INCH-POUND

MIL-STD-411F
10 MARCH 1997
SUPERSEDING
MIL-STD-411E
1 MARCH 1991

DEPARTMENT OF DEFENSE
DESIGN CRITERIA STANDARD

AIRCREW STATION ALERTING SYSTEMS

AMSC N/A FSC 15GP

FOREWORD

1. This standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Revision E to MIL-STD-411 was prepared under the auspices of the tri-service and industry Aircrew Station Standardization Panel (ASSP). The document has been updated to reflect current technologies and methods of presenting alerting messages to the aircrew. Guidance has been added and requirements established for electronic displays and night vision imaging system compatibility.

3. Revision F to MIL-STD-411 has been prepared to reflect current DoD policy and procedures for standardization documents used by DoD and is redesignated as a Department of Defense design criteria standard.

4. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Air Warfare Center Aircraft Division, Code 414100B120-3, Highway 547, Lakehurst, NJ 08733-5100, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

CONTENTS

CONTENTS

CONTENTS

CONTENTS

1. SCOPE

1.1 Scope. This standard covers aircraft aircrew station alerting systems including general functions; operational logic; information content of messages; and physical characteristics of the alerting system's visual, auditory, and tactile signals.

1.2 Purpose. The purpose of this standard is to establish uniform aircrew station alerting systems to maximize recognizability. The use of new technology is encouraged where it can be demonstrated that the use of the technology will result in shorter aircrew response times and more effective aircrew action subsequent to presentation of the alert.

1.3 Applicability. The requirements specified herein apply to all aircrew station alerting systems in aircraft acquired by the Department of Defense.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, and 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3, 4, and 5 of this standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

DEPARTMENT OF DEFENSE

MIL-S-9320	-	Signal, Warning, Audible, for Headset, Type MA-1
MIL-M-18012	-	Markings for Aircrew Station Displays, Design and Configuration of
MIL-C-25050	-	Colors, Aeronautical Lights, and Lighting Equipment, General Specification for
MIL-L-25467	-	Lighting, Integral, Red Aircraft Instrument, General Specification for
MIL-L-85762	-	Lighting, Aircraft, Interior, Night Vision Imaging System (NVIS) Compatible

STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-203	-	Aircrew Station Controls and Displays: Location, Arrangement and Actuation of, for Fixed Wing Aircraft
MIL-STD-783	-	Legends for Use in Aircrew Stations and on Airborne Equipment

MIL-STD-1472 - Human Engineering Design Criteria for Military Systems, Equipment and Facilities

(Unless otherwise indicated copies of the above specifications and standards are available from the Standardization Document Order Desk, 700 Robbins Ave., Bldg. 4D, Philadelphia, PA 19111-5094.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Abbreviations and acronyms. The abbreviations and acronyms used in this standard are defined as follows:

a. crt - cathode ray tube

b. db - decibel

c. fc - footcandle

d. fL - footlambert

e. Hz - Hertz (cycles per second)

f. NVIS - night vision imaging system

g. VSTOL - vertical and short take off and landing

h. VTOL - vertical take off and landing

3.2 Alert signal. A signal which alerts the aicrew to the existence of a warning, caution, or advisory condition.

3.3 Angle of incidence. The angle between the line of direction of anything (as a ray of light or line of sight) striking a surface and a line perpendicular to that surface drawn to the point of contact.

3.4 Annunciator. A cueing device which is activated only when required to provide status or condition information of a warning, caution, or advisory nature to the aircrew. An annunciator may be any mechanically, electrically, or electronically driven device used to produce an audio, visual or tactual cue, verbal message, or any similar alerting signal.

3.5 Audio signal. A signal which is heard rather than seen or felt.

3.5.1 Audio caution/master caution signal. An audible signal which indicates the existence of a particular impending dangerous condition requiring attention, but not necessarily immediate action.

3.5.2 Audio warning/master warning signal. An audible signal which indicates the existence of a particular hazardous condition requiring immediate corrective action.

3.5.3 Tone. A sound with definable regularity of oscillation or no oscillation (steady tone).

3.5.4 Voice message. An audio signal with a verbal communication format.

3.6 Contrast and contrast ratio. For the purposes of this standard, contrast (C) is defined as:

$$C = \frac{L(T)-L(B)}{L(B)}$$

where L(T) is the total luminance (image plus background) and L(B) is the luminance of the background portion. Contrast ratio defined as L(T)/L(B) and is one more than the contrast.

3.7 Design eye line. The design eye line is a segment of the over the nose vision line connecting two points which represents the predicted eye positions of the extremes of the aircrew population.

3.8 Design eye position. The design eye position is the midpoint of the design eye line from which all crewstation dimensions are related and referenced.

3.9 Display. A device which presents information to one or more aircrew members via one or more of the senses.

3.9.1 Dedicated alert display. A display whose sole purpose is to present alert signals.

3.9.2 Integrated display. A display which can operate in several modes or functions, one of which is the presentation of alert signals.

3.9.3 Transilluminated display. A display in which the light passes from behind the display surface through translucent portions.

3.10 Flag. A visual mechanical or electromechanical device used to show a change in the status of an indicator, instrument, or its associated system.

3.11 Indicator. A display device, usually mechanical or electromechanical, which indicates discrete conditions or status of a system.

3.12 Tactial signal. A signal which is felt rather than seen or heard.

3.13 Visual signal. A signal which is seen rather than heard or felt.

3.13.1 Advisory signal. A visual signal which indicates a safe or normal configuration, condition of performance or operation of essential equipment, or attracts attention and imparts information for routine action purposes.

3.13.2 Annunciator assembly. A grouped assembly of two or more warning, caution, or advisory legend signals arranged categorically or functionally.

3.13.3 Caution signal. A visual signal which indicates the existence of a condition requiring immediate attention but not immediate action.

3.13.4 Legend signal. A visual signal containing alphanumeric characters or symbols.

3.13.5 Master caution signal. A visual signal which indicates that one or more caution signals have been energized.

3.13.6 Master warning signal. A visual signal which indicates that one or more warning signals have been energized.

3.13.7 Nonlegend signal. A visual signal which has no alphanumeric characters or signals arranged categorically or functionally.

3.13.8 Warning signal. A visual signal which indicates the existence of a hazardous condition requiring immediate action to prevent loss of life, equipment damage, or abortion of the mission.

4. GENERAL REQUIREMENTS

4.1 Aircrew station alerting system.

4.1.1 Functional requirements. The following requirements are considered requisites in the design of an effective alerting system:

a. Should not give audible and visible caution and warning alerts when all systems are operating normally.

b. Should reduce aircrew information assimilation and memory demands.

c. Should minimize the time required for the aircrew to detect and to assess failure conditions and to initiate corrective actions.

d. Should provide visual alerts which can be detected and understood easily under high altitude, high ambient light and critical conditions; such as, high-G, high workload, high stress, low light level.

e. Should be standardized to maximize recognizability.

f. Should provide for alerting system growth capability in a form that does not necessitate additional system components.

4.1.2 Selection and presentation of signals.

4.1.2.1 Luminance contrast and levels. Visual signals shall be presented and located to provide a perceptible luminance contrast to minimize the effects of excessive ambient light. At any location, the signals shall have a luminance and contrast that is fully readable and easily recognizable in a 10,000 fc lighting environment.

4.1.2.2 Selection of signals. The selection of signals, visual versus audio, shall be in accordance with MIL-STD-1472. Specific signals shall be provided to furnish the

aircrew all information for operation and maintenance functions as required by the acquiring activity (see 6.3.1). Conditions which fall into the warning, caution, or advisory category shall be based on the aircraft's subsystems, its roles and missions, and the aircrew's information requirements.

4.1.2.3 Presentation of signals. Presentation of signals shall be as specified by the acquiring activity (see6.3.1). Signals shall not be actuated by transient, erroneous, or random sensor signals.

4.1.3 Signal displays.

4.1.3.1 Legends. Legends shall be in accordance with MIL-STD-783.

4.1.3.2 Color. Unless otherwise specified in the contract or purchase order, all colors specified herein shall be in accordance with MIL-C-25050, aviation colors. Color coding of electronic displays shall be used as a coding method. For electronic color displays, chromaticity shall be in accordance with the system specification and shall ensure discriminability of the alert message.

4.1.3.3 Luminance and contrast.

4.1.3.3.1 Transilluminated displays. The luminance level of dedicated transilluminated signals and legends shall be compatible with the expected surrounding luminance and operating conditions and shall have a discernible contrast to ensure that alert messages can be perceived by the crewmember under all expected lighting conditions.

4.1.3.3.2 Electronic displays. The luminance and contrast of electronic displays shall have a discernible contrast to ensure that alert messages can be perceived by the crewmember under all expected lighting conditions.

4.1.3.4 Lettering. All characters shall be upper case except on integrated displays, on which lower case characters may be used. All letters and numbers on dedicated signal assemblies shall be in accordance with MIL-M-18012. Letters and numbers on electronic displays should be in conformance with the labeling requirements of MIL-STD-1472. Character dimensions shall be as specified in 5.2.9.

4.1.3.5 Visual signal flash rate. Flashing presentations should be avoided; however, where they are required for their alerting value, they shall have a flash rate between three to five Hz. The "ON" time shall be approximately equal to the "OFF" time. No more than two flash rates shall be used. Where two flash rates are used, the second rate shall be one to two Hz. Flashing presentations which could be simultaneoulsy active should have synchronized flashes.

4.1.3.6 Test systems. A single test switch shall be provided for testing all dedicated displays and, where possible, all subsystem circuitry within a given crew station. A test switch is not necessary if the function is automated within an integrated alert display. Blank signals, provided for a growth capability on the annunciator assembly shall also be included as part of the test circuitry.

4.1.3.7 Alerting signals. The system should be designed to minimize the effects of undetected, false, or nuisance alerts, or any condition which would cause a crewman to perceive an alert signal to be energized when it is not.

4.1.3.8 Cancellation of master warning/caution signal. The master warning signal and master caution signal shall remain "ON" until it is cancelled by the crewman or cancelled automatically when the problem has been corrected. Audio portions of alerting signals shall be automatically cancelled within ten seconds if not previously cancelled by a crewmember. Upon cancellation, the master warning/caution signal shall be reset automatically to be able to annunciate new alerting situations.

4.1.4 NVIS lighting compatibility.

4.1.4.1 Alerting system. When NVIS lighting compatibility is a requirement, the alerting system shall be in accordance with MIL-L-85762. Compensatory means of attention getting, such as auditory or flashing, may be required to augment the visual signal.

5. DETAILED REQUIREMENTS

5.1 Dedicated signal assemblies.

5.1.1 Signal perception. The legend on light signals, when energized, shall be readable in a 10,000 fc environment with the source illumination striking the face of the display at an angle of incidence of 90 degrees. When not energized, the legend shall not be perceptible in the presence of high ambient illumination.

5.1.1.1 Light signal luminance. The luminance level of dedicated transilluminated signals and legends shall be measured by averaging the readings within small sub-areas of the signal or legend. Readings on an illuminated letter which is a portion of a word or legend, may be averaged if a minimum of three readings taken on separate locations on each letter make up the average luminance. Warning light signal utilizing opaque letters and a translucent background may be divided into a minimum of five approximately equal subareas for determination of luminance compliance. Each subarea (containing at least three separate readings, which may be averaged) shall individually meet the luminance requirements. All legends shall be capable of being read in bright sunlight. The average contrast ratio of any lighted legend to the background shall be 2.0 minimum when the display is subjected to ambient illumination of 10,000 fc at 5,000 ± 500 degrees Kelvin color temperature. The contrast ratio of any unlighted legend to the background shall be less than 0.1 for any legends, which are slightly visible.

5.1.2 Location and arrangement of signals. The location and arrangement of dedicated warning, caution and advisorty signals shall be in accordance with MIL-STD-203 or as specified by the acquiring activity (see 6.3.1). Warning signals shall be installed within the pilot’s 30 degree (total included angle) forward cone of vision. When space is limited or the required number of warning signals is excessive, warning signals may be grouped outside of the pilot’s 30 degree forward cone of vision, provided a master warning signal is installed within the pilot’s 30 degree forward cone of vision. Additionally, the master caution signal shall be located within the pilot’s 30 degree forward cone of vision.

5.1.3 Warning signals. When required, legend warning and master warning signals shall be used in all aircrew stations. A master warning signal, when required, shall be energized simultaneously with any individual warning signal.

5.1.3.1 Color. Except where NVIS compatibility is required, the color of the warning signals shall be aviation red. Where NVIS compatibility is required, the color of the warning signals shall be in accordance with MIL-L-85762.

5.1.3.2 Legend. Except when NVIS compatibility is required, the warning legend, when energized, shall be opaque on a translucent background as shown on figure 1. When NVIS compatibility is required, the legend, when energized, shall be translucent on an opaque background. The character height of the legend shall subtend a viewing angle of not less than 20 minutes of arc when measured from the aft most point of the design eye line (see 3.7). The character proportions shall be in accordance with MIL-M-18012. The minimum horizontal separation between two legends shall be two times the width of the widest character. The minimum vertical separation between two legends shall be two character heights. The minimum vertical separation between two lines in the same legend shall be one-half the height of a character.

5.1.3.3 Luminance. The luminance of light signals shall be not less than 150 fL at the point of entry of the light source when the signals are operated at rated voltage. Not less than two lamps, operated in parallel, shall be employed for each incandescent and light emitting diode type legend warning light. When installed in the flight aircrew station and unless otherwise specified by the acquiring activity (see 6.3.1), lights shall automatically be dimmed to 15 ± 3 fL when the pilot's primary interior light control is "ON". The design shall preclude inadvertent dimming during daylight conditions. When installed in other aircrew stations, the warning lights shall automatically be dimmed to 15 ± 3 fL when the operators primary light control is “ON”. Except when NVIS are being used within a crew station, the dimmed warning lights shall automatically reset to full bright when any of the following conditions exist.

a. Main aircraft power is turned off.

b. Pilot’s primary interior light control is off.

c. High intensity lights are energized.

When an NVIS-compatible lighting mode is selected, the dimmed warning lights shall not reset to full bright when any of the above conditions exist, but shall remain at their NVIS compatible level. When an NVIS compatible lighting mode is being used within a crew station, the lighting circuit logic shall preclude the system from obtaining a luminance level which will degrade external vision or NVIS performance.

5.1.3.4 Presentation. Warning signal presentation in the cockpit shall be steady "ON". An exception to the steady "ON" presentation is the Wheels Warning Legend which must attract the aircrew's attention during a critical mission phase (see 5.1.3.6 and 5.1.3.7). When installed in other aircrew stations, the warning signal presentation may be flashed as specified in 4.3.5.

5.1.3.5 Master warning signal reset. The master warning signal shall have a push-to-reset or voice reset capability which deenergizes the master warning signal while the applicable legend light remains "ON".

5.1.3.6 Wheels warning legend (VSTOL aircraft). A "WHEELS" legend indicator, when specified by the acquiring activity (see 6.3.1), shall be installed and connected so that it flashes whenever the following conditions exist simultaneously:

a. The aircraft is in a landing configuration, as specified by the acquiring activity (see 6.3.1), and,

b. The landing gear is not down and locked.

MASTER CAUTION

TRANSLUCENT AVIATION YELLOW LETTERS AND OPAQUE BACKGROUND

CAUTION

MASTER WARNING

TRANSLUCENT AVIATION RED BACKGROUND AND OPAQUE LETTERS

WARNING

TRANSLUCENT AVIATION GREEN, BLUE OR WHITE LETTERS AND OPAQUE BACKGROUND

ADVISORY

FIGURE 1. Legend presentation.

A time delay, sufficient to allow the the landing gear to fully extend, shall be installed in the wheels warning system to eliminate the nuisance activation and flashing of the "WHEELS" legend indicator.

5.1.3.7 Wheels warning legend (VTOL aircraft). A "WHEELS" legend indicator, when specified by the acquiring activity (see 6.3.1), shall be installed on VTOL aircraft equipped with retractable landing gear. The indicator shall be connected so that it flashes whenever the airspeed and collective pitch (or other combination of functions approved by the acquiring activity, (see 6.3.1), indicate that the VTOL is configured for landing and the landing gear are not down and locked. A time delay, sufficient to allow the landing gear to be fully extended, shall be installed in the wheels warning system to eliminate the nuisance activation and flashing of the "WHEELS" legend indicator.

5.1.4 Caution signals. When required, legend caution and master caution signals shall be used in all aircrew stations. The master caution signal shall be energized simultaneously with any individual caution signal.

5.1.4.1 Color. Except where NVIS compatibility is required, the color of the caution signals shall be aviation yellow. Where NVIS compatibility is required, the color of the caution signals shall be in accordance with MIL-L-85762.

5.1.4.2 Legend. When illuminated, the legend shall be translucent on an opaque background as shown on figure 1. The character height of the legend shall subtend a viewing angle of not less than 20 minutes of arc when measured from the aft most point of the design eye line (see 3.7). Character proportions shall be in accordance with MIL-M-18012. The minimum horizontal separation between two legends shall be two times the width of the widest character. The minimum vertical separation between two legends shall be two character heights. The minimum vertical separation between two lines in the same legend shall be one-half the height of a character.

5.1.4.3 Luminance. The luminance of the light signals shall be not less than 150 fL when the signals are operated at rated voltage at the point of entry of the light source. No less than two lamps, operating in parallel, shall be employed for each incandescent and light emitting diode type legend caution light. When installed in the flight aircrew station, the master caution signal shall be dimmed to 15 ± 3 fL and the caution signals shall be automatically reduced to 1.0 ± 0.50 fL when the pilot's primary interior light control is "ON". Caution signals shall be capable of being dimmed to a luminance of 0.1 fL when NVIS compatibility is required. The design shall preclude inadvertent dimming during daylight conditions. When installed in other aircrew stations, the caution signals shall automatically be dimmed to 15 ± 3 fL when the operator's primary panel light control is "ON". Except when NVIS are being used within a crew station, the dimmed caution signals shall be automatically reset to full bright when any of the following conditions exist:

a. Main aircraft power is turned off.

b. Pilot’s primary light control is off.

c. High intensity lights are energized.

When an NVIS compatible lighting mode is being used within a crew station, the lighting circuit logic shall preclude the system from obtaining a luminance level which will degrade external vision or NVIS performance.

5.1.4.4 Presentation. The master caution signal shall have a steady "ON" light presentation unless a flashing presentation is approved by the acquiring activity (see 6.3.1). All other caution signals shall have a steady "ON" light presentation.

5.1.4.5 Master caution signal reset. The master caution signal shall have a push-to-reset or voice reset capability which deenergizes the master caution signal while the applicable caution signal remains "ON".

5.1.5 Advisory signals. The use of advisory signals in the cockpit area shall be minimized to avoid unnecessary distraction of the aircrew and to minimize those factors which deteriorate night vision capability of the crew. They shall not be used where other methods, such as, switch labeling and mechanical visual signals may be employed. Advisory signals may be either of the legend or nonlegend type. If a nonlegend signal is employed, a readily identifiable legend shall be provided adjacent to, and preferably above, the signal.

5.1.5.1 Color. Except where NVIS compatibility is required, the color of advisory signals in the cockpit shall be aviation green. In other crew stations, advisory signals may be aviation green, aviation blue, or aviation white. The use of blue or white advisory lights should be avoided wherever dark adaptation must be maintained. For NVIS compatibility, the color of advisory lights in all compartments shall be NVIS green A or NVIS green B, as specified in MIL-L-85762.

5.1.5.2 Legend. Legend type advisory signals installed in the crew station shall employ translucent legends on an opaque background as shown on figure 1. The character height of the legend shall subtend a viewing angle of no less than 20 minutes of arc when measured from the aft most point of the design eye line (see 3.7). Character proportions shall be in accordance with MIL-M-18012. The minimum horizontal separation between two legends shall be two times the width of the widest character. The minimum vertical separation between two legends shall be two character heights. The minimum vertical separation between two lines in the same legend shall be one-half the height of a character.

5.1.5.3 Luminance. The luminance of the signals shall not be less than 150 fL when the signals are operated at rated voltage at the point of entry of the light source. In the crew station, advisory signals shall be dimmed to 1.0 ± 0.50 fL when the pilot's primary interior light control is "ON". Advisory signals shall be capable of being dimmed to a luminance of 0.1 fL when NVIS compatibility is required. The design shall preclude inadvertent dimming during daylight conditions. In other crew stations, advisory signal luminance may be greater than 1.0 ± 0.50 fL when ambient conditions so dictate. Except when NVIS are being used within a crew station, the signals shall be automatically reset to full bright when any of the following conditions exist:

a. Main aircraft power control is turned off.

b. Primary interior light control is off.

c. High intensity lights are energized.

When an NVIS-compatible lighting mode is being used within a crew station, the lighting circuit logic shall preclude the system from obtaining a luminance level which will degrade external vision or NVIS performance.

5.1.5.4 Presentation. Advisory signal presentation shall be steady "ON", unless otherwise specified by the acquiring activity (see 6.3.1).

5.2 Integrated alert displays.

5.2.1 Benefit. The benefit of an integrated display for the presentation of warning, caution and advisory messages is that it allows a single location for message presentation. It can present a concise alphanumeric message for each alerting situation, information about the alert urgency level, recommended corrective actions, and feedback to the crew when faults are corrected.

5.2.2 Display type. Display types may include cathode ray tube, plasma, thin film electroluminescent, liquid crystal, or a medium approved by the acquiring activity (see 6.3.1). The requirements herein apply to any type display. The presentation medium used for the information display is left to the discretion of the airframe manufacturer and the acquiring activity (see 6.3.1).

5.2.3 Number and location of displays. The number of displays shall be based upon the informational requirements of the aircrew and the reliability of the displays. Unless otherwise specified, all warning, caution and advisory messages shall be presented within the operator's 30 degree (total included angle) forward cone of vision, on a single display surface. If more than one display is present at a crew station, the display farthest to the left should display all warning, caution and advisory messages. Warning, caution and advisory messages may be presented on a head-up display only with acquiring activity approval (see 6.3.1). The location of the display(s) and the viewing angle(s) should be such that the readability is not degraded, even in illumination up to 10,000 fc through the aircraft windows. If interactive control functions are included with the display, they shall be within the anthropometric reach of the operator using them, as constrained by the crew station installation for the particular air vehicle involved. The requirements for control and display integration and for the specific display under consideration shall be as specified in MIL-STD-1472.

5.2.4 Message presentation. The presentation of warning, caution, and advisory messages shall be as specified herein. Alternate means of communicating warning, caution, or advisory messages that take advantage of integrated interactive technologies may be used when approved by the acquiring activity (see 6.3.1).

5.2.4.1 Warning messages. The presentation of warning messages shall have precedence over caution and advisory messages and routine display information. What constitutes routine display information will be dependent on the aircraft's role, mission and flight phase and shall be approved by the acquiring activity (see 6.3.1). Whenever one or more warning conditions are present, the message(s) shall appear in a location dedicated for the presentation of warning messages. The dedicated location may be at the top or bottom of the display. The warning message location may blank out any display symbology or video, except that which has been determined to be flight critical, when presenting a message. Only the appropriate active warning message(s) shall appear; however, the location for presenting the warning messages shall be large enough to present as many messages as there are warnings within the system. Warning messages shall remain presented until the causative condition has been corrected.

5.2.4.2 Caution messages. The presentation of caution messages shall have precedence over advisory messages and routine display information. Caution messages shall remain presented until either the causative condition has been corrected or the operator takes an action to store the message in overflow memory (see 5.2.5.3) for later recall.

5.2.4.3 Advisory messages. The presentation of advisory messages shall have precedence over routine display information. Advisory messages shall be presented until either the causative

condition no longer exists or the operator takes an action to store the message in overflow memory (see 5.2.5.3) for later recall.

5.2.5 Message format.

5.2.5.1 Syntax. Warning, caution, and advisory messages shall concisely convey the nature of the problem and the specific subsystem or location. A standard syntax is desirable for all messages, but shall be subordinate to a clear statement of the problem if not appropriate.

5.2.5.2 Prioritization. Messages should be grouped by urgency level. Warnings shall be presented at the top of the annunciator area of the display (which may be at the top or bottom of the display), with cautions and advisories following in that order. The acquiring activity shall approve a scheme for ordering alert messages, such as in order of occurrence, in order of priority, within urgency levels (see 6.3.1).

5.2.5.3 Overflow memory. A system to display messages stored in overflow memory shall be used when the number of active messages exceeds the capacity of the display. If there are more messages than there is space to display them all, an indication shall be provided to the operator that additional alerts exist. Any overflow messages shall be stored and a capability shall be provided to recall/scroll through alerts so stored. If a new alert condition arises:

a. The new message shall be placed with messages of equal criticality.

b. If room does not exist on the display, a message of lower criticality shall be replaced. The replaced message shall be moved into overflow. If no lower criticality message exists, a message of equal criticality shall be moved into overflow.

c. Messages placed in overflow shall be grouped with messages of equal criticality.

5.2.5.4 Color coding. When color is used to provide a unique and easily distinguishable coding method for all three alerting categories, red shall be reserved for warning messages, yellow shall be reserved for caution messages and a third color (green preferred with blue and white as non-flight deck options) shall be used to represent advisory level messages. The chromaticity of the third color shall be significantly different from the chromaticities of the red and yellow signals. All three selected colors must be different enough from the background color so that symbols and words are easily readable.

5.2.5.5 Minimum message duration. It is possible for a warning or caution condition to exist for such a short period of time that a crew member may not have a chance to identify the condition, even though the condition has been cured or otherwise ended. Therefore, a minimum message display time of three seconds is required for all warning and caution messages.

5.2.6 Options and control.

5.2.6.1 Message prioritization. As a minimum, messages shall be prioritized by urgency level. A prioritization scheme that is flight phase adaptive should be incorporated in the alerting system. Aircraft configuration variations and exceptions shall be considered in tailoring a scheme to specific aircraft.

5.2.6.2 Inhibit logic. An inhibit logic may be incorporated in the alerting system. Depending on system specifics, "on ground" conditions may inhibit certain caution messages as well as inhibiting caution messages during an "ENGINE OUT" warning condition. The inhibit scheme

should be flight phase related, that is, non-critical messages should be inhibited during critical phases of flight, during high workload periods, and during multiple failure situations. Any specific methodology for applying an inhibit logic shall be evaluated and approved by the acquiring activity prior to implementation (see 6.3.1).

5.2.6.3 Storage and recall. If specified by the acquiring activity, a capability shall be provided to enable the crew to store and recall caution and advisory level messages. The display shall provide an indication of the quantity and type of messages that are in memory. Both selective and total storage and recall capabilities should be provided.

5.2.7 Display luminance and contrast. Displays shall be in accordance with MIL-STD-1472. For monochrome displays, luminance and contrast shall be in accordance with the system specification and shall be such that alert messages are easily readable from the design eye position (see 3.8) in any ambient light condition. The minimum display luminance shall not be less than 1.5 fL to prevent the dimming of the display to such a level that would make the alert message unreadable. For color displays luminance contrast shall be in accordance with the system specification and shall ensure the discriminability of the alert message from the background.

5.2.8 Display size. Specific aircraft design characteristics shall determine the minimum number of message lines to be displayed, allowing for the need to have characters large enough to be legible to crewmembers seated in their normal flight positions. If legends are abbreviated, the display shall be wide enough so that any message will fit on one line.

5.2.9 Character dimensions. The alphanumeric character dimensions and spacing shall be selected for speed and accuracy of interpretation and shall be in accordance with MIL-STD-1472. The height of symbols and characters shall subtend a viewing angle of no less than 20 minutes of arc when measured from the design eye position (see 3.8). Character dimensions and fonts shall be evaluated and approved by the acquiring activity before implementation (see 6.3.1).

5.2.10 Maintenance record. A capability shall be provided to have all warning and caution messages recorded in non-volatile memory for maintenance purposes. None of the advisory messages shall be stored for maintenance purposes. Because several warning and caution conditions will normally be present before the start of the engine, the storage of warning and caution conditions in a non-volatile memory shall be inhibited while the "on ground" conditions exist. If any of these conditions are still present when the "on ground" condition no longer exists, they shall be recorded in non-volatile memory for maintenance records. The memory shall be capable of being cleared by maintenance personnel when the existing record is no longer required.

5.2.11 Test provisions. A convenient means shall be provided for testing all integrated display characters and functions.

5.3 Audio warning signals. Audio warning signals, when used, shall conform to the requirements specified herein and to the audio display requirements of MIL-STD-1472.

5.3.1 Master warning signals. A nonverbal audio master warning signal shall produce an output with the following frequency and interruption rates:

a. Fundamental audio output frequency shall sweep from 700 to 1,700 Hz in 0.85 seconds.

b. Interruption interval shall be 0.12 seconds.

The cycle shall be repeated until the signal generator is deenergized.

5.3.2 Bail-out signal. The audio bail-out signal for use in troop carriers, cargo transport, and all other multicrew aircraft shall be a bell. The bell shall strike at a continuous rate of 5 ± 1 beats per second and shall be audible during flight to all aircrew members and passengers.

5.3.3 Wheels-up signal. When a nonverbal audio wheels-up signal is used, the signal shall be in accordance with MIL-S-9320 and shall have the following tone.

a. Frequency 250 ± 50 Hz.

b. Fundamental tone interrupted at 5 + 1 Hz.

c. 50 ± 10 percent on-off cycle.

5.3.4 Audio angle of attack/airspeed/stall warning signal. When a nonverbal audio signal is used for presenting angle of attack/airspeed/stall warning information, referenced to a selected angle of attack/airspeed/stall speed, it shall be as specified in table I. The discrete position at which the chopped signal commences on either side of the "correct" signal will be readily adjustable.

TABLE I. Audio angle of attack/airspeed/stall warning signal.

ANGLE OF ATTACK	AIRSPEED	TONE SIGNAL
Low	Fast	1,600 Hz tone interrupted at a rate of 1 to 10 Hz, the rate increasing linearly with decreasing angle of attack/increasing airspeed.
Safe low	Safe fast	900 Hz steady tone, plus 1,600 Hz tone interrupted at a rate of zero to 1 Hz, the rate increasing linearly with decreasing angle of attack/increasing airspeed.
Correct	Correct	900 Hz steady tone.
Safe high	Safe low	900 Hz steady tone, plus 400 Hz tone interrupted at a rate of zero to 1 Hz, the rate increasing linearly with increasing angle of attack/decreasing airspeed.
High	Slow	400 Hz tone interrupted at a rate of 1 to 10 Hz, the rate increasing linearly with increasing angle of attack/decreasing airspeed (stall warning).

5.3.5 Nuclear radiation danger signal. When a nonverbal audio nuclear radiation danger signal is used, it shall consist of the following tones:

a. Square wave 500 ± 10 Hz

b. Square wave 400 ± 10 Hz

The two tones shall be presented alternately, each being heard for 0.30 ± 0.05 seconds. The change from one tone to the other shall be accomplished in 0.02 seconds or faster. The output of the signal generator shall be such that the tones reaching the operator's ear shall have an overall sound pressure level of 95 ± 3 db.

5.3.6 Verbal audio warning signals. Verbal warning signals shall be audible signals in verbal form indicating the existence of a hazardous or imminent catastrophic condition requiring

immediate action and shall only be used to complement red warning or other critical visual signals. The verbal warning signals shall be presented at levels that will ensure operator reception under noise conditions in the specific aircraft. There shall be provision for overriding and resetting the signals. The signal, when activated, shall always start at the beginning of the message and shall continue to be presented until either:

a. The causative condition is corrected.

b. A warning of higher priority is presented.

c. The signal is silenced by manual actuation of the override switch.

The structure for verbal warnings shall be:

a. General heading, such as, the system or service involved.

b. Specific subsystem or location.

c. Nature of emergency.

Verbal warning signals shall be as specified in MIL-STD-1472.

5.3.7 Other verbal audio signals. Where applicable, the specific requirements in 5.3.6 shall apply to other verbal audio signal assemblies.

5.4 Mechanical visual signals. The criticality of the mechanical visual signal and the informational requirements of the aircrew shall be used to determine if the onset of the mechanical signal will activate the master warning/master caution signal. When mechanical visual signals are used, the signal shall be in accordance with MIL-STD-1472 for a given type of signal device.

5.4.1 Color. Mechanical visual signals shall have white markings on a black background or as specified by the acquiring activity (see 6.3.1).

5.4.2 Markings. Mechanical visual signals shall be marked with a legend or symbol that is descriptive of the information being given.

5.4.3 Luminance.

5.4.3.1 Flags. The markings on flags shall be as luminous as the markings on the indicator or display in which it is mounted.

5.4.3.2 Indicators. Indicator luminance for lighted instruments shall be in accordance with MIL-L-25467.

5.5 Tactile signals. If tactile signals are used, they should be of such amplitude as to be detected by the part of the body being stimulated, and should be delivered by an apparatus that will always be in contact with the body. Tactile signals shall also be coded such that they could not be misconstrued as a normal vibration of the equipment or crew station. Any use of tactile signals in aircrew stations must have prior approval by the acquiring activity (see 6.3.1).

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The intended use of this standard is to establish uniform aircrew station alerting systems for military aircraft.

6.2 Issue of DoDISS. When this standard is used in acquisition, the applicable issue of the DoDISS must be cited in the solicitation (see 2.2.1).

6.3 Tailoring guidance. When this standard is cited in a contractual statement of work, it should specify: type of aircraft with alerting system requirements peculiar to that aircraft; type of alerting system signals and displays; and lighting requirements.

6.3.1 Alerting system options. The following alerting system options are included in this document:

a. Specific signals as required by the aircrew (see 4.1.2.2).

b. Presentation of signals (see 4.1.2.3).

c. Location and arrangement of signals (see 5.1.2).

d. Whether aircrew station lights are not dimmed when pilot’s primary interior light control in "ON" (see 5.1.3.3).

e. Landing configuration and whether a "WHEELS" legend indicator is required (see 5.1.3.6 and 5.1.3.7).

f. Type of master caution signal required (see 5.1.4.4).

g. Type of advisory signal presentation required (see 5.1.5.4).

h. Type of display presentation medium required (see 5.2.2).

i. Whether a head-up display is required (see 5.2.3).

j. Type of presentation for warning, caustion and advisory messages required (see 5.2.4).

k. Type of display information required (see 5.2.4.1).

l. Scheme for ordering alert messages (see 5.2.5.2).

m. Methodology for applying an inhibit logic (see 5.2.6.2).

n. Character dimensions and fonts for messages (see 5.2.9).

o. Color of mechanical visual signals (see 5.4.1).

p. Whether tactile signals are required (see 5.5).

6.4 Subject term (key word) listing.

Advisory
Annunciator
Auditory
Caution
Color
Contrast
Flag
Indicator
Legends
Luminance
Presentation
Signal
Tactile
Visual
Warning

6.5 International interest. Certain provisions of this standard (5.1.3, 5.1.4, and 5.1.5) are the subject of international standardization agreements (ASCC Air Standard 10/30 and NATO STANAG 3370). When change notice, revision, or cancellation of this standard is proposed which will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations.

6.6 Use of metric units. When metric units are preferred, conversion to metric units shall be performed and conform to the practices of FED-STD-376. If metric units are utilized, conformance to all of the requirements of this standard shall be maintained. The following conversion factors are applicable to this standard.

Footlamberts (fL) x 3.427 = candela per meter ^{2} (cd/m^2)

Footcandles (fc) x 10.764 = lux (lx)

6.7 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

CONCLUDING MATERIAL

Preparing activity:
Navy - AS
(Project 15GP-0116)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.

2. The submitter of this form must complete blocks 4, 5, 6, and 7.

3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	**1. DOCUMENT NUMBER** MIL-STD-411F	**2. DOCUMENT DATE (YYMMDD)** 1997 March 10

3. DOCUMENT TITLE AIRCREW STATION ALERTING SYSTEMS

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON *(if applicable)*	**7. DATE SUBMITTED** (YYMMDD)

8. PREPARING ACTIVITY

a. NAME Commander, Naval Air Warfare Center Aircraft Division	b. TELEPHONE *Include Area Code)* (1) Commercial (908) 323-7488 (2) AUTOVON 624-7488
c. ADDRESS *(Include Zip Code)* Code 414100B120-3 Highway 547 Lakehurst, NJ 08733-5100	**IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:** DEFENSE QUALITY AND STANDARDIZATION OFFICE 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22401-3466 Telephone (703) 756-2340 AUTOVON 289-2340