnings) were only presented to the front cockpit crew. With the introduction of weapon-system controls and displays to the front cockpit, as part of the ICAP III upgrade, this separate cockpit scheme for alert management is no longer necessary; which doesn't necessarily mean it's no longer desirable.

PRIORITIZATION

ICAP III alerts need to be prioritized and the prioritization scheme needs to make sense in the context of the existing aircraft-system alerts. Warnings should be displayed ahead of cautions, which should be displayed ahead of advisories. Within categories (warning, caution or advisory) alerts should be displayed in the order generated. For example when three advisories are generated, the last one generated should be displayed in higher precedence than the first, but after all the cautions or warnings. Warnings and cautions should provide sufficient information at the top level to inform the crew what condition exists and what corrective action is necessary. Advisories should provide sufficient information at the top level to inform the crew what system is affected and where to look for amplifying information if required.

CONSOLIDATION

Because the ICAP III upgrade added more alerts in addition to previously existing ICAP II alerts, and the display interface is only beginning the iterative design process, there is still a need for alert consolidation. Consolidating alerts adds display complexity. In order to get the detail required from a consolidated alert there must be a method to expand for more detail. This expansion could be on the same page creating greater breadth, or on a different page creating more depth. This would force the crew to "navigate" the display to find the detail needed.

By definition warnings and cautions direct action. Therefore, they need to be fairly explicit. This means there is less opportunity for consolidation of warning or caution messages because having the crew search for amplifying information is not desirable when action is required. Unlike warnings and cautions, advisories by definition do not require timely action. In the case of advisories it is desirable to consolidate display at the top level, provided the consolidated alerts are sufficient to direct the crew to a source of amplifying information. Consolidation reduces clutter on the primary display, helps suppress multiple advisories from the same system and reduces crew distraction.

USE OF COLOR

It is clear from almost every source that color is a powerful discriminator. It is also apparent, from FAA regulations and various human factors texts sited earlier, that a powerful learned association exists linking red with danger, yellow with caution and green with normal operations. Both F/A-18 and EA-6B designs use this association when presenting aircraft-system warnings, cautions and advisories. It is also apparent the existing ICAP III weapon-system alerts do not take advantage of this association.

CHAPTER 6: CONCLUSIONS

Several conclusions can be drawn from the preceding discussion. First, alert consolidation and display grouping is required. The effects on display navigation complexity must be assessed. Visual and auditory alert presentation must be integrated into the existing aircraft-system and ICAP III weapon-system architecture. The following paragraphs provide detailed discussion of these areas.

CONSOLIDATION OF ALERTS

Consolidation and clarification of alerts are needed to correct deficiencies identified during ICAP III developmental testing. The existing ICAP III alert strategy has an abundance of poorly associated and overly detailed alerts (Appendix A). The current alerts are also scattered over the entire display area as shown in Figure 4. Appendix B shows the proposed alerts grouped by severity (warnings, cautions and advisories) and the alerts recommended for removal. Note that warnings and cautions have not been consolidated, but advisories have been consolidated where practical. For example, the over fifty Multi-mission Advanced Tactical Terminal (MATT) alerts have been reduced to a single advisory displayed as “MATT”. Figure 4 also shows the recommended location of the alert window described in detail below.

DISPLAY NAVIGATION

The meaning of warnings and cautions is explicit at the top display level and no further navigation is required before taking corrective action. Further detail for

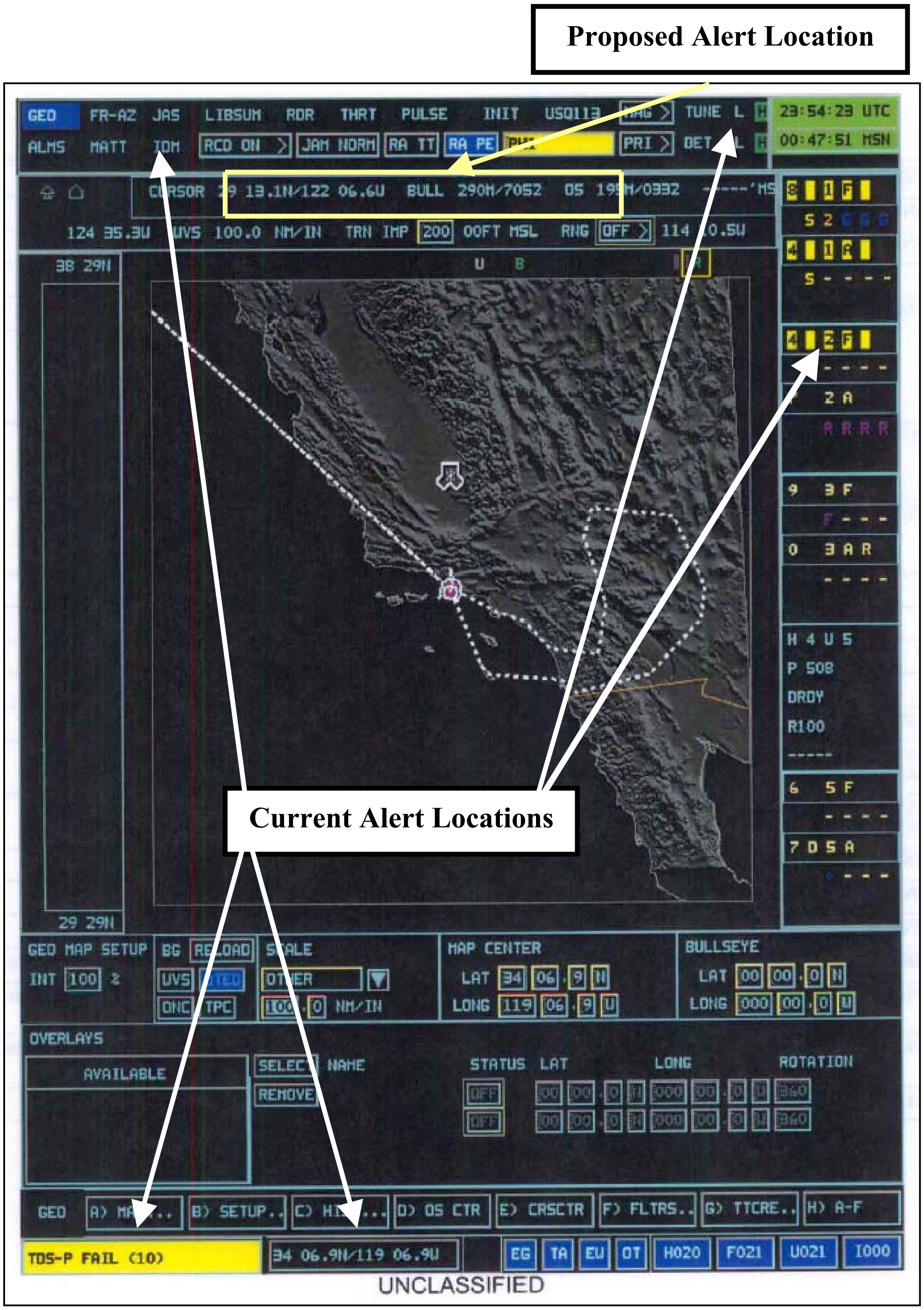

Figure 4. ICAP III CURRENT AND PROPOSED ALERT LOCATIONS. (ICAP III Weapon System Operator's Manual, 2003).

advisories may be obtained by selecting the existing Jammer Assignment Status (JAS) page for jammer advisories, or the existing Built In Test (BIT) page for all other advisories. Therefore display navigation with the proposed alert design is actually simpler and more straightforward than the current design despite the consolidation of alerts and locations.

VISUAL DISPLAY CONCLUSIONS

Alerts will be displayed in a dedicated window placed at the top center of Zone 3 on the existing primary tactical display pages (Figure 4). When no alerts are present the window will be stowed (not displayed). Display on the primary tactical display pages is sufficient because each individual crewmember spends over 80% of their time on these pages, and between all members of the crew one of these pages is selected almost all the time. Auditory display will ensure recognition in the unlikely event that no members of the crew have the primary tactical display pages selected. Auditory display will be discussed in more detail below.

The alert window will be of sufficient size to allow one 16 character alert to be displayed. Warnings will be displayed over cautions which will be displayed over advisories. Within categories the last alert generated will be displayed on top. When more than one alert is present a drop-down arrow [▼] will be placed on the right side of the window indicating more information is available by expanding the window. Placing the cursor on the drop-down arrow and pressing the SEL(select) key on the Aircraft Keyboard Pointing Device (AKPD), or placing the cursor in the alert window and selecting the MENU button on the (AKPD) will “pull down” a larger window showing all active alerts (Figure 5). This expanded displayed will present alerts in the same order discussed above. This function is consistent with other ICAP III window functionality and is already supported by existing software and hardware. Alerts will be displayed as black text, highlighted by the appropriate color for the severity of the alert. Warnings will be highlighted red, cautions yellow and advisories green.

ICAP III ALERT INTEGRATION WITH AIRCRAFT-SYSTEM ALERTS

Aircraft-system alerts potentially reflect danger to the safety of the aircraft. Weapon-system alerts potentially reflect danger to the success of the mission. Fusing

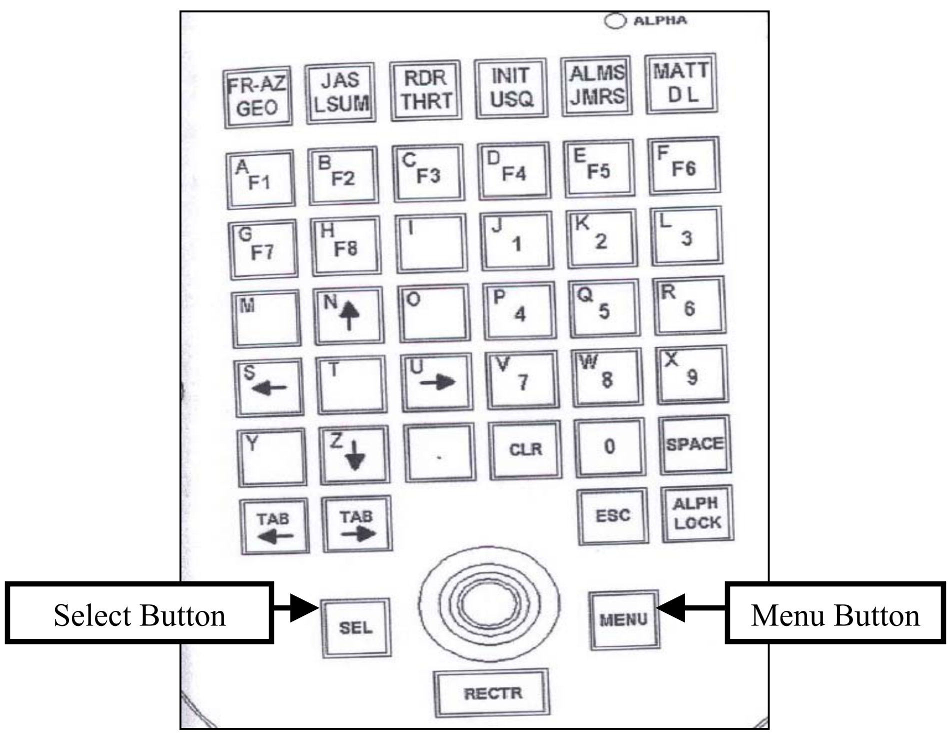

Figure 5. AIRBORNE KEYBOARD POINTING DEVICE
(ICAP III Weapon System Operator’s Manual, 2003).

these two related yet distinct alert types on the same display may seem desirable at first glance. However, having a physical distinction in display location (aircraft-system alerts displayed on dedicated light panels while weapon-system alerts are displayed on the TDS) serves to separate, define and solidify the potential impact.

This isn’t to imply that integration is not needed. A seemingly sensible but suboptimum solution would be reached if the weapon system were viewed apart from the context of integration in the EA-6B. In fact, the EA-6B historic division-of-labor between the front and aft cockpit crews provides a simple and effective solution. Even though the ICAP III modification makes some weapon-system controls and displays available to the front cockpit crew, the aft cockpit crew has most of the controls to correct weapon system related problems.

Current aircraft-system alerts are not selectable by the crew. That is to say they are displayed whenever conditions warrant, cannot be deselected, and are of fixed volume (can not be turned down). This scheme should continue to be followed for any additional auditory aircraft-system alerts added in the future. On the other hand, weapon-system alerts would integrate more easily if they could be selected by the crew. For example the aft crew could elect to hear weapon-system auditory alerts while the front cockpit crew chose not to. Or all three ECMOs could elect to hear weapon-system alerts but the pilot could choose not to. This would allow those members of the crew controlling the weapon system to have auditory cueing of system malfunction without interfering with the forward crew’s (or pilot’s) situational awareness of the aircraft-systems status. This discussion only pertains to auditory alerts, as the visual alerts will be present on all four displays as discussed earlier.

AUDITORY DISPLAY CONCLUSIONS

Whenever conditions exist to generate a weapon-system warning, an auditory display consisting of an interrupted beeping tone of 0.5 second duration (Hoffer, 2000) should be presented to any crew station with weapon-system tone selected on the ICS control panel. The purpose of this tone is to alert the crew to the presence of a weapon-system warning and direct their attention to the visual warning display or to the primary tactical displays if not already selected. If a member of the crew did not have one of the primary tactical display pages selected, those pages could be reached by a single button actuation. The auditory warning would only be displayed once for each occurrence of a persistent weapon-system warning. Because timely action is not required, cautions and advisories would not have an associated auditory alert. If a warning were corrected and then reoccurred the auditory warning would also reoccur.

Voice aural alerts are not recommended for weapon-system alerts for three reasons. First, an interrupted tone is sufficient to alert the crew to the presence of a weapon-system warning, and the visual display can adequately present the needed detail. Second, voice aural alerts could saturate the crew's auditory channel in a cockpit where three radios and four crewmembers could all be presenting voice information to the crew. Lastly, voice aural alerts are more appropriate for safety related aircraft-system alerts. Therefore an interrupted tone weapon-system auditory alert satisfies the requirement for weapon-system related warnings and makes sense in the existing, and possible future, aircraft-system alert schemes.

CHAPTER 7: RECOMMENDATIONS

I recommend NAVAIR PMA-234 identify resources and contract for prototyping of the alert design proposed above. Initial prototyping could be accomplished at the software support activity at Point Mugu, California. Once a prototype has been created developmental testing should be performed to ensure correction of previously identified deficiencies. Usability testing should be conducted to determine the level of improvement over the previous implementation. If necessary another iteration should begin to further improve the design.

A study should be undertaken to determine the feasibility of integrating existing aircraft-system alerts with the AN/AIC-45 digital ICS. Such integration would better align the EA-6B alert system with the existing "first generation" glass cockpit (Arbuckle, Abbott, & Schutte, 1998). It would also harmonize aircraft-system and weapon-system alerts.

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APPENDICES

APPENDIX A
CURRENT ICAP III ALERTS

ZONE 1 ALERTS

ALERT INDICATOR	ALERT MEANING	FUNCTION
BIT Label red	CBIT failure is reported.	BIT
IDM Label red	Own-ship receives an IDM off board Free Text or SEAD message.	IDM
JAS Label red	Assignment Not Made (any reason)	JAM MGMT
MATT Label red	Classified MATT OFP has been loaded, but MATT is determined to be not mission capable	MATT
Own-ship Latitude/Longitude white on red background	No navigation data or invalid latitude/longitude.	NAV
PHASE Dropdown Label background yellow	Phase Transition criteria has been met.	PHASE MISSION
PE RA white on blue background	RA Protected Entity Mode is enabled.	SYS STAT
TT RA white blue background	RA Target Tracks Mode is enabled.	SYS STAT
TUNE Indicator white on red background	No TJSR power, or no IM heartbeat.	TJSR
DET Indicator white on red background	No TJSR power, or no IM heartbeat.	TJSR
TUNE Indicator white on black background	TJSR power AND IM heartbeat.	TJSR
DET Indicator white on black background	TJSR power AND IM heartbeat.	TJSR
TUNE L Indicator white on black background	LR-700 did not complete an Aux Receiver dwell during the last LR-700 Status cycle.	TJSR
DET L Indicator white on black background	LR-700 did not receive Low Band pulse data in Aux receiver during the last LR-700 Status cycle.	TJSR
TUNE H Indicator white on black background	LR-700 did not complete a primary receiver dwell during the last LR-700 Status cycle.	TJSR
DET H Indicator white on black background	LR-700 did not receive pulse data in primary receiver during the last LR-700 Status cycle.	TJSR
TUNE L Indicator black on green background	LR-700 completed an Aux Receiver dwell during the last LR-700 Status cycle.	TJSR
DET L Indicator black on green background	LR-700 received Low Band pulse data in Aux receiver during the last LR-700 Status cycle.	TJSR
TUNE H Indicator white on black background	LR-700 completed a primary receiver dwell during the last LR-700 Status cycle.	TJSR
DET H Indicator white on black background	LR-700 received pulse data in primary receiver during the last LR-700 Status cycle.	TJSR
TUNE L Indicator black on yellow background	LR-700 in Spot Monitor or Selected Video mode.	TJSR

ZONE 4 ALERTS

ALERT INDICATOR	ALERT MEANING	FUNCTION
Line 1 red background Line 2 red ‘P’	Power loss. XMTR power below threshold.	JAM MGMT
Line 1 yellow background Line 2 yellow ‘S’	Steering Failure. XMTR antenna feedback does not agree with commanded steering.	JAM MGMT
Line 1 red ‘!’	Pod mismatch. Either a UE has been detected with a UEU JT Library loaded, or UEU detected with a UE JT Lib loaded.	JAM MGMT

JAMMER ASSIGNMENT STATUS (JAS) PAGE ALERTS

JAS ALERT TEXT	ALERT MEANING	FUNCTION
INVJT	Assignment Not Made – Invalid Jam Technique	JAM MGMT
NOJMR	Assignment Not Made – No Available Jammer	JAM MGMT
LPRTY	Assignment Not Made – Low Priority	JAM MGMT
FCOFF	Assignment Not Made – FASTCOMM Off	JAM MGMT
CLRD	Assignment Not Made – Assignment Cleared	JAM MGMT
STR	Assignment Not Made –Incompatible Steering	JAM MGMT
PCOFF	Assignment Not Made –PRIORITY CLEAR Off	JAM MGMT
NOCOM	Assignment Not Made –No COM Mode Channel Available	JAM MGMT
NORDR	Assignment Not Made – No Radar Mode Channel Available	JAM MGMT
INCJT	Assignment Not Made –Incompatible Jam Technique	JAM MGMT
POL	Assignment Not Made –Incompatible Polarization	JAM MGMT
MODEF	Assignment Not Made –Mode Switch Failure	JAM MGMT
COMFL	Assignment Not Made – Com Mode Failure	JAM MGMT
RDRFL	Assignment Not Made – Radar Mode Failure	JAM MGMT
-*	Assignment TSA-Modified	JAM MGMT
-F	Assignment FASTCOMM	JAM MGMT

ZONE 6 ALERTS

TEXT ALERT	ALERT MEANING	FUNCTION
REJECT PURGE	IM rejects operator purge request.	AEF MGMT
TDSIU OVERTEMP	TDSIU temperature out of limits	BIT
TDSIU FAIL	TDSIU has failed	BIT
VDP-IM PROC FL	Information management processor has failed	BIT
MM PROC FAIL	Mission management processor has failed	BIT
MIO FAIL	Miscellaneous input/output fail	BIT
TDSIU RSC FAIL	Radar scan converter fail	BIT
TDSIU POWER FL	TDSIU power fail	BIT
TDSIU HUB FAIL	TDSIU LAN hub fail	BIT
MAX LIST	At the time ASGN was depressed to transfer threat listings to the HCP, there existed more than the max allowed listings for the selected block missile.	HARM
POSS MSL EMI	MSL RDY condition with MSTR RAD on and a jammer assignment in band	HARM
CANT ADD LIST	No match found between AEF parameter and threat listings for current HARM code.	HARM
INV HARM PRI	One or more PRIs in Hand-Off-Word Is out of range for the selected Block missile.	HARM
INCOMP MSLBLK	Operator attempted to assign a target packet with a missile block ID that is incompatible with the HCP selected missile.	HARM
LSTNG SHORTD	More than 15 listings, compatible with the selected missile block, were available at the time of assignment to the HCP.	HARM
NO MSL RDY	Attempt to turn on ABL mode with no MSL RDY condition.	HARM
AVOID LAUNCH	Missile selected with Seeker and/or Control Section BIT failure(s).	HARM
RU BSITEONLY	Missile selected with Baro Sensor BIT failure.	HARM
MSTER RAD ON	Attempt to turn on ABL with active high band jamming or activating jamming while ABL is on.	HARM
CNT MTCH FRQ	Attempt to turn on ABL when no listing includes Pre-Launch Frequency.	HARM
TGTSEL FULL	Attempt to create a fifth HARM TGT packet.	HARM

ZONE 6 ALERTS (CONTINUED)

TEXT ALERT	ALERT MEANING	FUNCTION
CHK MSL BLK	The Glide and/or Geo Spec settings that would be displayed in Zone 5 TGTRNG are not compatible with the HCP selected missile that has just had a target packet assigned.	HARM
INAP HARM DA	TJSR or operator designated best fit has changed classification of an AEF for which a HARM target packet has been created.	HARM
IDM MSG RCV ER	An error was detected when the CMC attempted to receive a message from IDM.	IDM
ILLEGAL FREQ	Operator attempts a jammer assignment to Band 1, 2, or extended Band 7 that are not covered by the respective transmitter or the frequency is outside the UEU frequency limits.	JAM MGMT
CANT ASG XX	Operator attempts a jammer assignment and a 1553 data bus transmission error to station XX is detected for 3 successive data transmissions.	JAM MGMT
CANT CLR XX	Operator attempts to clear a jammer assignment to station XX and a 1553 data bus transmission error is detected for three successive data transmissions.	JAM MGMT
POD INTRPT X	Exciter on pod station X has indicated a primary power interruption that results in loss of all jammer assignments in both stations of that exciter.	JAM MGMT
JMRS ASGD XX	Operator performs a Clear Files, CMC IPL or library load when jammer assignments exist on station XX.	JAM MGMT
POD MISMATCH	Library load does not match UE/UEU Pod Load out.	JAM MGMT
PRESS REVAL	The operator attempts to change a FWS priority within the current mission phase or change a target track priority within the current mission phase or designate a target track PHASE PA eligible or ineligible within the current mission phase or load a library that has one or more PHASE PA eligible target tracks in mission phase one.	JAM MGMT
ASGN IN PROG	A low band adjustment is in progress.	JAM MGMT
NO NEW JAM RQMT	Jamming Assignment that will use MNB Jam Strategy but all of the beams are already covered by existing jamming assignment.	JAM MGMT
CANNOT REASSIGN	System cannot do a jammer reassign.	JAM MGMT
INVAL JAM TECH	Operator request DA with invalid jam technique.	JAM MGMT
TRACKER UNAVAL	CMC request LR-700 trackers, and no more trackers available.	JAM MGMT
TTRK NOT IN USE	Operator attempts a jamming assignment to a Target Track that is not in-use, i.e., does not exist.	JAM MGMT
BND SWTCH FAULT	Operator attempts to switch band of a band-switchable XMTR, and status is reported back as not switched.	JAM MGMT
NO ASGN BFR FUL	Jam assignment request results in a not-made, and there is no room in the not-made buffer.	JAM MGMT
CM PR CL ASG	The system clears jamming assignment(s) for any of several reasons.	JAM MGMT
INAP JAMMING	Operator designates a new best fit for an AEF that has current active AA jamming requirement.	JAM MGMT
JAM ASGN	Operator attempts to purge a target track that has jamming assignment.	JAM MGMT
NON EXISTNT CTF	Operator attempts a jamming assignment against a CTF that MM does not have.	JAM MGMT
NON EXISTNT AEF	Operator attempts a jamming assignment against an AEF that MM does not have.	JAM MGMT
JMR BW LIMIT	System determines that two or more jamming assignments on the same transmitter are no longer covered by the transmitter antenna beam width.	JAM MGMT
MATT CTF 80 PCT	MATT CTF is 80% full	MATT
MATT CTF 90 PCT	MATT CTF is 90% full	MATT

ZONE 6 ALERTS (CONTINUED)

TEXT ALERT	ALERT MEANING	FUNCTION
MATT CTF FULL	MATT CTF is full	MATT
M-ILO USER ID	MATT rejects a Log-on/Log-off request	MATT
M-ILO STATE	MATT rejects a Log-on/Log-off request	MATT
M-ILO FORMAT	MATT rejects a Log-on/Log-off request	MATT
M-ILO RPM	MATT rejects a Log-on/Log-off request	MATT
M-ILO PG LEN	MATT rejects a Log-on/Log-off request	MATT
M-ILO DTG	MATT rejects a Log-on/Log-off request	MATT
M-ILO TRAF TYPE	MATT rejects a Log-on/Log-off request	MATT
M-ISM LOGD ON	MATT rejects an SP Manager Log-on/Log-off Request	MATT
M-ISM RMT ONOFF	MATT rejects an SP Manager Remote Log-on/Log-off request	MATT
M-ISM LOG OFF	MATT rejects an SP Manager Log-off Request	MATT
M-ISM RMT FLTR	MATT rejects Activate/Deactivate Filter Request	MATT
M-ISM RMT BYPSS	MATT rejects Activate/Deactivate Filter Bypass Request	MATT
M-ISM RMT TAB	MATT rejects Tabular Print Fields Request	MATT
M-ISM STATE	MATT rejects an SP Manager Log-on/Log-off Request	MATT
M-GLF NOT SPMGR	MATT rejects File Record Request	MATT
M-CIS NOT SPMGR	MATT rejects File Record Request	MATT
M-USP NOT SPMGR	MATT rejects File Record Request	MATT
M-FRP NOT SPMGR	MATT rejects File Record Request	MATT
M-LDF NOT SPMGR	MATT rejects File Record Request	MATT
M-CCF NOT SPMGR	MATT rejects File Record Request	MATT
M-GLF FILE IND	MATT rejects File Record Request	MATT
M-CIS FILE IND	MATT rejects File Record Request	MATT
M-USP FILE IND	MATT rejects File Record Request	MATT
M-FRP FILE IND	MATT rejects File Record Request	MATT
M-LDF FILE IND	MATT rejects File Record Request	MATT
M-CCF FILE IND	MATT rejects File Record Request	MATT
M-GLF NUM EXCD	MATT rejects File Record Request	MATT
M-CIS NUM EXCD	MATT rejects File Record Request	MATT
M-USP NUM EXCD	MATT rejects File Record Request	MATT
M-FRP NUM EXCD	MATT rejects File Record Request	MATT
M-LDF NUM EXCD	MATT rejects File Record Request	MATT
M-CCF NUM EXCD	MATT rejects File Record Request	MATT
M-GLF FIELD	MATT rejects File Record Request	MATT
M-CIS FIELD	MATT rejects File Record Request	MATT
M-USP FIELD	MATT rejects File Record Request	MATT
M-FRP FIELD	MATT rejects File Record Request	MATT
M-LDF FIELD	MATT rejects File Record Request	MATT
M-CCF FIELD	MATT rejects File Record Request	MATT
M-GLF REC NAME	MATT rejects File Record Request	MATT
M-CIS REC NAME	MATT rejects File Record Request	MATT
M-USP REC NAME	MATT rejects File Record Request	MATT
M-FRP REC NAME	MATT rejects File Record Request	MATT
M-LDF REC NAME	MATT rejects File Record Request	MATT
M-CCF REC NAME	MATT rejects File Record Request	MATT
M-GLF USER ID	MATT rejects File Record Request	MATT
M-CIS USER ID	MATT rejects File Record Request	MATT
M-USP USER ID	MATT rejects File Record Request	MATT
M-FRP USER ID	MATT rejects File Record Request	MATT
M-LDF USER ID	MATT rejects File Record Request	MATT
M-CCF USER ID	MATT rejects File Record Request	MATT
M-GLF IN USE	MATT rejects File Record Request	MATT
M-CIS IN USE	MATT rejects File Record Request	MATT
M-USP IN USE	MATT rejects File Record Request	MATT
M-FRP IN USE	MATT rejects File Record Request	MATT
M-LDF IN USE	MATT rejects File Record Request	MATT
M-CCF IN USE	MATT rejects File Record Request	MATT

ZONE 6 ALERTS (CONTINUED)

TEXT ALERT	ALERT MEANING	FUNCTION
M-CIS NOTATION	MATT rejects File Record Request	MATT
M-FRP OWNPOS	MATT rejects File Record Request	MATT
M-CCF ACTIVE	MATT rejects File Record Request	MATT
M-LDF ACTIVE	MATT rejects File Record Request	MATT
M-LDF REFRENCD	MATT rejects File Record Request	MATT
M-IMR RPT TYPE	MATT rejects MATT Report Request	MATT
M-IMR USER ID	MATT rejects MATT Report Request	MATT
M-IMR FILE IND	MATT rejects MATT Report Request	MATT
M-IMR FIELD	MATT rejects MATT Report Request	MATT
M-IMR EXEC FAIL	MATT rejects MATT Report Request	MATT
M-ADF USER ID	MATT rejects Activate/Deactivate Filter Request	MATT
M-ADF STATE	MATT rejects Activate/Deactivate Filter Request	MATT
M-ADF NO GLF	MATT rejects Activate/Deactivate Filter Request	MATT
M-ADB USER ID	MATT rejects Activate/Deactivate Filter Bypass Request	MATT
M-ADB STATE	MATT rejects Activate/Deactivate Filter Bypass Request	MATT
M-CID NOT SPMGR	MATT rejects Correlation Index Distribution List Request	MATT
M-CID USER ID	MATT rejects Correlation Index Distribution List Request	MATT
M-CID CI LIST	MATT rejects Correlation Index Distribution List Request	MATT
M-CID NOT FOUND	MATT rejects Correlation Index Distribution List Request	MATT
M-CIF NOT SPMGR	MATT rejects Correlation Index Filter List Request	MATT
M-CIF CI LIST	MATT rejects Correlation Index Filter List Request	MATT
M-ADR NOT SPMGR	MATT rejects Activate/Deactivate Receiver Request	MATT
M-ADR RCVR ID	MATT rejects Activate/Deactivate Receiver Request	MATT
M-ADR STATE	MATT rejects Activate/Deactivate Receiver Request	MATT
M-ADR CMD FAIL	MATT rejects Activate/Deactivate Receiver Request	MATT
M-ADR LOOP FAIL	MATT rejects Activate/Deactivate Receiver Request	MATT
M-RLC NOT SPMGR	MATT rejects Receiver Link Configuration Request	MATT
M-RLC RCVR ID	MATT rejects Receiver Link Configuration Request	MATT
M-RLC REC NAME	MATT rejects Receiver Link Configuration Request	MATT
M-RCP NOT SPMGR	MATT rejects Receiver Control Parameters Request	MATT
M-RCP RCVR ID	MATT rejects Receiver Control Parameters Request	MATT
M-RCP COMSEC	MATT rejects Receiver Control Parameters Request	MATT
M-RCP RCVR DATA	MATT rejects Receiver Control Parameters Request	MATT
M-RCP MODE DATA	MATT rejects Receiver Control Parameters Request	MATT
M-SID NOT SPMGR	MATT rejects Symbol ID Filter Request	MATT
M-SID DEVICE	MATT rejects Symbol ID Filter Request	MATT
NAV MODE CHG	Navigation Mode has changed or CMC has transitioned into or out of CMC BACKUP MODE.	NAV
NEW PHASE	Indicates that the operator has transitioned from one mission phase to another.	PHS MSN
MRU TOP CARD FL	Operator attempts to initiate recording on a full MRU top card	RECORDING
MRU BOT CARD FL	Operator attempts to initiate recording on a full MRU bottom card.	RECORDING
CMC RESET	CMC	SYS STAT
TGT TRK FULL	Operator attempts to establish the 33rd target track.	SYS STAT
EEPROM CHKSM	CMC EEPROM checksum does not match stored value	SYS STAT
TJSR NO NAV	LR-700 has not received a Nav Data message for a period of time greater than 3 times the nominal Nav data period and has suspended tuning.	TJSR
TJSR SW RESET	LR-700 software has reset in response to an internal error condition or an IM command.	TJSR
TJSR INT RESET	LR-700 software has reset interfaces in response to an internal error condition or an IM command.	TJSR
TJSR AEF FULL	AEF Overload.	TJSR
TJSR PGM LD FL	LR-700 was unable to load an OFP from the MRU.	TJSR

ZONE 6 ALERTS (CONTINUED)

TEXT ALERT	ALERT MEANING	FUNCTION
TJSR MDB FL	LR-700 was unable to load an MDB file from the MRU.	TJSR
TJSR RA REVISIT	The ratio of Need to Revisit interval stays above one for RA sub-bands for more than one second	TJSR
TJSR TER LD FL	LR-700 was unable to load terrain data from the MRU.	TJSR
TJSR MRU COM FL	LR-700 was unable to communicate with the MRU.	TJSR
TJSR NAV INCNST	Nav Data is Valid but inconsistent with previous Nav Data.	TJSR
TJSR WRAx TEMP	ALQ-218 Not Warmed-Up. This alert will be sent if the ALQ-218 has determined that it is sufficiently cold to not achieve full performance.	TJSR

APPENDIX B
PROPOSED ALERTS

WARNINGS

ALERT INDICATOR	ALERT MEANING	FUNCTION
POWER LOSS	Transmitter power below threshold.	Jammers
STEERING	Antenna feedback does not agree with commanded steering.	Jammers
BEAM WIDTH LIMIT	Two or more jamming assignments on the same transmitter are no longer covered by the transmitter antenna beam width.	Jammers

CAUTIONS

ALERT INDICATOR	ALERT MEANING	FUNCTION
PHASE CHANGE	Time to change phase.	Jammers
TJSR TUNING	TJSR high or low band tuning failure	TJSR
POD MISMATCH	Library load does not match UE/UEU Pod Load out.	Jammers
TDSIU TEMP	TDSIU temperature above limit.	TDSIU
TJSR NO NAV	No nav data available to the TJSR.	TJSR
TJSR WRA (X) TEMP	TJSR WRA (X) temperature above limit.	TJSR

ADVISORIES

ALERT INDICATOR	ALERT MEANING	FUNCTION
IDM	An IDM degrade has been detected	IDM
IDM MSG RCV ER	An error was detected when the CMC attempted to receive a message from IDM.	IDM
JAMMERS	A requested jamming assignment was not made. Excuse on the JAS page.	Jammers
MATT	A MATT degrade has been detected	MATT
NAV	A navigation degrade has been detected	NAV
REJECT PURGE	A purge request has been rejected	TJSR
TRACKER UNAVAL	CMC request LR-700 trackers, and no more trackers available.	TJSR
TDSIU	A TDSIU degrade has been detected	TDSIU
MAX HARM LIST	Maximum HARM lists have been reached	HARM
CAN'T ADD LIST	A HARM ELINT modification was rejected	HARM
INV HARM PRI	HARM PRI out of limits	HARM
INCOMP MSLBLK	Operator attempted to assign a target packet with a missile block ID that is incompatible with the HCP selected missile.	HARM
LSTNG SHORTD	More than 15 listings, compatible with the selected missile block, were available at the time of assignment to the HCP.	HARM
NO MSL RDY	Attempt to turn on ABL mode with no MSL RDY condition.	HARM
AVOID LAUNCH	Missile selected with Seeker and/or Control Section BIT failure(s).	HARM
RU B SITE ONLY	Missile selected with Baro Sensor BIT failure.	HARM
MSTER RAD ON	Attempt to turn on ABL with active high band jamming or activating jamming while ABL is on.	HARM
CNT MTCH FRQ	Attempt to turn on ABL when no listing includes Pre-Launch Frequency.	HARM
TGTSEL FULL	Attempt to create a fifth HARM TGT packet.	HARM
CHK MSL BLK	The Glide and/or Geo Spec settings that would be displayed in Zone 5 TGTRNG are not compatible with the HCP selected missile that has just had a target packet assigned.	HARM
INAP HARM DA	TJSR or operator designated best fit has changed classification of an AEF for which a HARM target packet has been created.	HARM

ADVISORIES (CONTINUED)

ALERT INDICATOR	ALERT MEANING	FUNCTION
IDM MSG RCV ER	An error was detected when the CMC attempted to receive a message from IDM.	IDM
ILLEGAL FREQ	Operator attempts a jammer assignment to Band 1, 2, or extended Band 7 that are not covered by the respective transmitter or the frequency is outside the UEU frequency limits.	Jammers
CANT ASG XX	Operator attempts a jammer assignment and a 1553 data bus transmission error to station XX is detected for 3 successive data transmissions.	Jammers
CANT CLR XX	Operator attempts to clear a jammer assignment to station XX and a 1553 data bus transmission error is detected for three successive data transmissions.	Jammers
POD INTRPT X	Exciter on pod station X has indicated a primary power interruption that results in loss of all jammer assignments in both stations of that exciter.	Jammers
JMRS ASGD XX	Operator performs a Clear Files, CMC IPL or library load when jammer assignments exist on station XX.	Jammers
POD MISMATCH	Library load does not match UE/UEU Pod Load out.	Jammers
PRESS REVAL	The operator attempts to change a FWS priority within the current mission phase or change a target track priority within the current mission phase or designate a target track PHASE PA eligible or ineligible within the current mission phase or load a library that has one or more PHASE PA eligible target tracks in mission phase one.	Jammers
ASGN IN PROG	A low band adjustment is in progress.	Jammers
NO NEW JAM RQMT	Jamming Assignment that will use MNB Jam Strategy but all of the beams are already covered by existing jamming assignment.	Jammers
CANNOT REASSIGN	System cannot do a jammer reassign.	Jammers
INVAL JAM TECH	Operator request DA with invalid jam technique.	Jammers
TTRK NOT IN USE	Operator attempts a jamming assignment to a Target Track that is not in-use, i.e., does not exist.	Jammers
BND SWTCH FAULT	Operator attempts to switch band of a band-switchable XMTR, and status is reported back as not switched.	Jammers
NO ASGN BFR FUL	Jam assignment request results in a not-made, and there is no room in the not-made buffer.	Jammers
CM PR CL ASG	The system clears jamming assignment(s) for any of several reasons.	Jammers
INAP JAMMING	Operator designates a new best fit for an AEF that has current active AA jamming requirement.	Jammers
JAM ASGN	Operator attempts to purge a target track that has jamming assignment.	Jammers

ALERTS RECOMMENDED FOR REMOVAL

ALERT INDICATOR	ALERT MEANING	FUNCTION
TRACKER UNAVAL	CMC request LR-700 trackers, and no more trackers available.	Jammers
MRU TOP CARD FL	Operator attempts to initiate recording on a full MRU top card	RECORDING
MRU BOT CARD FL	Operator attempts to initiate recording on a full MRU bottom card.	RECORDING
CMC RESET	CMC	SYS STAT
TGT TRK FULL	Operator attempts to establish the 33rd target track.	SYS STAT
EEPROM CHKSM	CMC EEPROM checksum does not match stored value	SYS STAT

VITA

Major (USMC) Andy “Merk” Mercier, a native of Edgartown, Massachusetts, was commissioned in August 1989 through the NROTC Program at the Worcester Polytechnic Institute where he earned a Bachelor of Science Degree in Mechanical Engineering. Graduating from The Basic School in March 1990, flight school in June 1991, he was designated a Naval Flight Officer in July 1991 at NAS Pensacola, Florida.

After flight school, Maj. Mercier was trained as an EA-6B Prowler Electronic Countermeasures Officer (ECMO) at VAQ-129 in Whidbey Island, Washington. He was assigned to VMAQ-4 in Cherry Point, North Carolina in January 1992 where he completed two deployments to the Western Pacific and one to Sigonella, Italy to support operation “Deny Flight”.

He was assigned to VAQ-129 in Whidbey Island, Washington as an FRS instructor from June 1996 to June 1999. He remained in Whidbey from June 1999 to May 2000 as the requirements technology officer (N83) on the staff of the Commander Electronic Attack Wing Pacific. In this capacity he served as the chairman of the fleet project team responsible for operator input to the ICAP III Request For Proposal (RFP), and chairman of the Aircrew Systems Advisory Panel during ICAP III design. He also served on the ICAP III mission software design IPT.

Maj. Mercier graduated from U. S. Naval Test Pilot School (Class 119) in July 2001. Maj. Mercier was assigned to Naval Strike Aircraft Test Squadron where he served as an EA-6B project officer, EA-6B platform coordinator and currently operations officer. He also serves on the E/A-18G design advisory group.