TR-2481
30 August 1993

GROUND PROXIMITY WARNING SYSTEM
VOICE WARNING UNIT
REQUIREMENTS STUDY

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13. ABSTRACT (*Maximum 200 words*)

This report provides a record of the engineering considerations driving the establishment of initial Ground Proximity Warning System (GPWS) Voice Warning Unit (VWU) requirements. The work was stopped before sections 4, 5, and 6 of appendix A could be completed.

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SUMMARY

This report documents the results of a systems engineering effort related to the integration of the Ground Proximity Warning System (GPWS) voice capability on the A-6E, F-14B, EA-6B, SH-60B and T-45 aircraft. The work was stopped before sections 4, 5, and 6 of appendix A could be completed.

PREFACE

This report provides a record of decisions made affecting the initial requirements for the GPWS Voice Warning Unit (VWU).

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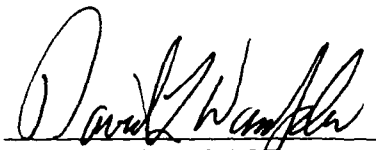
Prepared by: 
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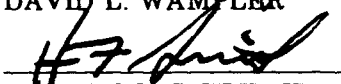
Approved by: 
HARLAN F. SMITH, JR.

I. INTRODUCTION

A. PURPOSE

This report provides a record of the engineering considerations driving the establishment of initial Ground Proximity Warning System (GPWS) Voice Warning Unit (VWU) requirements . The normal turn-over of technical support personnel can result in inadequate information being available to management to support the making of informed decisions. Experience has shown "requirements creep" will occur during the acquisition of equipment. The information contained herein is intended to provide some background for the basis of VWU requirements to support the making of informed decision regarding the justification of proposed changes to requirements.

B. BACKGROUND

1. A significant cause of Navy aircraft mishaps is controlled flight into terrain (CFIT). This is defined as a collision with the ground or water by an aircraft that is capable of normal flight and a pilot who is not disabled. Naval aircraft are categorized into three GPWS categories. Category I includes transport, airborne early warning and patrol aircraft; category II (CAT II) includes fighter and attack aircraft; and category III (CAT III) includes helicopters.

2. GPWS CAT II aircraft (e.g.: A-6E, EA-6B, F-14B, T-45 (glass cockpit)) and a CAT III aircraft, the SH-60B, need a means to convert computer warnings into voice warnings. The voice warning messages must be integrated with (injected into) the intercommunication set (ICS).

3. The Naval Air Warfare Center, Aircraft Division (NAWCAD), Patuxent River, MD is developing the CAT II GPWS algorithm. Some CAT II testing has been performed, but the voice capability has not yet been developed, and the ICS integration has not yet been studied.

4. The Naval Air Systems Command Headquarters (NAVAIRHQ) awarded a contract for a standalone CAT III system to Cubic Defense Systems of San Diego, CA on 17 August 1993. The CH-53E is the lead platform for the standalone CAT III unit. Current plans call for the SH-60B to be a second CAT III lead aircraft, with a GPWS algorithm integrated into an onboard computer.

5. This report is the formal documentation of systems engineering efforts related to the integration of GPWS voice capability on the A-6E, F-14B, EA-6B, SH-60B and T-45 (glass cockpit) aircraft. The engineering reported herein was performed at the Naval Air Warfare Center, Aircraft Division, Indianapolis, during the second half of fiscal year 1993.

II. TECHNICAL CONSIDERATIONS

A. AIRCRAFT CONFIGURATIONS

1. A-6E

The A-6E is currently upgrading most aircraft to the SWIP configuration. IOC was in 1988, and the SWIP upgrade is schedule to be completed by 1997. The CP-3 computer used in the SWIP upgrade does not have a MIL-STD-1553 interface. But, the CP-3 computer interfaces to the Armament Interface Unit (AIU). The AIU is a MIL-STD-1553B bus controller. A SWIP BLOCK UPGRADE IA is planned for Initial Operational Capability (IOC) in 1995 with completion in 2001. However, the SWIP BLOCK UPGRADE IA is being considered for cancellation by congress. The CP-4 computer used in the SWIP BLOCK UPGRADE IA does have a MIL-STD-1553 interface. Both AC and DC power are available. The A-6E has an AN/AIC-14 intercommunications set (ICS).

2. F-14B

The F-14B is developing an A/B UPGRADE, with an IOC planned for 1994. The A/B UPGRADE will be followed by a BLOCK 1 upgrade in 1996. The BLOCK 1 upgrade will include a MIL-STD-1553 interface, and the program insists that all new equipment use the MIL-STD-1553 interface. Both AC and DC power are available. The F-14 uses an LS-460B for a ICS stations, which have spare 10KΩ input channels.

3. EA-6B

Current fleet aircraft are in several configurations. An ADVCAP upgrade is planned for an IOC in 1995. The ADVCAP configuration will have a MIL-STD-1553 interface. Both AC and DC power are available. The EA-6B has an AN/AIC-14A intercommunications set (ICS).

4. SH-60B

The SH-60B is upgrading to a BLOCK I configuration. A BLOCK II upgrade is planned for IOC in 2000. The SH-60B uses an AN/AYK-14 mission computer with a MIL-STD-1553 interface. Both AC and DC power are available. The CV-3519 Audio Converter-Processor performs the ICS function. The CV-3519 has not spare input channels, but an external audio interface unit is in use to combine the ALR-47 missile warning tone with the stabilator warning tone before the stabilator warning tone enters the CV-3519.

5. T-45

The T-45 computer has a MIL-STD-1553 interface. Both AC and DC power are available, but the AC power is single phase only. The contractor furnished equipment (CFE) ICS has no spare input channels, but there TACAN and radar altimeter interfaces to the ICS that are suitable for daisy chaining through the VWU.

B. HOST COMPUTER INTERFACE

The F-14 has a policy that all new interfaces to it's 5400 computer must be on the MIL-STD-1553 data bus. All of the GPWS candidate aircraft configurations studied have a MIL-STD-1553 data bus that can be used for VWU integration.

C. ICS INTERFACE

Several approaches to ICS integration are required to accommodate the several aircraft.

1. Spare ICS input approach

The F-14 has several spare inputs to the LS-460B ICS station. They are approximately 10KΩ balanced inputs, but have different frequency responses. The signal level has not yet been determined.

2. ICS bus injection approach

The A-6E and EA-6B use AIC-14 style ICS systems. The AN/AIC-14 in the A-6E uses single ended (unbalanced) signal lines that exhibit ground loop noise. The AN/AIC-14A in the EA-6B uses balanced signal lines. The signal levels are about the same in both systems. The AIC-14 style ICS uses multiple crew stations that are interconnected on 600Ω buses. A disadvantage to this approach is the loading of the ICS bus, which decreases the volume of all signals delivered to the crew station. However, it may be that using the 10KΩ output from the VWU would overcome the bus loading problem.

3. Daisy chain approach

a. The T-45 and SH-60B both have CFE ICS systems with no spare inputs. However, they do have existing tone inputs to the ICS. The best approach for these aircraft appears to be to daisy chain the VWU with an existing tone input. The daisy chain approach allows the integration to be made by changing the aircraft wiring without modification of the CFE ICS. In the daisy chain approach, the existing voice (tone) signal is disconnected from the ICS and reconnected to the VWU. This approach requires the VWU to have an adjustable voice (tone) input. Inside the VWU, the voice input is combined with the VWU reproduced voice. The VWU output is then connected to the ICS at the point where the existing voice (tone) was disconnected. The impedance, grounding and signal levels of the tone inputs have not yet been determined. The common impedance for voice signals within the Navy is 600Ω.

b. As an alternative on the A-6E and EA-6B, there may be existing tone signals that could be daisy chained through the VWU.

D. ADDITIONAL (NON-GPWS) MESSAGES

1. F-14

The F-14 is investigating the use of voice warnings to augment some existing cockpit warning lights. It seems likely that the F-14 will implement some type of voice warning system before GPWS is integrated. However, the approach being used by the F-14 is to sense existing lamp voltages and relay signals, rather than to integrate a warning algorithm in a computer. The F-14 could gain weight and space savings by consolidating the two voice functions in a single unit. However, since both voice units will probably be small and light, consolidating the voice function may not be cost effective. The F-14 did not otherwise identify any non-GPWS message requirement to be implement in GPWS.

2. Other aircraft

Other aircraft did not identify non-GPWS voice message requirements.

E. AIRCRAFT POWER

1. T-45

The T-45 does not have MIL-STD-704 power. However, equipment designed for MIL-STD-704 power can be used on the T-45 so long as only single phase AC is required. The T-45 does provide DC power.

2. Other aircraft

Other aircraft have both AC and DC MIL-STD-704 power. Experience has shown that power dropouts due to generator bus changes last longer than stated in the current version of MIL-STD-704.

3. AC, DC and battery power

It should be possible to design the VWU to operate satisfactorily from either single phase AC or from DC power. Use of DC power should be permitted, if not encouraged, because it should result in lower weight, smaller size, lower cost and higher reliability. Since the GPWS is not a flight critical system, it is not necessary to operate it from battery power.

F. KEY REQUIREMENTS

An initial set of key requirements was developed to support a survey of currently available nondevelopment items (NDI). The minimal list of key requirements was then expanded to include those requirements that seemed appropriate for the acquisition of modified NDI. Many design, construction, standardization, reliability, and maintainability requirements commonly required for research and development acquisitions were not included. The specification was annotated to show the background and rationale for each requirement.

Although the advise of experts in the several engineering specialties was followed in the formulation of the key requirements and additional requirements, a comprehensive formal review of the adequacy of the requirements has not been performed. Therefore, the specification provided in appendix A should be viewed as a draft.

III. CONCLUSIONS

1. The MIL-STD-1553 data bus is the command input interface of choice on all aircraft.
2. The daisy chain approach to ICS integration appears very practicable
3. The aircraft are not now interested in additional, non-GPWS messages.

IV. RECOMMENDATIONS

1. The ranges of the gains of the voice input and reproduced voice output signals could be reduced and/or more accurately specified if testing were done on the target aircraft. Reducing the ranges of the gains may result in a cost savings. The recommended testing would include developing an interface test box, identification of candidate signals for daisy chaining or ICS signal injection points, temporary rewiring of the aircraft for testing, and measurement of aircraft signal levels and gain requirements for VWU signal injection into the ICS.

2. The draft specification in appendix A should be updated after a review by a full systems engineering team just prior to acquisition of the VWU. The goal of the review should be to reflect changes in referenced documents, remove requirements that are not necessary for such an NDI acquisition (if any), and to add requirements necessary to reduce the risk of an NDI acquisition (if any). Prior to the review, the team should be briefed on NDI acquisition concepts, and how they differ from traditional engineering and manufacturing development acquisitions.

APPENDIX A

DRAFT SPECIFICATION WITH ANNOTATION

INCH-POUND

AS-XXXX

MILITARY SPECIFICATION

VOICE WARNING UNIT, GROUND PROXIMITY WARNING SYSTEM GENERAL SPECIFICATION FOR

This specification is approved for use by the Naval Air Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

This specification contains requirements applicable to the first time acquisition of the Ground Proximity Warning System (GPWS) Voice Warning Unit (VWU) as a Non-Developmental Item (NDI). Some characteristics applicable to form, fit, and function interchangeability are not specified in order to permit design freedom during the first acquisition (e.g. physical dimensions, mounting features, weight, connector(s) and pinouts, electric power voltage(s) and consumption, and data bus message definitions). This specification should be amended after qualification of the VWU to assure interchangeability during subsequent acquisitions. The VWU is a Weapons Replaceable Assembly (WRA) for Navy fighter and attack jets and for Navy helicopters. The VWU is used to integrate the GPWS algorithm implemented in a general purpose computer (GPWS computer) with the intercommunication set (ICS). The VWU will convert GPWS computer generated digital warning messages into analog voice messages compatible with the ICS electrical interface.

The term "GPWS computer" was used rather than "mission computer" (MC), so that the computers considered for implementing the GPWS algorithm would not be limited to MCs.

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 Systems Command (PMA-209), Naval Air Systems Command Headquarters, 1421 Jefferson Davis Highway, Arlington, VA 22243-1253, by using the self-addressed Standardization Document improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

ASMC N/A FSC 58XX

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2. APPLICABLE DOCUMENTS

2.1 Government Documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks 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

SPECIFICATIONS

MILITARY

MIL-P-15024	-	Plate, Tags and Bands for Identification of Equipment
MIL-P-15024/2	-	Plate, Identification, Unit Or Plug-In Assembly
MIL-N-18307	-	Nomenclature and Identification for Electronic, Aeronautical and Aeronautical Support Equipment, Including Ground Support Equipment

STANDARDS

MILITARY

MIL-STD-130	-	Identification Marking Of U.S. Military Property
MIL-STD-196	-	Joint Electronics Type Designation System
MIL-STD-461C	-	Electromagnetic Emission And Susceptibility Requirements For The Control Of Electromagnetic Interference, 4 August 1986

MIL-STD-461C is used specifically rather than the latest version, MIL-STD-461D, because Rolan Brakensiek, DP704N, said NAVAIR did not like REV D, and did not want REV D used until a NOTICE 1 is issued in about one year (4th quarter 1994).

MIL-STD-704	-	Aircraft Electric Power Characteristics
MIL-STD-810	-	Environmental Test Methods and Engineering Guidelines
MIL-STD-973	-	Configuration Management
MIL-STD-1472	-	Human Engineering Design Criteria For Military Systems, Equipment And Facilities
MIL-STD-1553A	-	Aircraft Internal Time Division Command/Response Multiplex Data Bus, 30 April 1975
MIL-STD-1553B	-	Aircraft Internal Time Division Command/Response Multiplex Data Bus, 21 September 1978

MIL-STD-1553A and MIL-STD-1553B are called out separately to permit requiring the VWU remote terminal (RT) to be operated by either 1553A or 1553B bus controllers (BCs). There is a difference in BCs such that an RT qualified to 1553B will not necessarily respond correctly to a 1553A BC.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.2 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets, or MS standards), 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. REQUIREMENTS

3.1 Definition. The VWU shall be a single WRA suitable for use on the F-14B, EA-6B, A-6E, T-45 and SH-60B aircraft. It shall include MIL-STD-1553 data bus, analog input signal interface, memory, control circuits, digital to analog converter, variable gain analog signal amplifiers, and analog signal output interfaces (see figure 1).

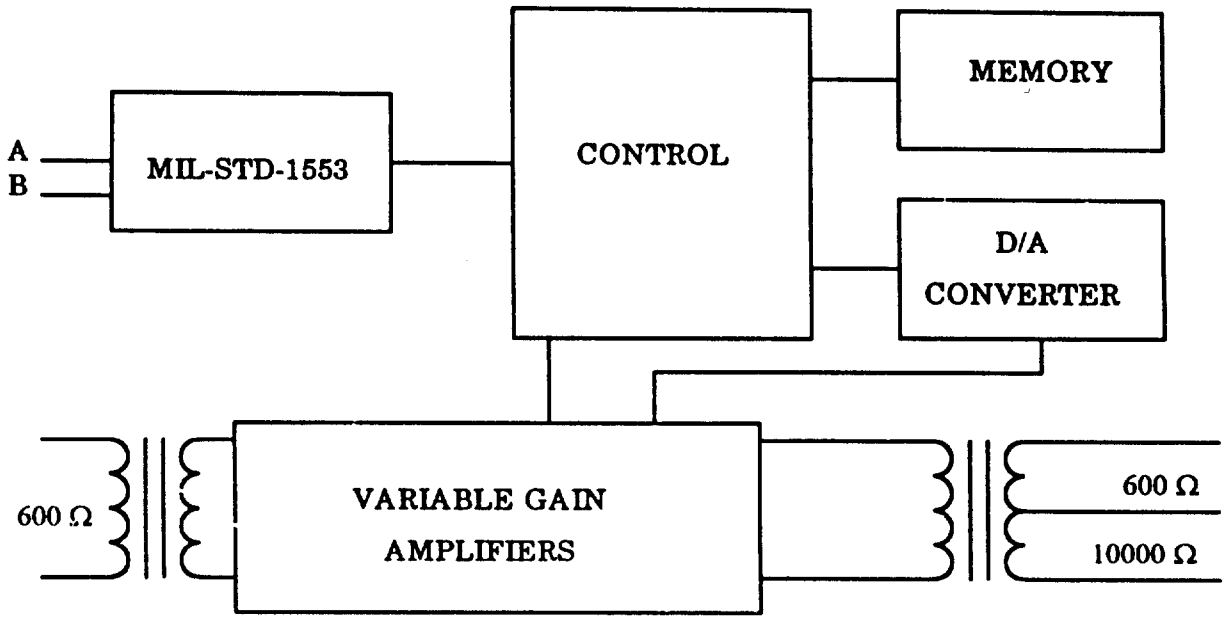

FIGURE 1. Functional block diagram.

The functional block diagram not a restriction on physical implementation. Rather, it introduces the functional areas that are controlled by specification requirements.

3.1.1 Interfaces.

3.1.1.1 GPWS computer command interface. The GPWS computer command_interface shall operate as a remote terminal (RT) on a dual standby redundant multiplex data bus in accordance with MIL-STD-1553B. The data bus interface shall interoperate with both MIL-STD-1553A and MIL-STD-1553B bus controllers for RT to bus controller (BC), BC to RT, and RT to RT transfers, and for the mode commands listed below.

There is a difference in BCs such that an RT qualified to 1553B will not necessarily respond correctly to a 1553A BC.

3.1.1.1.1. Remote terminal address. The remote terminal address shall be determined by the operating configuration.

The RT address must be tailorable by the aircraft integrator. If an existing configuration cannot be used, the VWU must be ECP'd. Such an ECP should be 100% backward compatible as long as there are sufficient operating configurations.

3.1.1.1.2. Mode commands. The VWU shall recognize the subaddress/mode code of 00000 as a mode command, and may optionally recognize 11111 as a mode command. The system shall implement the following mode commands:

00010	Transmit Status Word
00100	Transmitter Shutdown
00101	Override Transmitter Shutdown
01000	Reset Remote Terminal
10010	Transmit Last Command

This minimum set of mode commands was copied from another specification.

3.1.1.1.3. Broadcast commands. The VWU shall not respond to broadcast commands.

This eliminates potential integration problems by making sure that the VWU will not give an unacceptable response to a broadcast command already in use on the aircraft.

3.1.1.1.4. Stub coupling. The VWU shall provide for transformer coupling and may provide for direct coupling.

Lower cost and smaller connector size can be achieved by not requiring direct coupling. A direct coupled interface is not expected on the target aircraft. If a direct coupled application were later encountered, an external transformer can be installed to convert from direct coupling to transformer coupling.

3.1.1.1.5. Data bus messages. The VWU shall be capable of transmitting and receiving partial messages where the first data word transmitted or received is always the word defined as word one (-01) for the message, and the last word transmitted or received is the word corresponding to the word count in the transfer command, with each word transmitted in the defined order.

Improper handling of partial messages was encountered on another program. This is a hole in MIL-STD-1553 that must be filled by the equipment specification or ICD.

3.1.1.1.5.5. Command input message. The command input message shall have the number of the message to be reproduced.

Only one input message is anticipated. The message number can reasonably be expected to be the first word of a one word message.

3.1.1.1.5.6. Status message. The status message shall transmit the BIT status, the configuration code and the configuration identification number.

The BIT status and configuration identification number are contractor defined. Therefore, the format for this message will be contractor defined. The configuration code and configuration identification number provide a check to the GPWS computer that the VWU is operating in the right configuration for the GPWS software version.

3.1.1.2 Voice input. A two wire 600 ohm input shall be provided. Both wires shall be isolated from ground.

600 Ω is the Navy standard ICS impedance. Ground isolation is necessary to prevent noise from ground loops.

3.1.1.3 Configuration code input. A configuration code input shall be provided. The configuration code input shall include a parity bit.

The configuration code input is the means to tailor VWU performance to the aircraft configuration.

3.1 1.4 Low impedance voice output. A two wire 600 ohm output shall be provided. Both wires shall be isolated from ground.

600 Ω is the standard ICS impedance. Ground isolation is necessary to prevent noise from ground loops.

3.1.1.5 High impedance voice output. A two wire 10K ohm output shall be provided. Both wires shall be isolated from ground.

10K Ω is the impedance of an unused spare input on the F-14 ICS. Ground isolation is necessary to prevent noise from ground loops.

3.1.1.6 Power interface. A MIL-STD-704 utilization equipment interface shall be provided.

This paragraph was included for completeness in defining the interfaces.

3.1.1.7 Mechanical interface. The mechanical interface shall meet the crash safety shock requirement (see 3.4.7).

This paragraph was included for completeness in defining the interfaces.

3.2 Characteristics.

3.2.1 Performance.

3.2.1.1 Message reproduction. The VWU shall reproduce voice messages when commanded by the GPWS computer. The reproduced voice may either be a a recorded voice or be a synthesized voice.

Assigns responsibility to GPWS computer to decide when to issue warning from GPWS algorithm. Bob Portillo, SY-72D, said synthesized voice is OK.

3.2.1.1.1 Message capacity. The VWU design shall provide a recorded message capacity, not including test messages, for not less than thirty (30) messages having a combined duration, including test messages, not less than sixty (60) seconds.

Four messages are required for CAT II. The number of messages required for CAT III has not yet been definitively determined. Alan Choo, DP301N, expects the number of CAT III messages to be in the range from 15 to 20. Thirty (30) messages was picked to allow room for growth. Other factors include: (a) the use of two test messages and (b) sixty (60) seconds of speech (plus two test messages) fits easily into a 256K byte read only memory (ROM). The ROM sizing is based on 32K bits per second (BPS) CVSD modulation. CVSD modulation is commonly used in voice mail systems because of its compact storage of voice. 32K BPS is considered "toll quality" voice and is supposed to be acceptable voice quality for telephone carriers.

3.2.1.1.2 Message content. The messages in table I shall be provided. Message number 31 is reserved as a null test message for data bus testing. Message number 30 is reserved for GPWS computer controlled system testing. When message number 30 is commanded and there is no built in test (BIT) detected fault condition, the reproduced message shall be "Voice Warning

Test." When message number 30 is commanded and there is a BIT detected fault condition, the reproduced message shall be "Voice Warning Failure Detected."

TABLE I. Recorded messages.

Message Number	Message
0	Roll Out...Roll Out
1	Power...Power
2	Check Gear...Check Gear
3	Pull Up...Pull Up
4	(Reserved for CAT III)
5	(Reserved for CAT III)
6	(Reserved for CAT III)
7	(Reserved for CAT III)
8	(Reserved for CAT III)
9	(Reserved for CAT III)
10	(Reserved for CAT III)
11	(Reserved for CAT III)
12	(Reserved for CAT III)
13	(Reserved for CAT III)
14	(Reserved for CAT III)
15	(Reserved for CAT III)
16	(Reserved for CAT III)
17	(Reserved for CAT III)
18	(Reserved for CAT III)
19	(Reserved for CAT III)
20	(Reserved for CAT III)
21	(Reserved for CAT III)
22	
23	
24	
25	
26	
27	
28	
29	

CAT II messages are first on the list because the number of messages required for CAT III has not yet been determined conclusively. Consequently, the true number of spare messages is not known. Message number 31 provides a general facility for test, and may not be needed. Message number 30 provides a through the system test capability.

3.2.1.1.3 Voice qualities and intelligibility. The voice shall be a distinctive female voice. It shall express the urgency required of the warning by its inflection. The rate of speech shall be not less than one hundred fifty (150) nor more than one hundred sixty (160) words per minute. The intelligibility of the reproduced voice messages shall be not less than equivalent to the normally acceptable intelligibility criteria of MIL-STD-1472. The intelligibility of the voice reproduction design shall be not less than the normally acceptable intelligibility criteria of MIL-STD-1472 using the phonetically balanced (PB) test method and a distinctive female voice.

The voice quality and intelligibility requirements are a paraphrase of the *Baseline Ground Proximity Warning System (GPWS) Pilot Vehicle Interface (PVI) Design Perspective and Platform Integration Design Guide* of 30 April 1993 written by Bob Portillo, SY-72D.

3.2.1.2 Voice output. The voice output shall be the summation of the voice input and the reproduced voice message. The output power level shall be selectable between a low power output and a high power output. The maximum low power output signal to a matching load shall be not less than 27 microwatts (μw) at the low impedance and high impedance outputs, but not both outputs simultaneously. The high power output shall be 44 ±1 dB higher than the low power output. The total harmonic distortion of the voice input signal in a passband of 250 Hz to 4000 Hz at the maximum output power levels and at lessor output power levels shall not be greater than 8% over the full range of environmental conditions (see 3.4), and shall not be greater than 5% at normal room temperatures during bench testing.

The voice input allows an existing ICS input to be used to inject the VWU signal combined with the existing signal. The high power output affords the aircraft integrator the same high power that radios have for emergency mode operation. If emergency mode operation is not required for aircraft integration, the low power output provides the signal levels typically found in the AN/AIC-14 series of intercommunications systems. The total harmonic distortion requirement is based on the recommendation of Jose Sanchez, DP305N, and is similar to that of the AN/AIC-14A. The frequency band is the minimum acceptable frequency band for speech transmission equipment per MIL-STD-1472.

3.2.1.2.1 Voice input gain. The normal gain of the voice input signal through the VWU to the voice output shall be adjustable by not less than ±20 dB in a passband of 250 Hz to 4000 Hz using matching source and load impedances. The gain of the voice input signal shall be reduced from the normal gain by not less than 20 dB when the voice message is being reproduced. The normal gain of the voice input is not required to amplify the voice input signal in excess of the maximum power output capability of the voice output. The normal and reduced voice input gains shall be determined by the operating configuration.

The gain is adjustable to account for increases or decreases from impedance mismatch. The frequency band is the minimum acceptable frequency band for speech transmission equipment per MIL-STD-1472. Gain reduction of the input signal during voice message reproduction allows the output power of the VWU to be dedicated to producing the warning message. Otherwise, the VWU would have to be designed to output both the warning message and the input signal simultaneously at a higher combined power level. Although the input signal may need to be amplified, the maximum output level will not exceed 27 μw for the low level signal. The input signal gain is stored in memory so that no adjustments to the VWU will be required at installation. Neither can the gain be manipulated by the crew (except for total ICS volume control). ISSUE: should the gain be programmable in memory or at the connector?

3.2.1.2.2 Reproduced voice output. The reproduced voice low power output signal shall be adjustable from not less than 27 μw down to not greater than 4 μw in a passband of 250 Hz to 4000 Hz. The reproduced voice low power output signal level shall be determined by the operating configuration.

The low power output provides the signal levels typically found in the AN/AIC-14 series of intercommunications systems. The frequency band is the minimum acceptable frequency band for speech transmission equipment per MIL-STD-1472. The reproduced voice low power output signal level is stored in memory so that no adjustments to the VWU will be required at installation. Neither can the signal level be manipulated by the crew (except for total ICS volume control). ISSUE: should the output power be programmable in memory or at the connector?

3.2.1.3 Operating configuration. The VWU shall store not less than thirty two (32) operating configurations in memory. The operating configuration shall be selected by the configuration code input at the time power is applied. Each operating configuration shall include:

The operating configurations are stored in memory to eliminate adjustments (and potential errors) at installation. The number of operating configurations was set to 32 arbitrarily, 16 being thought too few. There being no reason to change the operating configuration in flight, the required complexity of the system was limited.

a. The selection of the data bus address for the interface to the mission computer.

b. A reproduced voice message output level factor.

c. Voice input gain factors (normal and reduced).

Operating configuration zero (00000) shall provide a MIL-STD-1553B data bus command interface operating at address 00001, reproduced voice message low power output signal of 17 μw, and voice input gain factor of 0 dB.

Operating configurations 00000 provides defined conditions that can be used for acceptance/receiving inspection testing. These configuration parameters could be changed to match the first user platform in the future.

3.2.1.4 Power. The VWU shall utilize electric power in accordance with MIL-STD-704 and shall be in accordance with the utilization equipment requirements of MIL-STD-704. The VWU may use either **single phase** AC power or 28 Volt DC power. All performance requirements shall be met during normal, abnormal and emergency operation of the electric system. All performance requirements shall be met during bus or power source transfers where voltage and frequency do not vary between zero and normal operating limits for longer than 120 milliseconds, and during a normal transient occurring upon completion of the transfer.

DC power is preferred because it is smaller in size to implement. However, AC power is permitted so that NDI equipment would not be arbitrarily excluded. Single phase AC power is required for T-45 compatibility. The T-45 does not have a true MIL-STD-704 AC power system.

3.2.1.5 Memory programming. The memory, including the configuration identification number, the operating configuration, recorded voice messages and any other data required to be changed when changes are made to the configuration identification number, the operating configuration or the recorded voice messages, shall be reprogramable by the government.

The government must be able to change or add new voice messages, data bus configurations, and output power configurations without being tied to the VWU vendor. Each memory change would necessarily result in a configuration number change.

3.2.1.6 Built in test. The VWU shall perform BIT after power is applied.

The BIT concept is that a system GO condition can be verified by the GPWS computer commanding the test message 30. Crew verification of the GO condition would be by hearing the test message via the ICS. The BIT could be waived, but should be waived only if the MTBF were so high that failure is unlikely. ISSUE: should there be a manually initiated BIT capability (BIT button)? ISSUE: should there be a BIT indicator (GO, NOGO, or BIT status number)?

3.2.2 Physical characteristics.

3.2.2.1 Size. The size shall be small enough that the VWU can be mounted in existing unused avionics bay space without the relocation of other WRAs. (Desired size is 6 inch x 6 inch x 2 inch, or similarly small form factor.)

Mounting locations have not yet been identified.

3.2.2.2 Weight. The weight shall be kept to a minimum, and shall not exceed TBD pounds.

A weight budget has not yet been established.

3.2.2.3 Cooling. The VWU shall meet all performance requirements under all specified environmental conditions without external cooling provisions.

This requirement is necessary to preclude the use of cooling air, etc.

3.3 Design and construction.

3.3.1 Parts, materials and processes.

3.3.1.1 Prohibited parts, materials and processes. The following parts, materials and processes shall not be used in the design or manufacture of the VWU: **chlorofluorocarbons (CFCs),** silver-cased tantalum capacitors, aluminum electrolytic capacitors, batteries, non-hermetically sealed relays, wire and cable having polyvinyl choloride (PVC) or FEP/polyimide (Kapton) insulating material , polyvinyl choloride (PVC) , combustible materials, magnesium and magnesium alloys. The following parts, materials and processes shall not be used in the design or manufacture of the VWU except by specific written permission of the acquisition activity: **ozone depleting chemicals**, wet slug tantalum capacitors, liquid crystal displays (LCDs), reed relays, electron tubes, adhesives, dissimilar metals.

NDI should not arbitrarily be restricted to MIL-STD-5400 parts, materials and processes. On the other hand, lessons learned that resulted in prohibiting or restricting parts, materials, or processes in MIL-D-5400 should not be ignored. CFCs should be prohibited, even in NDI, to preclude selecting an NDI product that becomes un-manufacturable before most platforms have received their orders.

3.4 Environmental conditions. The VWU shall be so designed and constructed that no fixed part or assembly shall become loose, no moving or movable part or control be shifted in setting, position, or adjustment, and no degradation be caused in the performance specified herein during operation or after storage in the ambient conditions that follow:

This is based on MIL-STD-5400, 4.6.2 equipment operational requirements, under environmental service requirements. ISSUE: should additional environmental conditions be specified and tested?

3.4.1 Temperature. The ambient temperature conditions are shown in table II. The ambient temperature within the specified temperature ranges may remain constant for long periods and may vary at a rate as great as 1 degree per second.

TABLE II. Temperature conditions.

Temperature parameter	Equipment operating	Equipment nonoperating
Temperature (normal range)	-54 to +71 °C	-57 to +95 °C
Temperature (30 minute intermittent)	+95 °C	(N/A)
Temperature shock	-54 to +95 °C	-57 to +95 °C

Temperatures are as described in MIL-STD-5400 for Class 2.

3.4.2 Altitude. The altitude, for both continuous operation and nonoperating exposure, ranges from sea level (30.0 in Hg) to 70,000 ft (1.32 in Hg). The altitude may remain constant for long periods and vary at a rate as high as 0.6 inch of mercury per second.

Altitude is as described in MIL-STD-5400 for Class 2.

3.4.3 Temperature-altitude combination. The temperature-altitude combinations are shown in figure 2.

Temperature-altitude combination is as described in MIL-STD-5400 for Class 2.

3.4.4 Humidity. The VWU shall withstand the effects of humidities up to 100 percent, including conditions wherein condensation takes place in and on the equipment, during operation and nonoperating exposure.

Humidity is as described in MIL-STD-5400.

3.4.5 Vibration. TBD

3.4.6 Shock. The VWU shall not suffer damage or subsequently fail to provide the performance specified herein when subjected to 18 impact shocks of 20g, consisting of 3 shocks in opposite directions along each 3 mutually perpendicular axes. Each shock impulse shall have a time duration of 6 to 9 milliseconds. The "g" value shall be within ±10 percent when measured with a 0.2 to 250 Hz filter.

Shock is as described in MIL-STD-5400 for equipment shock.

3.4.7 Crash safety shock. When normally mounted, the VWU shall withstand at least 12 impact shocks of 40g, consisting of 2 shocks in opposite directions along each 3 mutually perpendicular axes. Each shock impulse shall have a time duration of 6 to 9 milliseconds. The "g" value shall be within ±10 percent when measured with a 0.2 to 250 Hz filter. Bending and distortion shall be permitted; however, there shall be no failure to the attaching joints, and the equipment or dummy load shall remain in place.

Crash safety is as described in MIL-STD-5400 for mounting base (crash safety) shock.

3.4.8 Bench handling. The VWU shall withstand the shock environment of MIL-STD-810 method 516.4 procedure VI.

Bench handling is tailored from MIL-STD-5400 environmental test conditions.

3.4.9 Sand and dust. The VWU shall withstand, in both an operating and nonoperating condition, exposure to sand and dust particles as encountered in operational areas of the world.

Sand and dust is as described in MIL-STD-5400.

3.4.10 Fungus. The VWU shall withstand, in both an operating and nonoperating condition, exposure to fungus growth as encountered in tropical climates. In no case shall overall spraying of the equipment be necessary to meet this requirement.

Fungus and dust is as described in MIL-STD-5400.

3.4.11 Salt atmosphere. The VWU shall withstand, in both an operating and nonoperating condition, exposure to salt-sea atmosphere.

Salt atmosphere is as described in MIL-STD-5400.

3.4.12 Explosive conditions. The VWU shall not cause ignition of an ambient-explosive-gaseous mixture with air when operating in such an atmosphere.

Explosive atmosphere is as described in MIL-STD-5400.

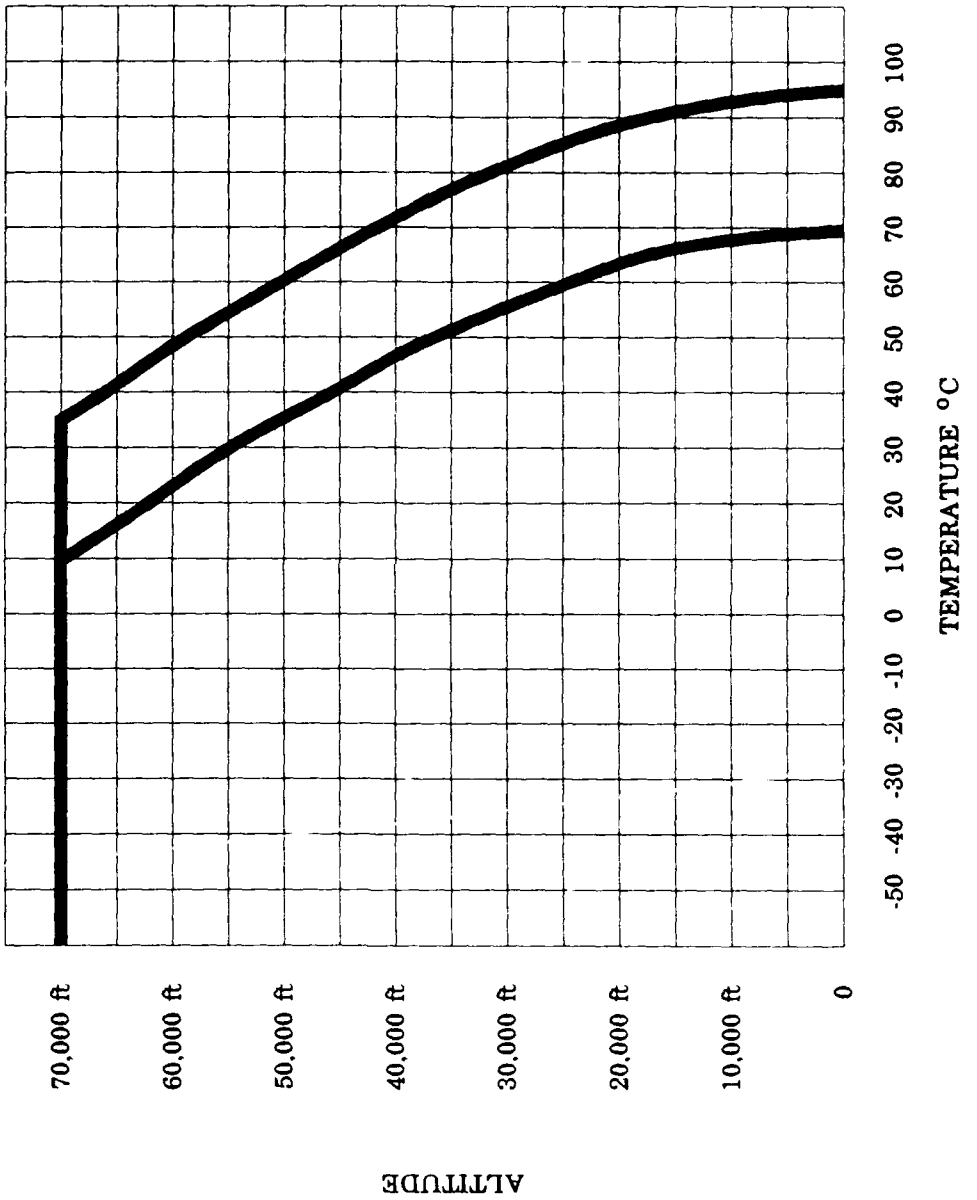

FIGURE 2. Temperature-altitude combination.

3.5 Reliability. The VWU shall have a specified mean time between failures (MTBF) (θ_0) not less than TBD with a minimum lower test MTBF (θ_1) of not less than TBD as defined in MIL-STD-781.

An MTBF has not yet been established.

3.6 Electromagnetic compatibility. The VWU shall meet the electromagnetic compatibility (EMC) requirements shown in table III (contractor testing). The VWU shall meet all performance requirements when operated in the environment shown in table V (government testing).

TABLE III. EMC requirements.

MIL-STD-461C Requirements	Exceptions
CE01	
CE03	
CE07	
CS01	
CS02	The susceptibility signal applied shall have an amplitude of 3 volts peak-to-peak.
CS06	
CS11	
RE01	
RE02	
RS01	
RS02	
RS03	Frequency ranges and modulation shall be in accordance with table IV.
RS06	

The EMC requirements were recommended by Bill Swift, DP704N. Note that there are two phases of testing: contractor and government. Contractor testing is "black box." testing of the VWU by itself. Government testing is "as installed" testing of the VWU installed in the platform. A contractual issue that must be addressed is: for what remedial action is the contractor liable if there is a non-compliance discovered in a platform test after delivery has begun on other platforms.

TABLE IV. RS03 test levels.

Frequency 6 (MHz)	Modulation			Power Density[4] (mw/cm^2)	V/m[5] (ref)
.014-30	AM 90% 1 KHz SINE WAVE			0.66	50
220	PAM [1]	10 μsec PW[2]	200 pps[3]	10.6	200
220	PAM	200 μsec PW	200 pps	10.6	200
425	PAM	4 μsec PW	300 pps	10.6	200
900	PAM	2 μsec PW	1000 pps	10.6	200
900	PAM	125 μsec PW	300 pps	10.6	200
1250	PAM	10 μsec PW	3000 pps	10.6	200
1350	PAM	5 μsec PW	3000 pps	10.6	200
3000	PAM	3 μsec PW	1000 pps	10.6	200
3000	PAM	70 μsec PW	200 pps	10.6	200
3300	PAM	10 μsec PW	3000 pps	10.6	200
3300	PAM	50 μsec PW	3000 pps	10.6	200
3600	PAM	1 μsec PW	1000 pps	10.6	200
5600	PAM	1 μsec PW	600 pps	10.6	200
9100	PAM	0.5 μsec PW	1000 pps	10.6	200
9375	PAM	0.2 μsec PW	1000 pps	10.6	200
13900	PAM	0.2 μsec PW	50000 pps	10.6	200
15500	PAM	0.2 μsec PW	50000 pps	10.6	200
33200	PAM	0.2 μsec PW	2000 pps	0.106	20

Notes:
1. Pulse Amplitude Modulated.
2. Microseconds Pulse Width.
3. Pulses Per Second.
4. Peak Power Density for PAM signals is defined as the power density measured by an average power measuring device if the generator is run CW; i.e. average power density within the pulse envelope.
5. Volts Per Meter equivalent shown for reference only.
6. The frequencies listed should be taken as approximate. System performance must be demonstrable at any arbitrary frequency within +5% of the frequencies listed. Frequency ranges listed with more than one modulation shall be repeated as necessary to include all different modulations as shown.

TABLE V. Operating environment.

Frequency 6 (MHz)	Modulation			Power Density[4] (mw/cm^2)	V/m[5] (ref)
.014-30	AM 90% 1 KHz SINE WAVE			0.66	50
215-225	PAM [1]	10 μsec PW[2]	200 pps[3]	10.6	200
215-225	PAM	200 μsec PW	200 pps	10.6	200
400-450	PAM	4 μsec PW	300 pps	25	310
850-940	PAM	2 μsec PW	1000 pps	200	870
850-940	PAM	125 μsec PW	300	200	870
1215-1365	PAM	10 μsec PW	3000 pps	10.6	200
1260-1400	PAM	5 μsec PW	3000 pps	25	310
2900-3100	PAM	3 μsec PW	1000 pps	17500	8100
2900-3100	PAM	70 μsec PW	200 pps	17500	8100
3100-3500	PAM	10 μsec PW	3000 pps	50000	13700
3100-3500	PAM	50 μsec PW	3000 pps	50000	13700
3550-3700	PAM	1 μsec PW	1000 pps	2500	3000
5400-5800	PAM	1 μsec PW	600 pps	320	1100
9000-9160	PAM	0.5 μsec PW	1000 pps	500	1375
9300-9400	PAM	0 2 μsec PW	1000 pps	40	390
13500-14500	PAM	0.2 μsec PW	50000 pps	40	390
15400-15700	PAM	0.2 μsec PW	50000 pps	10.6	200
33000-33400	PAM	0.2 μsec PW	2000 pps	2500	3070

Notes:
1. Pulse Amplitude Modulated.
2. Microseconds Pulse Width.
3. Pulses Per Second.
4. Peak Power Density for PAM signals is defined as the power density measured by an average power measuring device if the generator is run CW; i.e. average power density within the pulse envelope.
5. Volts Per Meter equivalent shown for reference only.
6. The frequencies listed should be taken as approximate. System performance must be demonstrable at any arbitrary frequency within +5% of the frequencies listed.

3.7 Configuration management. Configuration management of the VWU shall be in accordance with the basic requirements of MIL-STD-973 as a minimum. The VWU shall store the configuration identification number in memory.

"Basic requirements" is the first paragraph under "general requirements." Basic requirements include configuration identification, configuration control, configuration status accounting, and configuration audits. This is basic policy in DOD INST 5000.2, PART 9, SECTION A, and is applicable to NDI when the development of technical data is required to support off-the-shelf equipment or software. Configuration identification is required for data bus RTs to ensure compatibility with platform software.

3.8 Nomenclature and marking. Nomenclature assignment shall be in accordance with MIL-STD-196 and MIL-N-18307. Information and identification plates shall be in accordance with MIL-P-15024 and MIL-P-15024/2. Permanency and legibility of external marking shall be in accordance with MIL-STD-130.

This requirement is tailored from MIL-STD-454.