METRIC

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MILITARY HANDBOOK

AIRCRAFT/STORE ELECTRICAL INTERCONNECTION SYSTEM

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FOREWORD

1. This Handbook was developed by a team including members from the three US military services, the UK MOD, the SAE AS-1B committee, and contractors. It includes information previously published in document ASD-TR-87-5028 with certain elements of ASD-TR-91-5009. Some of this information was also published in DEF-STAN-00-69 (Part II), which is written around MIL-STD-1760B. This version of this Handbook is written around MIL-STD-1760C and assumes that the reader is also reading 1760C.

2. This Handbook provides information on the implementation of a standardized electrical interconnection system, as defined by MIL-STD-1760, into both current and future aircraft and stores. It provides guidance on design considerations and options for including the standard interface capability at the aircraft's store stations and for providing a common electrical interface on carriage stores and mission stores. As a handbook, it cannot be invoked as a requirement in a contract.

3. Trends in weapon system designs (aircraft and stores) caused concern over the general proliferation of aircraft-to-store electrical interfacing requirements and the resulting high cost to achieve interoperability between aircraft and stores. The intent of MIL-STD-1760 is to reduce the aircraft/store electrical integration problem by specifying a standard electrical interface between aircraft and stores. The standard electrical interface is based on recognized trends in store management systems which use serial digital data transmission for control, monitor and release of stores. In general, the handbook provides the following:

a. An overview of MIL-STD-1760 requirements, exclusions and future growth provisions.

b. Detail design considerations applicable to the Aircraft Station Interface (ASI), Mission Store Interface (MSI), Carriage Store Interface (CSI) and the Carriage Store Station Interface (CSSI), with application guidelines.

c. Aircraft/Store Physical Design Considerations.

d. A commentary on the purpose of each requirement in MIL-STD-1760.

e. A summary of changes between the various revisions of MIL-STD-1760.

4. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this DRAFT should be addressed to:

ASC/ENOI, 2530 Loop Rd W, WPAFB, OH 45433-7101, or e-mailed to:

James.Byrd@wpafb.af.mil.

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1. SCOPE

1.1 Purpose.

This Handbook is intended to provide useful information on the application of MIL-STD-1760. It is for use by: System Program Offices (SPOs), Aircraft Prime Contractors, Avionics and Store System Designers, System Integrators and Equipment Manufacturers and Users. The standard has a significant impact on the system design of related avionics systems, such as the Stores Management System (SMS), the Power Distribution System (PDS) and Data Transfer Equipment (DTE). It also impacts the design of the stores themselves.

This Handbook was prepared to increase awareness of available methods for improving aircraft/store interoperability. Additionally, this Handbook emphasizes to the aircraft designer, carriage store designer and mission store designer the importance of the complete weapons systems approach to the solution of the interoperability problem. The systems approach is one that recognizes the interrelationships of components and parts within the aircraft/carriage store/mission store system, and the interactions between the parts of the system.

While it is recognized that each weapon system is somewhat unique, an effort has been made to present recommended design practices in a manner that will help the designer to adapt various recommendations to his particular situation. It should be recognized, however, that any given design practice may not be equally effective in all weapon systems. This use of this Handbook must be complemented, therefore, by sound engineering judgement.

1.2 Background.

The material contained in this Handbook is intended to provide the weapon system designer with the following types of information:

a. A thorough understanding of the requirements imposed by MIL-STD-1760.

b. Identification of design problem areas that could contribute to an interface incompatibility.

c. A presentation of design techniques, components and design practices that might be useful in implementing MIL-STD-1760.

d. Practical guidance and associated rationale for users of MIL-STD-1760 in future applications.

For most weapon systems, a low level of interoperability is inevitable unless the designer recognizes the design risks, is aware of their causes and available means of minimizing the risks, and organizes all phases of the weapon system development in the original design to enhance interoperability. Retrofitting after an interoperability problem is discovered is expensive and seldom contributes to weapon system reliability.

The complete Aircraft/Store Electrical Interconnection System (AEIS) is comprised of three elements: Electrical, Physical and Logical. The electrical element specifies the aircraft-to-store interface signal set and associated electrical characteristics including interrelationships between the various interfaces. The physical element specifies the mechanical aspects necessary for achieving intermateable electrical connections within the system. The logical element defines digital data transfer aspects such as the communication protocol, formatting rules for messages and standard data words. As an example of one MIL-STD-1760 installation, figure 1 is a photograph of a MIL-STD-1760, primary signal set umbilical cable between the ASI on the bottom of a B-52 bomber and the MSI on the top of a Joint Directed Attack Munition (JDAM).

The electrical interface is comprised of two signal sets, a Primary Signal Set and an Auxiliary Signal Set. Both signal sets are applicable to the aircraft, the carriage store and the mission store parts of the interface.

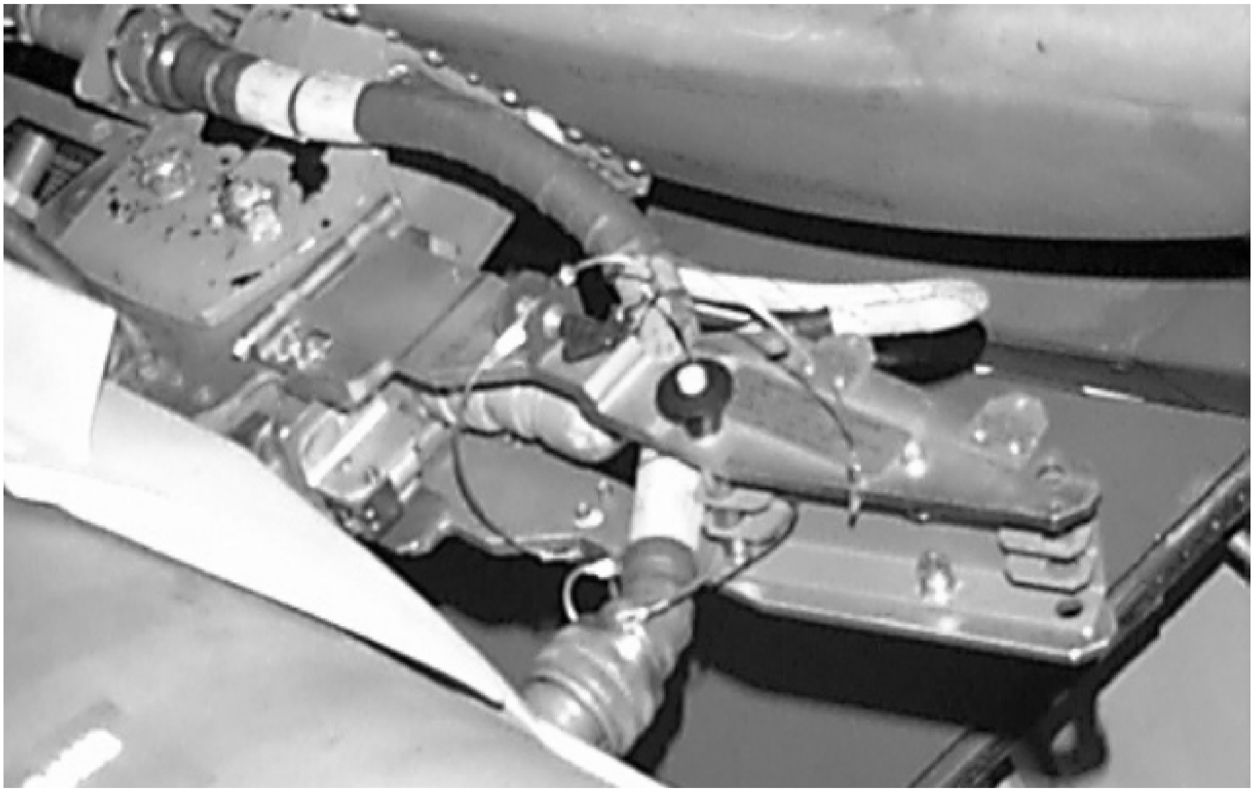


FIGURE 1. Photograph of MIL-STD-1760 umbilical between B-52 and JDAM.

1.3 Limitations.

This Handbook and MIL-STD-1760 do not cover aircraft and stores compatibility relating to mechanical, aerodynamic, logistic and operational factors. Size, shape, loads, clearances and functional limitations are not specified in MIL-STD-1760.

2. APPLICABLE DOCUMENTS

2.1 General.

The documents listed below are not necessarily all of the documents referenced herein, but are the ones that are needed in order to fully understand the information provided by this handbook.

2.2 Government documents

2.2.1 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 Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto. Note that this list also includes documents that have been cancelled, but provide significant historical background information.

SPECIFICATIONS

MIL-B-5087	Bonding, Electrical and Lightning Protection for Aerospace Systems
MIL-E-6051	Electromagnetic Compatibility Requirements, Systems
MIL-R-6106	Relays, Electromagnetic, General Specification for
MIL-A-8591	Airborne Stores, Suspension Equipment and Aircraft-Store Interface (Carriage Phase); General Design Criteria for
MIL-C-38999	Connectors, Electrical, Circular, General Specification for
MIL-R-39016	Relays, Electromagnetic, Established Reliability, General Specification for
MIL-C-39029	Contacts, Electrical Connector, General Specification for
MIL-DTL-83538	(Plus its slash sheets) Connectors and Accessories, Electrical, Circular, Umbilical, Environment resistant, Removable Crimp contacts, for MIL-STD-1760 Applications (Metric), General Specification For
MIL-I-85850	Integrated Voice Communication System
MS-27495	Tool, Contact, Connector Assembly and Disassembly

STANDARDS

MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Emission and Susceptibility, Test Methods for
MIL-STD-464	Electromagnetic Environmental Effects Requirements for Systems
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-1498	Circuit Breakers, Selection and Use of
MIL-STD-1512	Electroexplosive Subsystem, Electrically Initiated, Design Requirements and Test Methods
MIL-STD-1553	Aircraft Internal Time Division Command/Response Multiplex Data Bus
MIL-STD-1560	Insert Arrangements for MIL-C-38999 and MIL-C-27599 Electrical, Circular Connectors
MIL-STD-1815A	Ada Programming Language

MIL-STD-1818	Electromagnetic Effects Requirements for Systems, Interface Standard for

HANDBOOKS

MIL-HDBK-235	Electromagnetic (Radiated) Environmental Considerations for Design and Procurement of Electrical and Electronic Equipment
MIL-HDBK-244	Aircraft-Store Integration
MIL-HDBK-1553	Multiplex Applications Handbook

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

2.3 Other Government documents, drawings, and publications.

The following other Government documents form a part of this document to the extent specified.

ASD-TR-91-5009	MIL-STD-1760 Application Guidelines
ASD-TR-87-5028	Design Principles and Practices for Implementation of MIL-STD-1760 in Aircraft and Stores

NOTE: This handbook includes all material from these two technical reports that was judged to be relevant to current MIL-STD-1760 installations.

(Copies of the above Aeronautical Systems Division technical reports are available from ASC/ENAS, 2530 Loop Road West, Wright-Patterson AFB OH 45433-7101.)

2.4 Non-Government standards and other publications.

The following document(s) form a part of this handbook to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS, and supplent thereto.

EIA-STD-RS-170	Electrical Performance Standards -Monochrome Television Studio Facilities
EIA-STD-RS-343A	Electrical Performance Standards - High Resolution Monochrome Closed Circuit Television Camera
EIA-STD-RS-485	Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems

(Application for copies should be addressed to the Electronics Industries Association, 2001 Eye Street NW, Washington DC 20006.)

NATO STANDARDISATION AGREEMENT

STANAG 3350AVS	Monochrome Video Standard for Aircraft System Applications

(Copies of NATO standards are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094, phone (215) 697-2179.)

2.5 MIL-STD-1760.

For the purposes of this document, “MIL-STD-1760” is a generic term referring to any version of the aircraft/electrical interconnection system standard. The current version at the time of writing this Handbook is Revision C, notice 1, referred to herein as “MIL-STD-1760C” or “MIL-STD-1760C notice 1”.

3. DEFINITION OF TERMS AND ACRONYMS

3.1 Definition and use of terms.

Terms used within this document are as defined in the referenced documents, MIL-HDBK-244, the NATO Glossary of Terms and Definitions for Military Use and as follows.

3.1.1 Aircraft.

Any vehicle designed to be supported by air, being borne up either by the dynamic action of the air upon the surfaces of the vehicle, or by its own buoyancy. The term includes fixed and movable wing aircraft, helicopters, gliders and airships, but excludes air-launched missiles, target drones and flying bombs.

3.1.2 Aircraft/store electrical interconnection system (AEIS).

A system composed of electrical (and fiber optic) interfaces on aircraft and stores through which aircraft energize, control and employ stores. The AEIS consists of electrical interfaces necessary for the transfer of electrical power and data between aircraft and stores and from one store to another store via the aircraft.

3.1.3 Electrical interface types.

The AEIS consists of five electrical interface types as follows:

3.1.3.1 Aircraft station interface (ASI).

The interface on the aircraft structure where the mission or carriage store is electrically connected. This interface is usually on the aircraft side of an aircraft-to-store umbilical cable. Some carriage configurations may not use an "umbilical cable", e.g. rail launchers.

The Aircraft Station Interface locations include pylons, conformal and fuselage hard points, internal weapon bays and wing tips.

3.1.3.2 Carriage store interface (CSI).

The interface on the carriage store structure to which the aircraft is electrically connected. This interface is on the carriage store side of an umbilical cable.

3.1.3.3 Carriage store station interface (CSSI).

The interface on the carriage store structure to which the mission store is electrically connected. This interface is usually on the carriage store side of the carriage store-to-mission store umbilical cable. Some carriage stores, such as rail launchers, may not use an "umbilical cable" but use some other cable/connector mechanism.

3.1.3.4 Mission store interface (MSI).

The interface on the mission store structure to which the aircraft or carriage store is electrically connected. This interface is on the mission store side of an aircraft-to-store umbilical cable, a carriage store-to-mission store umbilical cable, or a rail launcher cable/connector mechanism.

3.1.3.5 Routing network aircraft subsystem port (RNASP).

The electrical interface between the high bandwidth network or low bandwidth network and other subsystems within the aircraft. This interface point is defined in order to identify the "aircraft" end of the high bandwidth and low bandwidth networks and allows network performance to be specified in two-port network terms.

3.1.4 Standard store interface (SSI).

Any electrical aircraft/store interface which complies with MIL-STD-1760.

3.1.5 Non-standard store interface (NSSI).

Any electrical aircraft/store interface which does not comply with MIL-STD-1760.

3.1.6 Aircraft station.

A primary hard-point fixture, or fixtures, on the aircraft structure at which one or more primary store stations and/or MIL-STD-1760 ASIs may be simultaneously located.

3.1.7 Store.

Any device intended for internal or external carriage and mounted on an aircraft suspension and release equipment, whether or not the device is intended to be separated in flight from the aircraft. Stores are classified in two categories as follows:

3.1.7.1 Carriage store.

An article of suspension and release equipment that is mounted on aircraft on a non-permanent basis. Pylons and primary ERUs, such as a MAU-12 (UK 119 ERU), are not considered carriage stores. Examples of, non-AEIS, carriage stores include, but are not limited to, the TER-7 (UK CBTE No2 Mk1) and LAU 7.

3.1.7.2 Mission store.

A device which supports a specific mission. This term excludes suspension and release equipment and carriage stores. Examples of mission stores include, but are not limited to, the following:

Missiles
Bombs
Nuclear weapons
Rocket pods, dispensers capable of ejecting multiple submunitions, guns and gun pods
Torpedoes
Pyrotechnic devices
Sonobuoys
Flares, chaff dispensers
Drones
Pods (laser designator, electronic countermeasures, store control, data link, reconnaissance)
Fuel and spray tanks
Target and cargo drop containers

Note that individual rockets, gun rounds and submunitions are not considered to be stores.

3.1.8 Interoperable store.

Any store with an SSI that is intended for use on two or more aircraft types, excludes special carriage trays.

3.1.9 Store selection.

A store is defined as having been selected when any function or signal, other than store communications or store interruptive BIT, has been activated or applied to that store.

3.1.10 Store communication.

Transmission to/from a store via the MIL-STD-1553 data bus.

3.1.11 Reversionary activity.

The process which may occur following a detected system or store failure, which attempts to allow system availability to be maintained.

3.1.12 Arming.

The process of preparing a store for employment from a safe condition. Arming is only initiated as a result of a positive request from the aircrew to the aircraft. Arming does not include the transition to an irreversible state.

3.1.13 Irreversible commit.

A process which results in irreversible changes in the employment states of stores and which excludes the store separation process. Subsequent to irreversible commit, either a clean release or hang-fire will be achieved.

3.1.14 Store employment.

The process which allows a store to fulfill its intended operational requirement.

3.1.15 Store separation.

Any process which results in the intended separation of stores from the aircraft while in flight. The process includes bomb release, missile launch, rocket fire and jettison activities.

3.1.16 Firing.

The process of causing a projectile to be separated from the aircraft through a tube. It is usually applied to firing guns, rockets and dispenser type munitions.

3.1.17 Release.

Separation of stores from the aircraft in flight, usually in a vertical direction, for the purposes of employing the store. This would include "Eject Launch".

3.1.18 Launch.

The process of separating self-propelled stores, such as missiles, from the aircraft in flight for the purposes of employing the store.

3.1.19 Jettison.

The process by which stores are intentionally separated from the aircraft in a safe and unarmed condition. Jettison is normally performed following a system or store failure, or when the safety of the aircraft may be in jeopardy. Stores may be selectively jettisoned individually or in groups. Emergency jettison separates all appropriate stores from the aircraft in a minimum period of time.

3.1.20 Stores management system (SMS).

The aircraft avionic subsystem that controls and monitors the operational status of aircraft installed stores and provides and manages the communications between aircraft mounted stores and other aircraft subsystems.

3.1.21 Suspension and release equipment (S&RE).

All airborne devices used for carriage, suspension, employment and jettison of stores, such as ERUs, adapters, launchers, pylons etc. The S&RE includes "permanently mounted" equipment such as parent bomb racks, e.g. MAU-12s, and removable carriage stores (see 3.1.7.1).

3.1.22 Provisions.

Materials and space provided in advance to allow incorporation of added functions in the aircraft or store without modification other than the addition or changes to connectors, cables and hardware/software necessary to control the added functions.

3.1.23 Hierarchical bus network.

A network of two or more MIL-STD-1553 buses where one or more buses has a command response protocol independent of one or more of the buses and which have data passing relationships.

3.2 ACRONYMS AND ABBREVIATIONS.

Acronyms and abbreviations used in this Handbook are defined as follows:

A, Amp	Ampere
AI	Aircraft Armament Interoperable Interface
AAM	Air-to-Air Missile
AAO	Air-to-Air Override
AC	Alternating Current
A/C	Aircraft
ADC	Air Data Computer
AEIS	Aircraft/Store Electrical Interconnection System
AFB	Air Force Base
AFR	Air Force Regulation
AGM	Air-to-Ground Missile
AHRS	Altitude and Heading Reference System
AIM	Air Intercept Missile

ALCM	Air Launched Cruise Missile
ALWT	Advanced Light Weight Torpedo
AM	Amplitude Modulation
AMAC	Aircraft Monitor and Control
AMRAAM	Advanced Medium Range Air-to-Air Missile
ARM	Anti-Radiation Missile
ASCU	Avionics Simulator and Control Unit
ASALM	Advance Strategic Air Launched Missile
ASAT	Anti-Satellite
ASDI	Alternate Serial Digital Interface
ASI	Aircraft Station Interface
ASPJ	Advanced Self-Protection Jammer
ASW	Anti-Submarine Warfare
AVS	AEIS Validation System
A/W	Aircraft Wiring
BC	Bus Controller
Bit	Binary Digit
BIT	Built-in-Test
BITE	Built-in-Test Equipment
BPS	Bits Per Second
BSGT	Boresight
BW	Bandwidth
CBU	Cluster Bomb Unit
CCIR	International Radio Consultative Committee
CCITT	International Telegraph and Telephone Consultative Committee
CMTT	Joint CCIR/CCITT Study Group of Television and Sound Transmission
CDR	Critical Data Review
CJ	Combat Jettison
CMRR	Common Mode Rejection Ratio
CRT	Cathode Ray Tube
CSI	Carriage Store Interface
CSSI	Carriage Store Interface
dB	deciBel
dBm	deciBels above 1 milliWatt
dBmV	deciBels above 1 millivolt
DAS	Defensive Aids System
DC	Direct Current
DEF STAN	Defense Standard (UK)
ECM	Electronic Countermeasures
EED	Electro-Explosive Device
EJ	Emergency Jettison
EM	Electromagnetic
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
ERU	Electro-explosive Release Unit
ESE	Existing Store Equipment
ESI	Existing Store Interface
FCC	Fire Control Computer

FCS	Flight Control System
FDD	Fault Detection Diagnostics
FDM	Frequency Division Multiplexing
FLIR	Forward Looking Infra-Red
FM	Frequency Modulation
FOV	Field of View
g	Gravity
GND	Ground
GPS	Global Positioning System
GHz	Giga Hertz
GSE	Ground Support Equipment
HBW, HB	High Bandwidth
HB1	High Bandwidth 1
HB2	High Bandwidth 2
HB3	High Bandwidth 3
HB4	High Bandwidth 4
HF	High Frequency
HOL	High-Order Language
HSDB	High Speed Data Bus
HUD	Head-Up Display
HVM	Hyper Velocity Missile
Hz	Hertz (also kHz, MHz, GHz)
IBU	Interference Blanking Unit
IBIT	Interruptive BIT
ID	Identification
IF	Intermediate Frequency
IFF	Identification, Friend or Foe
IIR	Imaging Infra-Red
INE	Inertial Navigation Equipment
INS	Inertial Navigation System
IOC	Initial Operating Capability
ISA	Instruction Set Architecture
I/O	Input/Output
I/P	Input
IFOL	In Flight Operable Lock
ICD	Interface Control Document
IR	Infra-Red
IRLS	Infra-Red Line Scan
JDAM	Joint Directed Attack Munition
JSOW	Joint Stand Off Weapon
JTA	Joint Test Assembly
JTIDS	Joint Tactical Information Distribution System
kg	kilograms
kHz	kilo-Hertz
L1	Link 1 (GPS)
L2	Link 2 (GPS)
LAD	Low Altitude Dispenser
LANTIRN	Low Altitude Navigation and Targeting Infra-Red for Night
LAR	Launch Acceptability Region
LAT, lat	Latitude

LB	Low Bandwidth
LDD	Logical Design Definition
LLTV	Low Light Television
LLSP	Lower Least Significant Part
LONG, long	Longitude
LOS	Line of Sight
LRSOM	Long Range Stand Off Missile
LRU	Line Replaceable Unit
LSP	Least Significant Part
m	Meter
m	milli (prefix factor equal to 10^{-3})
max	Maximum
MAS	Master Armament Switch
MAU	Multiple Adapter Unit
MCW	Maneuvering Cluster Weapon
MER	Multiple Ejector Rack
MFCD	Multi-Function Controls and Displays
MHz	Mega Hertz
MICOS	Multifunctional Infrared Coherent Optical System
MIL-STD	Military Standard
min	Minimum or Minute
Mips	Million Instructions Per Second
MRASM	Medium Range Air-to-Surface Missile
MSER	Multiple Store Ejector Rack
MSOW	Modular Stand Off Weapon
MSP	Most Significant Part
MSI	Mission Store Interface
MTBD	Mean Time Between Defects
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
MTTT	Mean Time To Test
MUX	Multiplex
NA	Not Applicable
NFV	Narrow Field of View
No.	Number
NSSI	Non-Standard Store Interface
NTSC	National Television Systems Committee (US color TV multiplexing)
NWC	Naval Weapons Center
O/B	Outboard
OFP	Operational Flight Program
PAL	Permissive Action Link
PAL	Phase-Alternating Line (European color TV multiplexing technique)
PCB	Printed Circuit Board
PCE	Process Control Equipment
PDU	Power Distribution Unit
p-p	Peak-to-Peak
Ph	Phase
PSJ	Pilots Selective Jettison

QA	Quality Assurance
RF	Radio Frequency
REF	Reference
RET	Return
RGB	Red, Green and Blue (non encoded color format)
RIU	Remote Interface Unit
RF	Radio Frequency
RFI	Radio Frequency Interference
RMS	Root Mean of Squares
RNASP	Routing Network Aircraft System Port
RPV	Remotely Piloted Vehicle
RS	Radiated Susceptibility
RT	Remote Terminal
RTN	Return
S	Second(s) (also ns, µs, ms)
SAE	Society of Automotive Engineers
SAIR	Safe and In-Range
SAM	Surface-to-Air Missile
S&RE	Suspension and Release Equipment
SEAM	SRAAM/Sidewinder Expanded Acquisition Mode
sec	Second
SEL	Select, Selected
SEM	Standard Electronic Module
SEMP	Standard Electronic Module Programme
SJ	Selective Jettison
SMP	Stores Management Processor
SMS	Stores Management System
SNR	Signal to Noise Ratio
SOW	Statement of Work
SPJP	Self-Protection Jammer Pod
SRAM	Short Range Attack Missile
SRU	Shop Replaceable Unit
SSI	Standard Store Interface
SSIU	Store Station Interface Unit
STANAG	NATO standardization agreement
TBD	To Be Determined
TCP	Time Correlation Pulse
TER	Triple Ejection Rack
TFR	Terrain Following Radar
TGT	Target
TOW	Tube Launched Optically Tracked Wire Guided
TRIG	Trigger
TV	Television
TXR(S)	Transformer(s)
u	micro (prefix factor equal to 10^{-6})
UHF	Ultra High Frequency
USAF	United States Air Force
UV	Ultra Violet
UW	Under Water
V	Volts (also mV)

Vpp	Volt peak to peak (also mVpp)
VA	Volt Amps
VAC	Volts Alternating Current
VCW	Verify Control Word
VDC	Volts Direct Current
VEL	Velocity
VHF	Very High Frequency
VSWR	Voltage Standing Wave Ratio
VTR	Video Tape Recorder
WASP	Wide Area Special Projectiles
W	Watt (also mW)
WCMD	Wind Corrected Munition Dispenser
WCS	Weapon Control System
WFV	Wide Field-of-View
WRIS	Weapon Release Inventory Switch
WRT	With Respect To

4. GENERAL

4.1 Scope of the standard.

MIL-STD-1760 covers the “electrical” portions of the interactions between aircraft, carriage stores and mission stores. It defines a standard interface for the transfer of electrical power from the aircraft to the store and transfer of information between aircraft and store. Note that the word “store” is used in the standard and in this handbook to mean both carriage stores and mission stores. In cases where a statement only applies to one or the other, it should refer specifically to carriage stores or mission stores.

In addition, MIL-STD-1760 indirectly drives requirements on the networks used to transfer electrical power and information between the aircraft and the store. Non-electrical interactions such as transfer of fuel, hydraulic power, coolant, pneumatic power, etc. are not covered by MIL-STD-1760.

The intent behind MIL-STD-1760 is to support achievement of interoperability between independently designed stores and aircraft by imposing specific interface design requirements applicable to each. The overall goal of the standard is to remove non-standard electrical interfaces as an obstruction to interoperability. Modification of aircraft and store hardware to allow new individual combinations to operate together is to be minimized. The use of adapter modules is to be discouraged. In this way, the effort and cost necessary to integrate aircraft and stores will be minimized.

Although MIL-STD-1760 was developed in the early ‘80s, the approach and philosophy is fully compatible with the government acquisition reform initiatives of the late ‘90s. It is an open interface, published and available to all users, and intentionally written to minimize constraints on the hardware on either side of the interface. An analogy might be the electrical power outlets in your office – they must be standardized to accommodate interchangeability of appliances and computers purchased competively from multiple commercial or military sources, just as we would like aircraft and stores from different suppliers to work together.

MIL-STD-1760 is designed to be flexible enough to accommodate individual system peculiarities. In particular, implementation may change with technology advances as long as the interface characteristics are maintained. Non-electrical compatibility parameters such as size, weight, aerodynamics, avionics capabilities, etc. must be satisfied in addition to the electrical interface in order to realize interoperability. Total interoperability is achieved only after these other aircraft-store compatibility issues, i.e. other than MIL-STD-1760, have been addressed and resolved. Aircraft and store compliance solely with MIL-STD-1760 will not directly result in interoperability, but will remove electrical interfacing obstacles to achieving interoperability. Once the MIL-STD-1760 interfaces are installed on an aircraft, the electrical portion of the aircraft/store integration effort should be limited to developing aircraft software modifications to accommodate new stores.

The electrical interface between the aircraft and a carriage store or mission store, or between a carriage store and a mission store, is represented physically by the surface at which the two sides of the interface make, or break, electrical contact. This occurs at the contacts in a mated electrical connector set, one half of which is considered to be the aircraft side and one half of which is considered to be the store side. All electrical power and information is transferred between units, e.g. aircraft, carriage stores or mission stores, across these contacts. Ideally, a functionally equivalent unit can be substituted at the interface without changing the operational characteristics of the unit on the other side of the interface.

An aircraft achieves interoperability by providing one or more interoperable store stations. In general, an aircraft can contain other store stations that are not interoperable; for example, a station designed for carrying only external fuel tanks. For a store station to be an interoperable candidate, two criteria must be met. Firstly, the store station must contain suspension and release equipment such as an MAU-12 or a rail launcher. Secondly, the store station must be capable of carrying more than one store type, but not simultaneously. The intent of these criteria is to exclude “dedicated” store stations, such as internal guns and internal chaff dispensers, and to exclude locations such as equipment bays with replaceable ECM modules or stations for conformal fuel tanks.

In summary then, MIL-STD-1760 is an aircraft to store electrical interconnection system designed to cover all the foreseeable (20+ years) electrical and optical requirements for stores and their carrying aircraft. It minimizes the numbers of wires, with the consequent quantity and variety of connectors, and digitizes the analog signals (except for some RF, video and audio) that stores and aircraft formerly required.

The MIL-STD-1760 functional interfaces are illustrated in figure 2. The specific implementation of a particular subsystem, i.e. mission store or carriage store or aircraft electronics, is the responsibility of that subsystem designer and is independent of the other subsystems from the perspective of the AEIS. The interface characteristics, however, are controlled by MIL-STD-1760 so that any subsystem may be interchanged with any functionally equivalent subsystem and still maintain circuit compatibility at the interface.

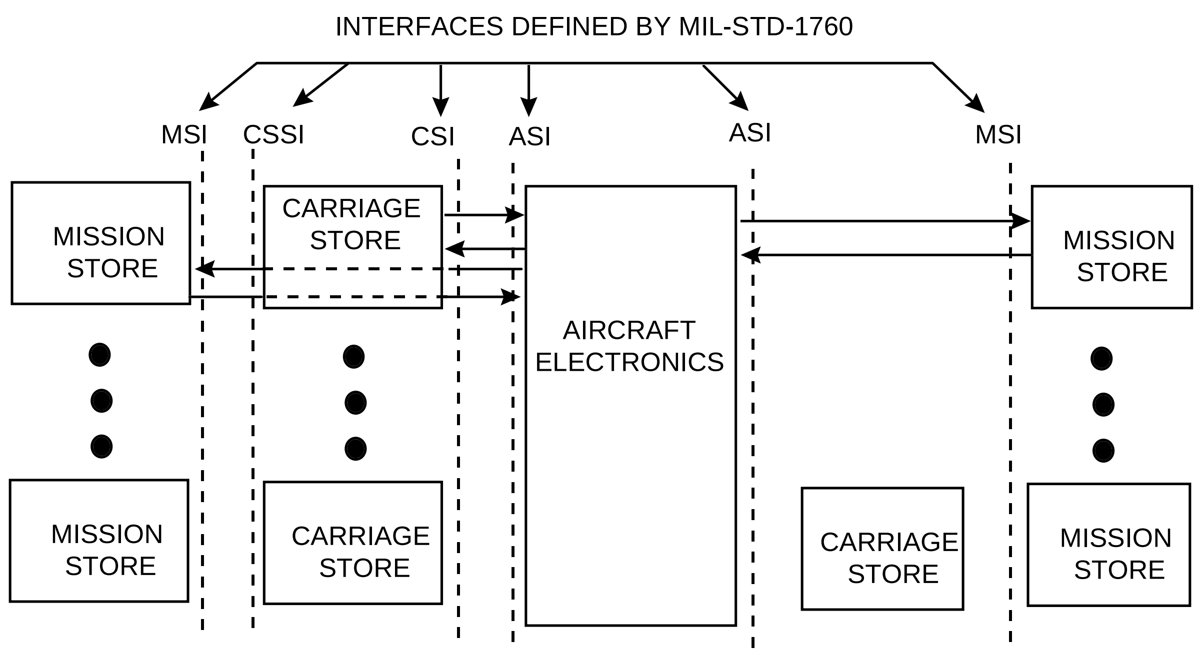


FIGURE 2. MIL-STD-1760 functional interfaces.

4.2 MIL-STD-1760 interface definitions.

Five interfaces are defined in the standard and are listed below.

Aircraft Station Interface
Mission Store Interface

Carriage Store Interface
Carriage Store Station Interface
Routing Network Aircraft System Port (not a key external interface as the other four are)

These interfaces are designed to allow for the carriage of a store on an aircraft with indirect or direct electrical connections, that is, with or without a carriage store. The interfaces are shown, with a variety of typical configurations, in figures 1 and 4 of the standard. The physical locations shown in the figures are typical locations. Whether the ASI connector is at the bottom of a pylon, in an access "well" in the pylon, on a piece of store station electronics (SSE) equipment, or on some other structure for non-pylon carriage modes, e.g. conformal carriage, does not change the underlying interface definitions and requirements.

Following are definitions of each interface segment, as illustrated in figure 1 of the standard:

Aircraft Station Interface (ASI). An aircraft station that complies with MIL-STD-1760 is defined as an ASI. The "aircraft station" is taken to be at the lowest point of electrical equipment that is designed exclusively for the aircraft type and model, whether or not the particular piece of equipment is permanently attached to the basic airframe. For example, an under wing or under fuselage pylon is considered to be part of the aircraft even though it may be installed or removed depending on the requirements at the time. The interoperable interface location on a pylon is at the connection point that is considered as the lowest point of the aircraft. Typically, an umbilical cable is mated to this connector to allow electrical connection with the installed carriage store or mission store. In effect, this umbilical cable acts as an "extension cord" from the ASI to the store's electrical connector.

Carriage Store Interface (CSI). Carriage stores that are capable of being carried on aircraft stations that comply with MIL-STD-1760 and have a compliant CSI and compliant CSSI(s) are defined as MIL-STD-1760 compliant carriage stores. The interconnection point at the carriage store for interfacing with the aircraft is defined as the CSI. The performance characteristics of the ASI to CSI umbilical must be considered in establishing the characteristics of the CSI. The CSI is physically the electrical connector which is permanently part of the carriage store and through which the carriage store is electrically connected to the aircraft.

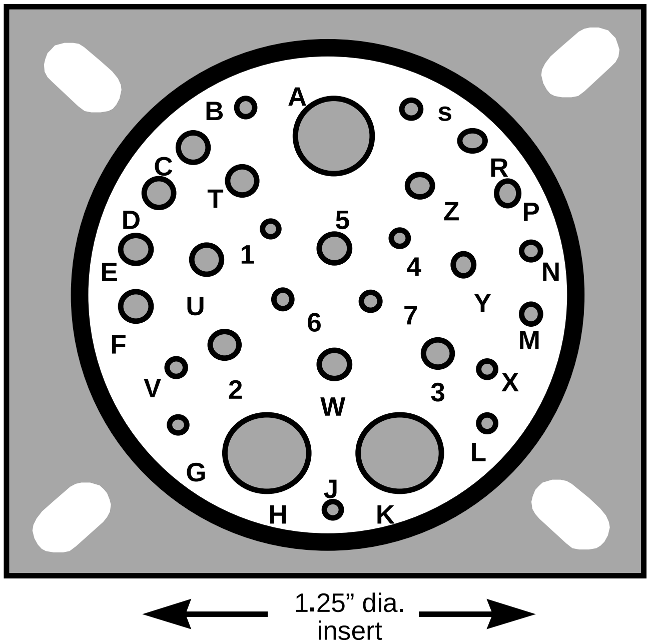
Carriage Store Station Interface (CSSI). The interconnection point at the carriage store for interfacing with the mission store is defined as the CSSI. The performance characteristics of the CSSI to MSI umbilical must be considered in establishing the characteristics at the CSSI. The CSSI is physically the electrical connector which is permanently part of the carriage store and through which the carriage store is electrically connected to a mission store.

Mission Store Interface (MSI). The electrical interface on mission stores which complies with MIL-STD-1760 is defined as the MSI. The MSI is the physical connector which is a permanent part of the mission store through which the store is electrically connected to the carrying aircraft (or carriage store).

Routing Network Aircraft System Port. This is the aircraft-end of the high bandwidth and low bandwidth networks. Requirements are defined here only to allow network parameters to be expressed in two-port network terms. This reference point is not a key external interface as the other four are.

4.3 MIL-STD-1760 interface elements.

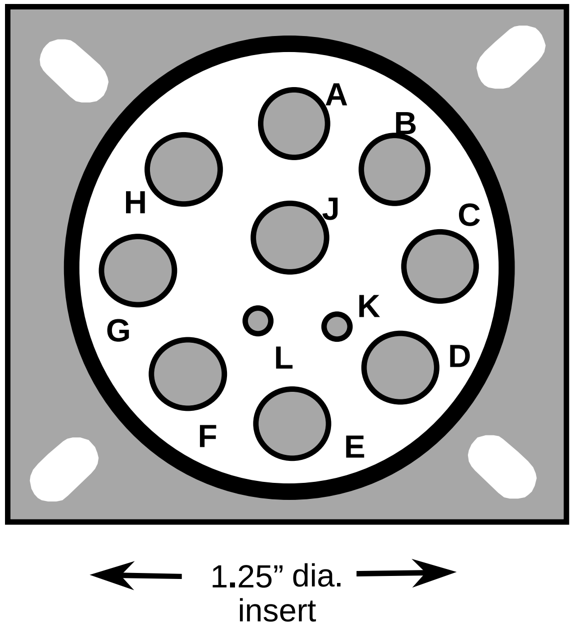
Three hierarchical elements in the interface are covered by the standard. The electrical element concerns the signal set; the physical concerns the connectors and contacts; and the logical concerns the communications architecture, message content and formatting and data transfer protocol. Figure 3 provides a sketch of the standard connector insert used for the primary signal set, and lists the function of each contact. Figure 4 provides a sketch of the standard connector insert used for the auxiliary power signal set and lists the function of each contact.



K, H	Mux A & B (twinaxial) (MIL-STD-1553)
5	High Bandwidth 1 (20 Hz - 1.6 GHz)
W, 3, 2	HB 2*, 3 & 4* (20 Hz - 20 MHz)
(HB 1, 2 = 50	Ohm co-ax, HB 3, 4 = 75 Ohm co-ax)
A	Low Bandwidth (twinaxial) (Audio)
Y, U	Fiber Optic 1* & 2* (reserved)
1	Release Consent
B, S	Interlock & interlock return
L, X, 7, 4, V	Address bits 0 thru 4
G, 6	Address parity & return
T	Structure ground (safety, 10 Amp)
C, D	28 VDC power 1 & return (10 Amp)
F, E	28 VDC power 2 & return (10 Amp)
P, M, J, Z	115 VAC, 3 phase & return (10 Amp)
R, N	270 VDC power* & return* (10 Amp)

* = Not required for Class II interface

FIGURE 3. Primary signal set.



A, C, E, G	115 V AC, 3 phases & Return (30 Amp)
B, D	28 V DC Power & Return (30 Amp)
F, H	270 V DC Power* & Return* (30 Amp)
J	Structure Ground (Safety, 30 Amp)
K, L	Interlock & Interlock Return

* = Not required for Class II interface

FIGURE 4. Auxiliary power signal set.

4.3.1 Electrical.

The electrical element is limited by defining 41 contacts and the signals that they are allowed to support. These signals are distributed across two connectors, the primary interface signal set connector and the auxiliary power signal set connector.

4.3.2 Physical.

This element concerns the connectors. These are MIL-C-38999 Series III, or MIL-C-83538, shells. They use specific inserts, designed to support MIL-STD-1760, which are included in MIL-STD-1560A. The contacts are standard MIL-C-39029 contacts, including two 50-ohm coaxial contacts (Slash sheets 102 and 103) for matched-impedance coaxial cable applications.

4.3.3 Logical.

This element is chiefly concerned with the data flow across the data bus interface. A breakdown of the prime areas of data flow is given in 4.5.8.

4.4 MIL-STD-1760 classes.

The standard defines four classes of interface and two signal sets. The two signal sets, namely the primary interface signal set and the auxiliary power signal set, are shown in figures 2 and 3 of the standard. The four classes of interfaces specified from these two signal sets are:

Class I Full primary interface signal set

Class IA Class I plus the auxiliary power signal set

Class II Class I minus HB2 and 4 and both the Fiber Optic and 270V DC provisions

Class IIA Class II plus the auxiliary power signal set minus the 270 VDC provisions

Mission stores are defined as being compatible with the applicable class above. This compatibility is achieved by complying with the requirements of the Standard applicable to those signals used by the store. If the signals required by a store are all contained within a Class II signal set, then the store is considered as a Class II (compatible) store. However, the store is not required to use all Class II signals. By definition, a Class II (compatible) store is also compatible with Class IIA, Class I and Class IA interfaces.

4.5 Summary of requirements.

MIL-STD-1760 defines the electrical interface requirements for supporting high bandwidth signals, multiplex data bus signals, low bandwidth signals, discrete signals and power. The electrical characteristics for supporting each of these signals are defined in the standard at the ASI, CSI, CSSI and MSI interconnection points. In the discussion that follows, the electrical connection within an ASI, CSI, CSSI or MSI for each signal is referred to as a signal port or simply a port. Except as specifically noted below, these signals are provided through the primary signal set interface.

4.5.1 High bandwidth signals.

Four high bandwidth ports, identified as HB1, HB2, HB3 and HB4 are available for transferring two types of high bandwidth signals, Type A and Type B, distinguished by the signal's frequency content:

Type A signals: 20 Hz to 20 MHz - Between ASI and aircraft and between ASI and ASI

Type B signal: 20 MHz to 1.6 GHz - Between ASI and aircraft only

(1) Radio frequency signals (Type B) such as GPS are transferred on HB1.

(2) Time correlation such as synchronization, clocking and blanking signals (Type A) are transferred on HB1 and HB2.

(3) Composite video signals (Type A) are transferred on HB3 and HB4.

The HB1 and HB2 ports are specified as 50-ohm (nominal) impedance circuits while the HB3 and HB4 ports are defined as 75-ohm (nominal) impedance circuits.

The extent that these signals are actually transferred between stores and aircraft subsystems, or between stores via the aircraft, varies with the mission requirements for each aircraft. As a result, the standard does not impose a specific network topology or capacity on the aircraft.

4.5.2 Digital multiplex data signals.

MIL-STD-1760 requires use of the MIL-STD-1553 data bus as far as possible. Standard MIL-STD-1553 bus controller and remote terminal hardware can generally be used, as long as the special requirements on voltage level are adhered to.

The data bus ports provide signal interconnections so that MIL-STD-1553B remote terminals in carriage stores or mission stores can exchange data with terminals in the carrying aircraft or in other carriage stores or mission stores. Redundant channels, Mux A and Mux B, are provided for transferring information, store control and store status data between aircraft and carriage stores or mission stores connected to a common data bus. Where mission stores are connected to a carriage store the same principles apply to the next hierarchical level. The carriage store or mission store's remote terminal is assigned a communications address via a set of address discretes (see 7.3) when connected to a specific ASI. The remote terminal in a store suspended on a carriage store is assigned an address via address discretes in the CSSI.

4.5.3 Low bandwidth signals.

One low bandwidth port is available for transferring bi-directional signals, 300 Hz to 3.4 kHz, between the aircraft and stores. The signals assigned to this port include tones and voice grade audio. The port characteristics were originally specified to also allow a future application of a low speed serial digital data link through this port, but this capability was dropped in Revision C of the Standard.

4.5.4 Discrete signals.

4.5.4.1 Release consent signal.

One port, identified as release consent, is used by the aircraft to transfer an enable/inhibit signal to the store for the purpose of granting consent to the store to act on safety critical commands received over the data bus. The actual store release is, however, commanded by the aircraft over the data bus, or through other media interconnecting the aircraft stores management system with the pylon ERU. The release consent signal is not a firing signal. The return line for release consent is the 28V DC Power 2 return line.

While release consent was originally established and named as an enable/inhibit safety interlock on the release of certain types of stores, the signal function has been broadened. The release consent is now viewed as a reversible enable/inhibit discrete for specific safety critical functions commanded of the store over the data bus.

4.5.4.2 Interlock interface.

Two ports, identified as interlock and its associated interlock return, are available to the aircraft for monitoring the mated status of the primary interface connector. Similar ports are available to the aircraft for monitoring the mated status of the auxiliary interface connector. This monitoring feature is provided by a continuity loop between interlock and interlock return in the store, such that as long as the store connector is mated, continuity exists.

While release of a store from the aircraft will break the electrical interconnection and thereby lose continuity, simple loss of continuity must not be used as the sole criteria to establish a store "not present" condition, since the store could be mechanically attached to the aircraft with the connector not mated. The operating sequence for rail launching some types of missile, e.g. AIM 120, provides a good example of the differences between electrical separation (umbilical retract) and mechanical separation.

4.5.4.3 Address signals.

Another type of discrete signal in the primary interface is the address signal. Five binary weighted address lines plus one parity line and one common return line, are provided by the aircraft as 7 ports. They are used to assign the store's MIL-STD-1553 terminal address, between 0 and 30, for data bus communication. This discrete set can also be used by the store to determine the mated status of the primary interface connector, i.e. the store's equivalent to the interlock discrete described in 4.5.4.2.

4.5.4.4 Structure ground.

One port is used to connect the aircraft structure to the store structure for the purpose of minimizing electrical shock hazards. The line must not be used specifically as a power or signal return line. The structure ground circuit is contained in both the primary and auxiliary interfaces.

4.5.5 Power.

Two power lines and two return lines are contained in the primary interface to transfer 28V DC Power 1 and 28V DC Power 2 to the store. Four lines are used to transfer 115/200V AC power (three phases and neutral - the “115” refers to the line-to-neutral voltage, the “200” refers to the line-to-line voltage) through the primary interface to the store. The auxiliary interface contains two lines for 28V DC power and return, and four lines for 115/200V AC power (three phases and neutral).

4.5.5.1 Primary 28V DC power.

The aircraft provides 28V DC 1 for use on non-safety critical store circuits and 28V DC 2 for safety critical circuits. Both are rated at 10 amperes continuous. In fact 28V DC 2 may be used for powering any circuitry, but because its prime use is for safety critical circuitry, the time for which it is likely to be available prior to store separation is very limited.

4.5.5.2 Primary 115V AC power.

The aircraft provides one channel of 3 phase 115V AC rated at 10 amperes continuous per phase. Store designs that do not utilize 28V DC 2 for powering safety critical circuits and therefore rely on voltages internally derived from the 115V AC, must design in appropriate safety interlocks of their own, as it is totally impractical for the aircraft to supply any such safeguards with power availability (except for deadfacing).

4.5.5.3 Auxiliary 28V DC power.

The aircraft provides one channel of auxiliary 28V DC power rated at 30 amperes continuous. It is intended for safety critical use and therefore has the same "rules" as Primary 28V DC 2.

4.5.5.4 Auxiliary 115V AC power.

The aircraft provides one channel of auxiliary 115V AC power rated at 30 amperes continuous per phase. As for the Primary 115V AC power, the aircraft will not provide power availability safeguards (except for deadfacing).

4.5.6 Growth provisions.

Provisions, two 16 gauge contact locations, for adding two fiber optic communication channels to the primary signal set are contained in the Class I primary interface. Provisions, two 16 gauge contacts, for adding one channel of 270V DC, power and return, to the primary signal set and auxiliary set are contained in the Class I primary and auxiliary interface.

4.5.6.1 Fiber optic interface.

The characteristics of these signals are not yet added to the standard and are not included in Class II interfaces.

4.5.6.2 270V DC power.

The characteristics of this power are not yet not added to the standard and are not included in Class II or Class IIA interfaces.

4.5.7 Connector types.

It is important to note that MIL-STD-1760C only specifies that the connectors being used have intermateability with MIL-C-38999 connectors (for Type I) and MIL-C-83538 (for Type II). This means the standard does not, by itself, require use of a mil-qualified source for the connectors. This also allows connectors to have modifications, such as a different backshell design, as long as they do not affect intermateability. MIL-C-38999 and MIL-C-83538 connector requirements which define the intermateability design fall into the categories listed below. In all cases, a shell size 25 is required. There is no difference in these requirements between primary and auxiliary connectors except for the insert arrangement.

Fixed sockets	MIL-C-38999 Slash Sheet 20 or 24
Free plug	MIL-C-38999 Slash Sheet 26
Snatch plug	MIL-C-38999 Slash Sheet 31 (lanyard release)
Blind mate (Launcher)	MIL-C-83538 launcher receptacle
Blind mate (Store)	MIL-C-83538 store receptacle
Blind mate (Buffer)	MIL-C-83538 buffer plug

4.5.7.1 Interface usage.

The basic categories discussed above apply for eject launch and non blind mate utilization as follows: MIL-C-38999 Slash 20 or 24 (jam nut or flange mount) can be used at the ASI, CSI, CSSI and MSI; Slash 26 can be used at the "top" of the umbilical, i.e., it is the mating half for the ASI and CSSI. If the store is not jettisonable, the Slash 26 may also be used, on a special umbilical, as the mating half for the CSI, that is the "top" and "bottom." Slash 31 can be used at the "bottom" of the umbilical, i.e., the mating half for the CSI and MSI.

The connector requirements specified for the MSI, and its mating half, used in both Blind-Mate Eject and Rail Launch applications, are those in MIL-C-83538. MIL-C-83538 is specifically for the "shells" only, as the insert arrangements are covered elsewhere.

4.5.7.2 Connector inserts.

Two connector insert arrangements are specified to fit the shells discussed above. These inserts are for the primary and auxiliary applications and are defined in MIL-STD-1560, arrangements 25-20 and 25-11 respectively. No other insert arrangements are authorized. Note that MIL-STD-1760 is not consistent with MIL-STD-1560 in calling out contacts (/102 and /103). This creates a problem when connectors are purchased with contacts included. A contact must be ordered separately for HB2 to meet 1760 contact requirements.

4.5.7.3 Connector contacts.

The contacts are those specified in MIL-C-39029 as listed in the standard. There are matched-impedance coaxial contacts, (slash sheet 102 and 103 are the pin and socket contacts, respectively), required for the high bandwidth 1 applications. It was necessary to develop new contacts, which are specifically designed for impedance matching with 50-ohm coaxial cable, in order to meet the stringent return loss (or VSWR) requirements of a MIL-STD-1760 high bandwidth 1 installation.

4.5.8 Logical requirements.

Appendix B of the standard establishes requirements on the communication rules, message requirements and data entities that apply to the MIL-STD-1553 data bus in the MIL-STD-1760 interface. Key features are:

a. The command word requirements are basically those in MIL-STD-1553B. Certain field requirements are enforced or mandated. Within the address field the broadcast option is limited to mode commands.

b. The status word requirements are basically those in MIL-STD-1553B. The implementation of the Service Request, Busy, Sub-system Flag and Terminal Flag bits are regulated by the standard.

c. The store is required to conduct protocol checks on all receive messages that can initiate safety critical actions. A "protocol check" failure reporting mechanism, along with other features, provide greater safety for things like arming and firing signals than a discrete signal could.

d. Automatic store ID is required. This allows for automated stores inventory, and allows the aircraft to identify correct control modes or software modes.

e. Mass data transfer capability is available; the method is standardized in Revision C.

f. Numerous standard data entities are defined and are to be used as far as possible.

g. Broadcast is permitted, with some restrictions.

4.5.9 Exclusions.

Aircraft/Store Electrical Interconnection System (AEIS) refers to standardized weapon interfaces and certain interrelationships between those interfaces. Performance requirements at this interface are specified in MIL-STD-1760. AEIS does not refer to a specific assembly or software embedded in an aircraft or store, i.e., it is implemented by various boxes, cables, programs, etc, and typically cannot be removed from the aircraft or store and regarded as an "AEIS" system. AEIS impacts several aircraft systems such as the stores management system and power distribution system. It is expected that implementations of the AEIS in different aircraft and stores will use different design technologies. However, the interface characteristics between an aircraft and store are standardized at each interface (ASI, MSI, CSI, CSSI) by MIL-STD-1760.

4.5.9.1 Stores management system.

Aircraft equipment assigned to the stores management system (SMS) implement the aircraft portion of the AEIS. In recent generation tactical aircraft, a "distributed" SMS has been selected. This SMS is typically composed of a central processor, dedicated and/or shared controls and displays, store station equipment (SSE) and miscellaneous aircraft interface equipment. The SSE is generally located close to the ASI. This SSE is referred to as Remote Interface Units, Station Decoders or Missile Interface Units etc., on various aircraft and provide a common function, a control of interface inputs and outputs required to operate a specific store or set of stores. For an SMS with such store station equipment, the aircraft's MIL-STD-1760 interface, i.e. the ASI, is implemented in this equipment at least as long as operation of other non-AEIS stores is required. The AEIS standard, therefore, impacts this SSE just as interface requirements of non-AEIS stores impact the SSE. However, the SSE is only one part of the SMS. Other major functions of an SMS include the processing of information, control and monitoring store states, and interfacing with other aircraft avionics. The AEIS standard has minimal impact on these other SMS functions. As examples, MIL-STD-1760 does not define control/display requirements for the man-machine interface nor specify the allocation of processor memory between volatile and non-volatile types. Therefore, although the AEIS impacts the SMS by imposing requirements on the SMS, MIL-STD-1760 is not a stores management system specification or standard and allows a high degree of SMS implementation flexibility.

4.5.9.2 Jettison.

At least two categories of jettison are defined by armament system specifications: emergency jettison and selective jettison. Other names are used for these functions but they can generally be classified into one of two categories.

a. Jettison of "all" stores in response to an emergency. The word "all" is qualified because in most cases air-air missiles are not jettisoned.

b. Jettison of only those stores selected by the flight crew. For this case, stores at selected stations can be jettisoned while other stores are retained.

4.5.9.2.1 Jettison function.

As a general case, the jettison function is achieved by the SMS and the suspension and release equipment (S&RE) at a store station. The S&RE provides a mechanical interface between aircraft and store analogous to the electrical interface provided by the AEIS. The power and information for achieving this jettison function does not normally cross AEIS interfaces and is not, therefore, addressed by the AEIS standard. The only cases where this might not apply are:

a. for selective jettison of mission stores from a carriage store,

b. for unarmed firing of a self-firing rail launched missile.

Both of these exceptions are actually unarmed releases and could, therefore, be provided through the capabilities in the AEIS interfaces.

4.5.9.3 Mission store functions.

Similar to the SMS functions discussed in 4.5.9.1, most internal store functions are not impacted by MIL-STD-1760. While the AEIS standard defines characteristics of the mission store interface, design and operating requirements on internal store functions are not covered by MIL-STD-1760. As examples, the AEIS standard does not define the power supply voltage levels for internal store circuitry, or the information transfer mechanism between subsystems within a missile, or the performance required for mid-course guidance.

4.5.9.4 Carriage store functions.

Carriage stores and interconnecting umbilicals can be inserted between the ASI and MSI (see figure 1 of the standard). Sections defining detailed interface requirements on carriage stores and umbilicals were added in MIL-STD-1760 Revision C. Prior to this, designers of carriage stores extracted needed CSI and CSSI characteristics from the ASI and MSI requirements. In extracting these characteristics, the performance degradation from the two umbilicals, ASI-CSI and CSSI-MSI, are important to the design of the carriage store.

4.5.9.5 Ground support equipment.

MIL-STD-1760 impacts the design of Ground Support Equipment (GSE) since GSE connects to the aircraft and store at the interfaces. However, the procedures and fault isolation algorithms will vary between different aircraft and stores. Therefore, MIL-STD-1760 does not address specific GSE design requirements. It is not the MIL-STD-1760 interface that is tested, but rather specific SMS or store implementations of that interface that are tested.

4.5.10 Future expansion of MIL-STD-1760.

MIL-STD-1760 is structured to allow future update to include advanced technologies presently in the development phase. Three technologies in various stages of development which may be applicable are: High Voltage DC electric power systems, fiber optics information distribution and High Bandwidth digital communications.

4.5.10.1 High voltage DC electric systems.

The high voltage DC (270V DC) electric system under development offers potential advantages over the existing standard 115/200 volt AC system. Contact locations suitable for 270V DC and 270V DC return are included in the MIL-STD-1760 connector. MIL-STD-704 includes 270V DC as a standard power system voltage, and it has been incorporated into some new aircraft. However, at the time of this writing (2000), the 270 V DC system has not been used at store stations. The issues associated with implementing 270V DC power are discussed in section 11.

4.5.10.2 Fiber optic interfaces.

Fiber optic communication techniques can offer advantages to future aircraft-store interface performance if high data rates or higher electromagnetic environmental requirements are needed. Two 16 gauge contact cavities in the MIL-STD-1760 primary connector are reserved for fiber optics. A specific Fiber Optic requirement was proposed, but not included as a requirement, in Revision C. When a specific fiber optic interface that meets the needs of stores interface is developed, it should be added to the standard. The issues associated with implementing the fiber optics interface, along with the proposed paragraphs, are discussed in section 12.

4.5.10.3 High bandwidth.

The high bandwidth (HB) transfer media requirements specified in MIL-STD-1760 include provisions for accommodating future weapon requirements. As such, no changes to the standard are expected for adding capacity in the form of additional bandwidth, higher signal levels etc. As an example, HB3 and HB4 ports are defined with a 20 MHz upper frequency limit for video applications. Typical video signals in current stores have an approximate 6 MHz upper frequency limit. However, high resolution video systems are being considered and are being included in military video standards, like STANAG 3350. As a result, MIL-STD-1760 includes the high bandwidth specification for encompassing the high resolution video.

4.6 Purpose, goals and projected benefits of MIL-STD-1760.

4.6.1 Previous lack of interoperability.

Within NATO countries, other than the US, aircraft are purchased to support specific missions, for example fighter or ground attack, and furthermore they tend only to purchase one type of aircraft for each mission. Also, in order to "keep an independent capability", many NATO countries also have different types of aircraft between them to support the same basic missions. In both the US and NATO, stores are developed largely independent of each other, even though the requirements may be very similar, and within NATO, mainly due to the earlier discussion, they quite often support only one type of aircraft. This situation has resulted in unique aircraft/store electrical interconnection requirements and a consequent proliferation of interface designs. Table I gives some examples of this. This lack of standardization has led to low levels of interoperability which can have a detrimental impact on force effectiveness. Technology advances have led to a quantum jump in the requirements of effectiveness, in both capability and flexibility, of mission stores and have also meant that the age-old requirements to stand-off from the target is now a practical proposition. This is now being reflected into the use of increasing amounts of avionic data and control information from aircraft systems and this, if allowed to proceed without a common interface standard, for example MIL-STD-1553B as required by MIL-STD-1760, will inevitably lead to insurmountable technical and/or funding problems.

TABLE I. Example of aircraft, stores and store missions.

Aircraft	Store	Store Mission
F4 M	Sparrow	MRAAM (Radar)
TORNADO (UK ADV)	Sky Flash	MRAAM (Radar)
ORION	Harpoon	Anti-Ship Missile
SEA HARRIER	Sea Eagle	Anti-Ship Missile
TORNADO (Germany)	Kormoran	Anti-Ship Missile
USAF	AIM-9J/P	SRAAM
USN	AIM-9L/M	SRAAM
TORNADO (Germany	AIM-9L	SRAAM
TORNADO (UK)	AIM-9L	SRAAM
USAF	LOCL POD	Area Denial
TORNADO (UK)	ALARM	Anti-Radar Missile
TORNADO (Germany)	ALARM	Anti-Radar Missile

Note: France has an equivalent for each of the stores listed above, for example anti-ship is Exocet, and these also have different interfaces.

4.6.2 Purpose and goals of MIL-STD-1760.

The application of this standard to new stores and to new and existing aircraft will significantly reduce and stabilize the number and variety of signals required at aircraft/store interfaces. This will minimize the cost impact of new stores on future stores management systems and increase store interoperability among the services within NATO and with our other allies. In practice, true interoperability will not be fully achieved, but a significant reduction in the support costs will accrue. It is important to understand that the goal of interoperability does not mean the standardization of all stores or aircraft systems per se. However, it should mean that all NATO aircraft should be able to carry, and employ, the NATO store specific to that aircraft mission, as well as the national specific solution with minimal, or preferably no, modifications.

4.6.3 General benefits of MIL-STD-1760.

The perceived benefits are increased interoperability of aircraft stores and decreased aircraft-store integration time and cost. Some aircraft system designers argue, however, that the electrical integration costs are inconsequential when compared with the physical integration problem and that the standard will not provide interoperability. The costs of physical integration are not pertinent to the MIL-STD-1760 issue. The fact remains that millions of dollars are wasted on unnecessarily complex electrical integration tasks. This problem may increase dramatically as the sophistication and electrical complexity of stores increase. MIL-STD-1760 alone will not provide electrical interoperability of various store types. If, however, interoperability is evaluated in terms of cost of integrating new stores, experience on programs like the current generation of GPS-guided weapons indicates a dramatic improvement as a result of MIL-STD-1760 since these stores all use the MIL-STD-1760 connector and signal set. After the first MIL-STD-1760 weapon was integrated on the aircraft, the follow on weapons could all be integrated with software changes only.

4.6.4 Logical definition benefits within MIL-STD-1760.

A workable, consistent logical definition for aircraft-to-store interfaces can dramatically facilitate the integration of new stores on an aircraft and enhance the interoperability of a single store on different aircraft. The standardized Logical Design Definition (LDD), however, is widely believed to increase the store and aircraft processing requirements. In some quarters, this is seen as increasing software and processing requirements of both the store and the aircraft armament system. This is far from the case, however, as an example of integrating the AIM-120 onto the F-16 illustrates. This integration caused a change of the inertial co-ordinate definition used on the F-16 avionics. This then became the de facto standard within MIL-STD-1760A Notice 3, which means that any future Standard Store Interface (SSI) store requiring this function must use the "standard" approach.

On the store side of the interface, the need to accommodate the MIL-STD-1553B word and message lengths has also been an issue. Why not allow say; 4 bits of x length transmitted as 1 word every y milliseconds or h length transmitted as 2 words every y milliseconds or x length transmitted as 4 "words" every 1 microseconds? The cost and time associated with integrating a new store on existing aircraft, or fielding a new aircraft capable of interfacing with a wide variety of unique store interfaces, outweighs any extra effort or costs involved with adherence to the standard. Processing and memory elements are dropping in price at a dramatic pace, so increased resource requirements in these areas have become much less significant than the cost of engineering and testing for new interfaces.

In addition to cost, capability must be considered. The ultimate capability provided by implementing interfaces meeting the standard will certainly be higher and more easily achieved than was the case with unique interfaces. Rarely has an increase in weapon capability been easily or cheaply attained. If adherence to the logical design requirements provides a store or aircraft with unused capability for future enhancements, then it appears to be a good investment. A final point to consider is that once a weapon system such as the F-16 is capable of meeting a sophisticated store's requirements (AIM-120, for example), much of the software and control capability can be applied relatively cheaply to later weapons. The AIM-120 transfer alignment, targeting and initialization schemes might be easily adapted for future weapons with similar requirements, rather than developing new and unique software modules for each weapon. The requirements of MIL-STD-1760 Appendix B should therefore be mandated as agreed to and published.

4.6.5 Extra bus usage imposed by standardized logical.

Adoption of MIL-STD-1760 and its standardized logical design has generated concern regarding data bus usage. A general feeling exists that bus loading will increase, possibly to unacceptable levels, with strict adherence to the standard. The basic protocols of MIL-STD-1553 tend to drive the overall bus usage, not the demands of the MIL-STD-1760 logical design definition. Secondly, aircraft stores management system architectures can have as great or greater impact upon bus usage than either MIL-STD-1553B or MIL-STD-1760 requirements. For example, an aircraft with station encoder-decoders (F-18) or remote interface units (F-16) on the weapons bus, as well as stores, will generally use more of that bus's capability than an aircraft with only stores and the bus controller (F-15C/D) on its armaments bus. In other words, given an identical store load, one aircraft will be using some of its bus capacity for communications above and beyond those required for the stores, and the other will not. A final point relates bus loading to mission phase. The greatest load on the bus occurs during the Store Description transfer between the store and central processor(s) or other stores. Typically, this occurs shortly after system or weapon initialization when time is not as critical as it is immediately prior to aircraft take-off. Bus designs should therefore be implemented that reduce non-store addresses and take advantage of the standardized formats, messages and data entities put forward by the standard.

4.6.6 Projected benefits of MIL-STD-1760.

4.6.6.1 Operational benefits.

These benefits arise primarily from two sources: Interoperability and Damage Tolerance. As indicated earlier, operational effectiveness is impaired by the inability to cross-operate stores across specific aircraft within, say, the US Air Force or between the US Air Force and US Navy or between either and NATO, be the latter Air Force or Navy. In times of conflict, the provisioning of stores at strategic locations able to cope with the variations in requirements (air to air or air to ground or air to ship) is a costly logistics exercise and certainly beyond the scope of most NATO countries. It must therefore be of immense value to be able to design stores which physically, connectors and wiring, are interoperable. In terms of data availability and the appropriate software "control", it will probably be some years before interoperability can be achieved. However, there is no reason why aircraft could not carry the appropriate control algorithms on a permanent "just in case" basis, providing the appropriate data is available from the prime sensors. Furthermore, it may be possible to employ a store in a useful, but degraded mode, where other more effective alternatives are out of stock. The advent of digital communication between stores and aircraft also means that a lot more information can be made available regarding damage, be it battle or failure, thus enabling the aircraft to utilize degraded operation modes as applicable. It should also be possible for other aircraft equipments, either duplicated SMS hardware, even distributed processing within the SMS LRUs, or non SMS equipment to assume a processing role. In the latter case, of course, access to the data bus would be required with the probable exclusion of Arming and Release functions. Many current stores have no means of indicating that all analog signals transmitted from the aircraft have indeed arrived. This means that no indication of capability, or serviceability is available and, furthermore, even if they did arrive, whether the store is utilizing them correctly. The use of the data bus alleviates this problem. Additionally, the fact that the data bus is redundant has significant benefit against faults or battle damage in the cables, connectors and bus controller.

4.6.6.2 Development, integration and certification benefits.

As demonstrated by recent stores programs that all used the same interface, there are major benefits to using a standard interface, such as:

a. Same connector(s) used for SSI stores,

b. Same SMS hardware used for SSI stores,

c. Same aircraft wiring used for SSI stores,

d. No increase in aircraft wiring, or LRU hardware (aircraft cost and weight) when an additional store is integrated,

(Note: the increase in weight due to software update is not considered significant.)

e. Generic system design, based on clearly defined interfaces and re-use of proven designs, reduces engineering required,

f. Reduced integration cost and time due to minimized documentation changes (re-used most of the Interface Control Document!),

g. Safety Maintained or enhanced,

h. Flexibility inherent in the MIL-STD-1760 signal set provides increased intervals between upgrades,

i. Common interface allows more software to be re-used,

j. Reduced size of software updates reduces cost of successive software validation exercises,

k. Certification of stores on aircraft is easier with a previously-certified, well understood interface.

4.7 The MIL-STD-1760 application process.

This section covers the process by which the MIL-STD-1760 requirements should be covered by system design.

The MIL-STD-1760 Application Process encompasses all those activities that are associated with the implementation of the AEIS in an aircraft or store program. These activities are those which are concerned primarily with the solution of the interoperability requirements of aircraft and stores, but also considers those which are specific to the design of particular avionic subsystems and which may incorporate non-AEIS functions. Clearly, there is a fine dividing line between these two types of activity. The biggest problem in defining the proper domain or boundaries of MIL-STD-1760 implementation requirements, occurs in defining how "deep" into the subsystem which supports the interface, usually the stores management system, the requirements must be defined. At one extreme, the implementation of MIL-STD-1760 consists of merely supplying the connectors and associated wiring, to which the specified functions are supplied. The other extreme involves the design of all the subsystems that are behind the interface. These may include all the electronic subsystems in the case of stores and, in the case of the aircraft, such subsystems as the SMS, the power distribution system, the analog networks, the aircraft data acquisition systems and an element of aircraft wiring. The point at which the dividing line between MIL-STD-1760 implementation and subsystem, or equipment, design should be drawn is a subjective issue and may well, in practice, depend on the constraints that prevail in a particular implementation. Any discussion providing practical implementation guidance must clearly cover particular system, hardware and software considerations and as such the discussion must encroach on the avionic/store subsystem designs. Consequently, it is important to first define the boundary, or definition, of the system that will implement MIL-STD-1760. These phases may be summarized as:

Phase 1 - System Definition

Phase 2 - System Performance Definition

Phase 3 – System Design and Development

Phase 4 - In-Service and Planned Improvements

Figure 5 shows the principal issues that need to be considered during each of these phases.

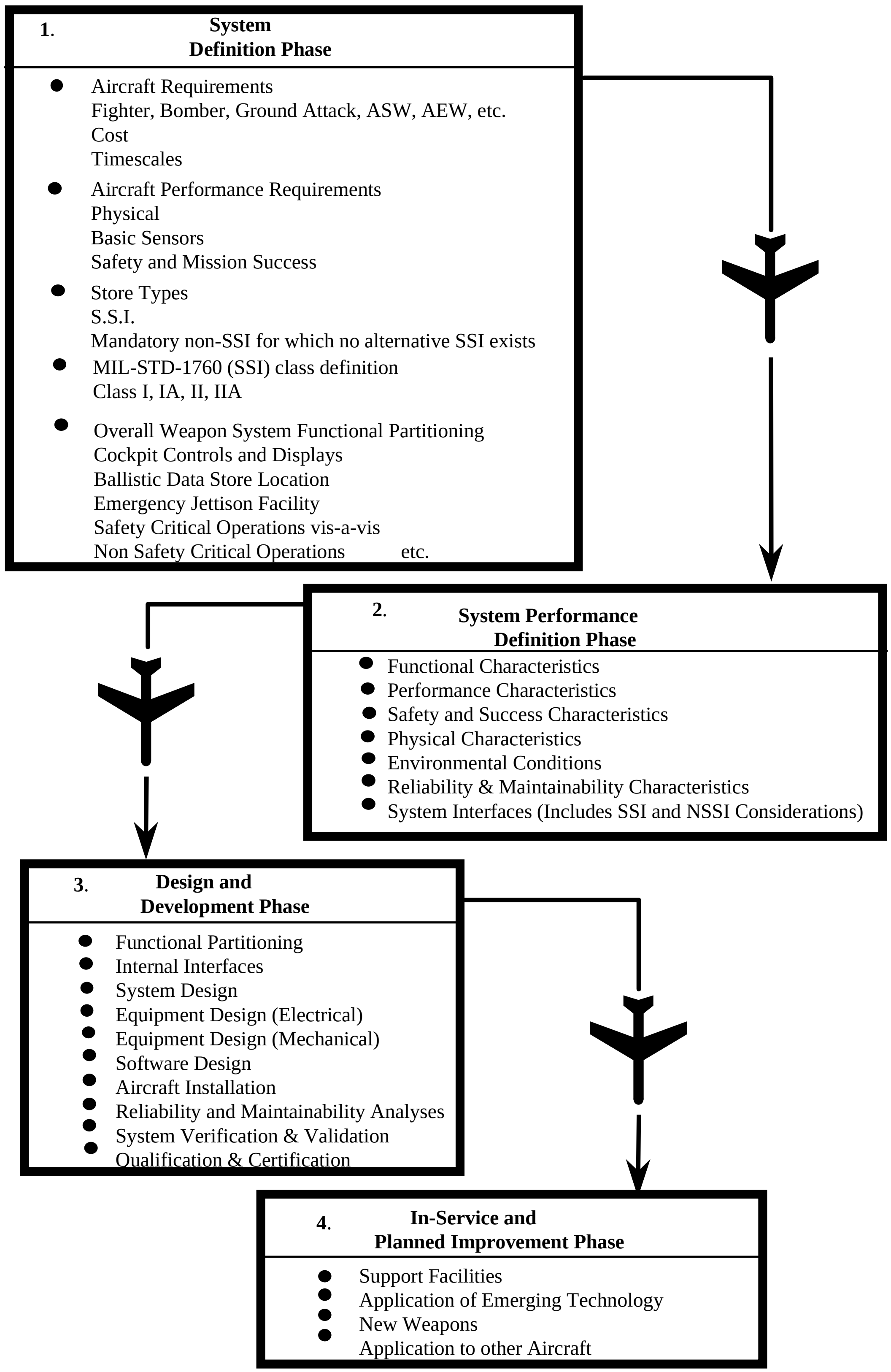


FIGURE 5. AEIS implementation phases.

5. SYSTEM DESIGN.

5.1 General.

This section addresses system level design considerations for aircraft and store systems which implement MIL-STD-1760 (AEIS) interfaces. The emphasis is on aspects of those systems directly associated with implementation, interconnection, and control requirements of the AEIS interfaces. Detailed information on other elements of aircraft and store system design is available elsewhere and not covered here, except for top level concepts that help put the interface system in perspective. The information presented in the remainder of this section is organized in terms of aircraft design considerations, store design considerations, system safety provisions, the interface design/documentation process, and future trends and considerations.

5.2 Aircraft design considerations.

The aircraft related AEIS functionality is the implementation and control of the Aircraft Station Interfaces (ASIs). The aircraft system that provides this functionality is the stores management system (SMS), which functions as a subsystem within the overall aircraft avionics suite. A diagram showing the relationships between the AEIS, SMS, stores, and other related systems is presented in figure 6.

The aircraft SMS performs several major functions such as information processing, interfacing with flight and ground crew, and interfacing with other aircraft avionics subsystems, in addition to interfacing with stores (through the aircraft ASIs) for control and monitoring of store functions. Of these functions, only the store interface portion of the SMS is directly impacted by MIL-STD-1760. Depending on individual system requirements and design decisions, the SMS function can be implemented with a number of different architectures and equipment mixes. Specific SMS functions may in some cases be physically implemented in electronic boxes assigned to systems that are not typically considered part of the SMS. As an example, one aircraft design may switch power to an ASI via the aircraft's power distribution system based on inputs from a Stores Management Processor (SMP). Even under this condition, power switching is an SMS function though the switching is actually performed by other system equipment. In this context then, the SMS is the primary aircraft system impacted by MIL-STD-1760. Additionally, the Logical Element requirements that are in MIL-STD-1760 may indirectly affect other aircraft systems. These indirect influences result primarily from data word standardization by the Logical Element and the possible feedthrough of the data word formatting requirements to the aircraft's avionics data buses. If desired, though, indirect impacts of this nature may be decoupled from the aircraft avionics by the SMS through incorporation of data re-formatting capabilities within the SMS. Such decoupling is performed on several current-generation aircraft.

Some specific SMS design considerations relative to satisfaction of AEIS interface requirements are discussed in the following subparagraphs.

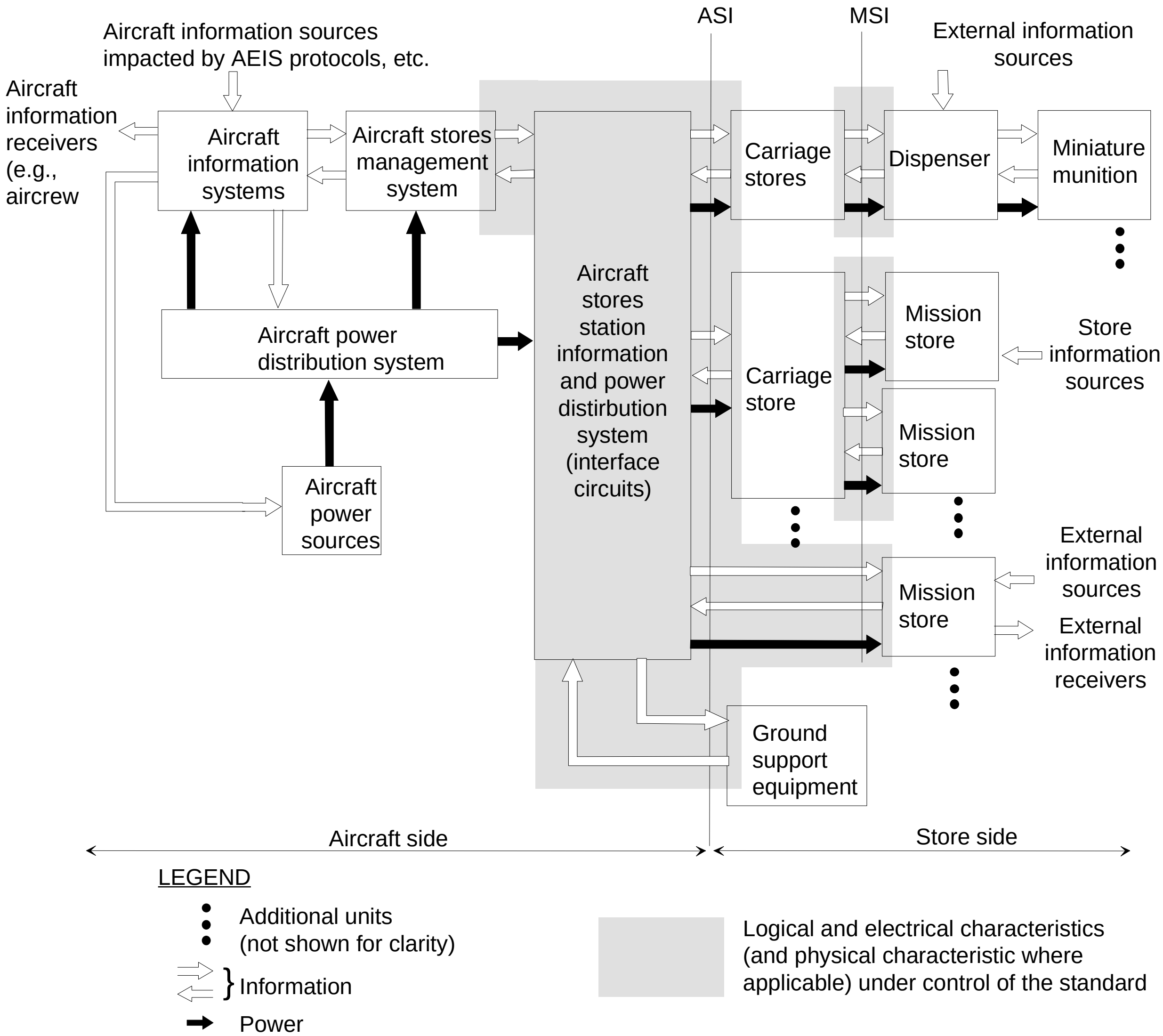


FIGURE 6. AEIS system relationships.

5.2.1 Interface arrangement and classes.

One of the major drivers of SMS design and implementation for any platform with MIL-STD-1760 store compatibility is the arrangement (quantity and location) and capability level of ASI interfaces that the system must support. An ASI is typically associated with every aircraft weapon station intended for interoperable weapon carriage. These stations may be located in external pylons (typically one primary carriage station per pylon) or in internal weapon bays (frequently multiple primary carriage stations per bay). Specialized weapon carriage devices such as rotary launchers or racks in large bomber bays may contain a significant number of primary weapon carriage stations and associated ASIs.

5.2.1.1 Classes defined.

Several interface classes of varying capability are defined in MIL-STD-1760 for ASI implementation, and the selection of interface class for each system ASI is a significant design consideration. The defined classes are shown in table II along with the applicable signals for each class. The standard requires the aircraft to provide the full signal capability identified by the designated class. By providing the full capability, a minimum level of service at the ASI is assured for store applications.

TABLE II. Interface classes.

SIGNAL TYPE	INTERFACE CLASS			
	I	IA	II	IIA
PRIMARY				
Mux A	E	E	E	E
Mux B	E	E	E	E
High Bandwidth 1	X	X	X	X
High Bandwidth 2	X	X	-	-
High Bandwidth 3	X	X	X	X
High Bandwidth 4	X	X	-	-
Low Bandwidth	X	X	X	X
Fibre Optic Channel 1	X	X	-	-
Fibre Optic Channel 2	X	X	-	-
Release Consent	X	X	X	X
Interlock	M	M	M	M
Address	C	C	C	C
28V DC Power 1	X	X	X	X
28V DC Power 2	X	X	X	X
115/200V AC Power	X	X	X	X
270V DC Power	X	X	-	-
Structure Ground	A	A	A	A
AUXILIARY				
Auxiliary 28V DC	-	X	-	X
Auxiliary 115/200V AC	-	X	-	X
Auxiliary 270V DC	-	X	-	X
Auxiliary Structure Ground	-	A	-	A
Auxiliary Interlock	-	M	-	M

LEGEND

E Aircraft is required to provide capability. Except for very special cases, the mission store is required to use interface.

X Aircraft is required to provide capability, but mission store has option of using or not using signal/power.

M Mission store is required to provide interface, aircraft must provide the interface capability (to implement deadfacing of power) but has option of monitoring or not monitoring it.

C Aircraft is required to provide capability and mission store must use interface if the store uses Mux A/B.

A Aircraft and mission store must implement interface.

NOTE: The fiber optic and high voltage DC interfaces are reserved, are not actually required by the standard at this time.

As an example, the Class II interface listed in table II includes the Mux A and Mux B serial digital data interfaces; High Bandwidth 1, High Bandwidth 3 and Low Bandwidth signal ports; address; interlock and release consent discretes; structure ground; and 28V DC Power 1, 28V DC Power 2, and 115/200V AC power interfaces. While a mission store is only required to implement those signals of the Class II interface needed for store operation, the aircraft is required to implement all of the Class II signals to provide this minimum service utility.

5.2.1.2 Choosing Classes.

Since Class IA represents maximum ASI capability, it would seem desirable for the aircraft to install Class IA ASIs at all aircraft stations. From a practical viewpoint, however, this level of capability is not considered necessary at all stations and would place an undue burden on aircraft systems. General guidance on types of applications envisioned for the various interface classes is therefore provided in the subsequent discussion. It must be realized, however, that the services required by certain types of stores as discussed below may change in the future.

The Class IA interface provides the full primary signal set plus the additional power capacity of the auxiliary power interface. This interface class is primarily envisioned for operating electronic pods with high power and multiple high bandwidth signal transfer requirements. Self-cooled, forward looking infrared pods and electronic countermeasures (ECM) pods are representative of this type of store. These pods are most likely to be installed on fuselage stations (centerline or cheeks) or on heavy wing stations.

The Class IIA interface is applicable to similar stores and aircraft stations. The major difference between Class IA and IIA interfaces is that Class IIA interfaces do not contain HB2 and HB4 ports or the provision of the currently undefined 270V DC supply. As a result, the primary impact of installing a Class IIA interface instead of a Class IA is that reduced support for multiple high bandwidth signal transfer requirements will be available. ECM pods and target acquisition pods are examples of high power-level pods that might require a high level of multiple HB signal transfer support.

A second category of store installations which might require Class IA or IIA interfaces is that of multiple carriage of smart stores on multiple station ejector racks or multiple station launchers which attach to a primary carriage station. These multiple carriage installations will, like the electronic pods, tend to be located at the heavy store stations. The major advantage of providing the auxiliary power interface to these multiple station carriage stores is to support the concurrent powering of many more, if not all, mission stores attached to the device. The concurrent powering might be needed for environmentally conditioning the mission stores prior to release. Without the auxiliary power capacity, operational restrictions might need to be imposed on the release sequence of the multiple mission stores for accommodating sequential environmental conditioning.

The Class I interface provides full primary signal support without the additional power capacity of the auxiliary interface. Use of this class is primarily projected for fuselage or heavy wing stations on those aircraft that lack the power system capacity for supporting Class IA. The power capacity of the auxiliary interface will, in many instances, exceed the unused power available from the aircraft generators. The Class I interface is directed at supporting stores such as low power (less than 4 KW) electronic pods, self-powered ECM pods, multiple sensor missiles, or some classes of anti-radiation missiles.

The Class II interface covers the minimum primary signal set capability of the aircraft. This class is directed at air-to-air stations and non-heavy air-to-ground stations. It is sufficient for stores of low to moderate power consumption that do not have extensive high bandwidth signal transfer requirements.

In addition to the MIL-STD-1760 store carriage requirements of a particular platform, carriage of non-1760 stores at all or some stations may be a requirement of some platforms. Though this is not strictly a MIL-STD-1760 issue, it does impact the design of some AEIS compatible systems. These systems must be able to efficiently provide either a designated AEIS signal set, or the signal sets of other designated stores, dependent on specific mission loadouts. Since there are typically some functional similarities between 1760 and non-1760 interfaces, efficiencies may be achieved by having some multi-purpose interface signals that can support either type of interface. Thus any non-1760 store carriage requirements should be identified and considered along with AEIS requirements in design of the aircraft SMS.

One final aspect of the interface arrangement that can significantly influence system design is the physical locations of the interfaces on the airframe. Distances from equipment bays, space for cable runs, groupings in nearby locations (such as weapon bays), and available nearby space for equipment items must be taken into consideration with regard to system hardware architecture and functional partitioning, hardware item physical sizes and shapes, cabling and installation design, etc.

5.2.2 System architectural alternatives.

A virtually infinite number of physical/functional architectures is possible for the stores management systems which control the MIL-STD-1760 ASIs (and other store interfaces, as applicable) on various aircraft. They are all variants or hybrid combinations of two underlying fundamental system architectures, however. These two basic architectures are the centralized architecture and the distributed architecture. Generic diagrams of these architectures are presented in figures 7 and 8.

5.2.2.1 Centralized architecture.

The centralized architecture illustrated in figure 7 is the simplest and most basic system configuration for SMS implementation. This architecture consists essentially of one central box which implements the SMS logic processing and power and discrete/analog switching functions necessary to control attached stores as well as the Suspension and Release Equipment (S&RE) such as pylon ejector release units at each station. This one central unit is typically supported by ancillary control/display panels and possibly dedicated function equipment items such as electrical fuzing power supplies and/or specialized missile controller units. It is subsequently referred to as the stores management control unit in this handbook. This unit interfaces to other avionics equipment through a mix of discrete, analog, and serial digital signals, or through a data bus as shown in the figure.

For the centralized SMS concept, MIL-STD-1760 significantly impacts stores management control unit design requirements. AEIS requirements may in particular increase the number of wires and cables in the wire bundles between this central unit and the station interfaces. Much of this increase may be typically avoided, though, through shared conductor usage between MIL-STD-1760 and non-1760 interfaces. Because of the significant required cabling to each station with the centralized approach, it is primarily appropriate for aircraft with a few closely located (with respect to the stores management control unit) store stations and sufficient space for routing the relatively large cable bundles to the station interfaces. The size, weight, and potential reliability/maintainability impact of routing large multi-conductor cable bundles to a number of physically distributed stations usually outweighs the simplicity and packaging efficiency of the centralized architecture for other platform station configurations.

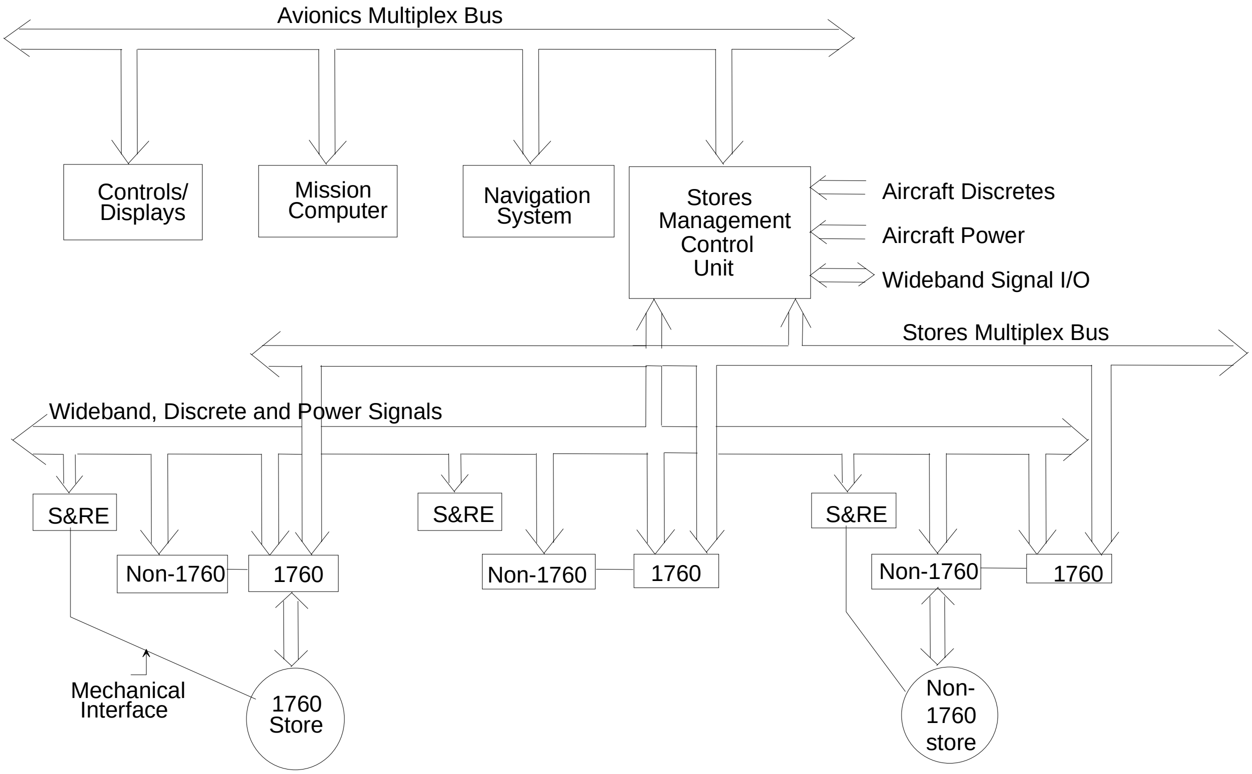


FIGURE 7. Centralized system architecture.

5.2.2.2 Distributed architecture.

The other fundamental SMS architecture, illustrated in figure 8, is the distributed architecture. This architecture effectively splits the centralized stores management control unit into separate units and distributes these units into different aircraft areas. The high level processing and control functions are normally retained in a centralized processing unit, with most store interface signal I/O being provided by local interface units at or near the store stations. These units are interconnected with a digital multiplex data bus, with a separate wideband signal routing network for transporting high bandwidth (video, RF, and pulse signals) and low bandwidth (audio, etc.) signals not suitable for digitization and transfer over the data bus. A limited power distribution network is also included for store and internal system power control and distribution requirements, though elements of this function may be performed by the aircraft power distribution system under SMS control in some implementations. Selected discrete signals used for certain critical functions such as safety interlocking or jettison initiation are also typically routed separately throughout the system. The distributed system minimizes cabling (through multiplexing of most signals over the data bus), and is particularly well suited for aircraft with significant numbers of store stations and/or physically distributed stations. This architecture (in many implementation specific variations) is the primary basis for most modern digital stores management systems in recent generation aircraft.

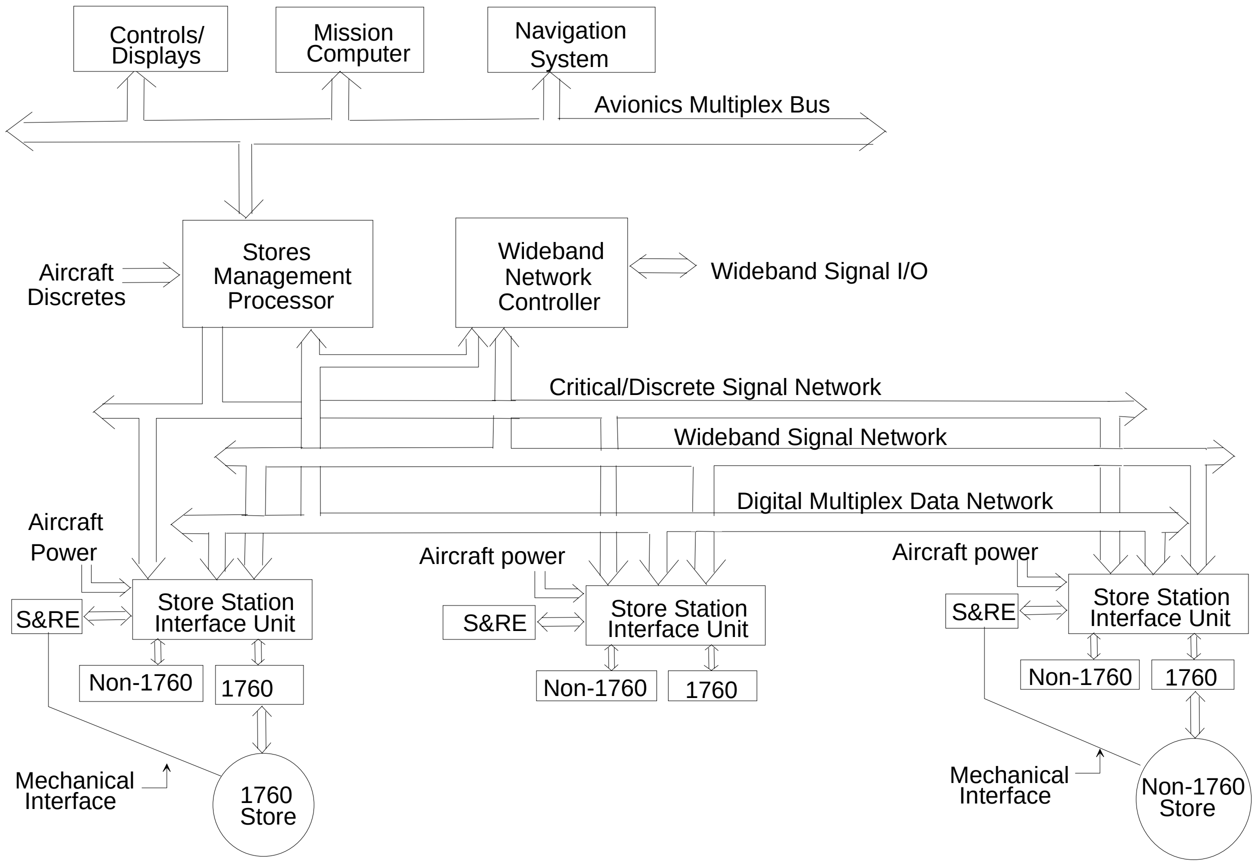


FIGURE 8. Distributed system architecture.

5.2.3 Major system elements.

The major system elements of a typical distributed SMS (as illustrated in figure 8) are described individually along with significant design considerations in the following subparagraphs.

5.2.3.1 Stores management processor.

The stores management processor, or SMP, is the heart of the system, providing centralized processing and storage and execution of the overall system operational flight program (OFP). This subsystem provides the primary interface to the remainder of the aircraft avionics, typically functioning as a remote terminal on an avionics data bus. It generally interacts with crew multi-function control/display devices through this interface and, also, receives avionics data needed for stores management or store conditioning functions (inertial and GPS data, fire control solutions, etc.). It also generally directly accepts dedicated input signals from cockpit panels or switches for certain critical functions such as master arm, emergency jettison, release (trigger or pickle button), etc. The SMP additionally functions as the controller of internal system data buses that interconnect with distributed interface units and/or stores. Some internal system power switching/control functions may also be performed in the SMP. This unit typically contains a micro- or mini-computer, memory, and I/O ports.

5.2.3.2 Store station interface units.

Store station interface units (SSIUs) located near the store stations provide localized I/O and low level control functions for the store interface signals. This is the element of the SMS that is most directly impacted by MIL-STD-1760 from a hardware standpoint. A block diagram of a typical SSIU is illustrated in figure 9.

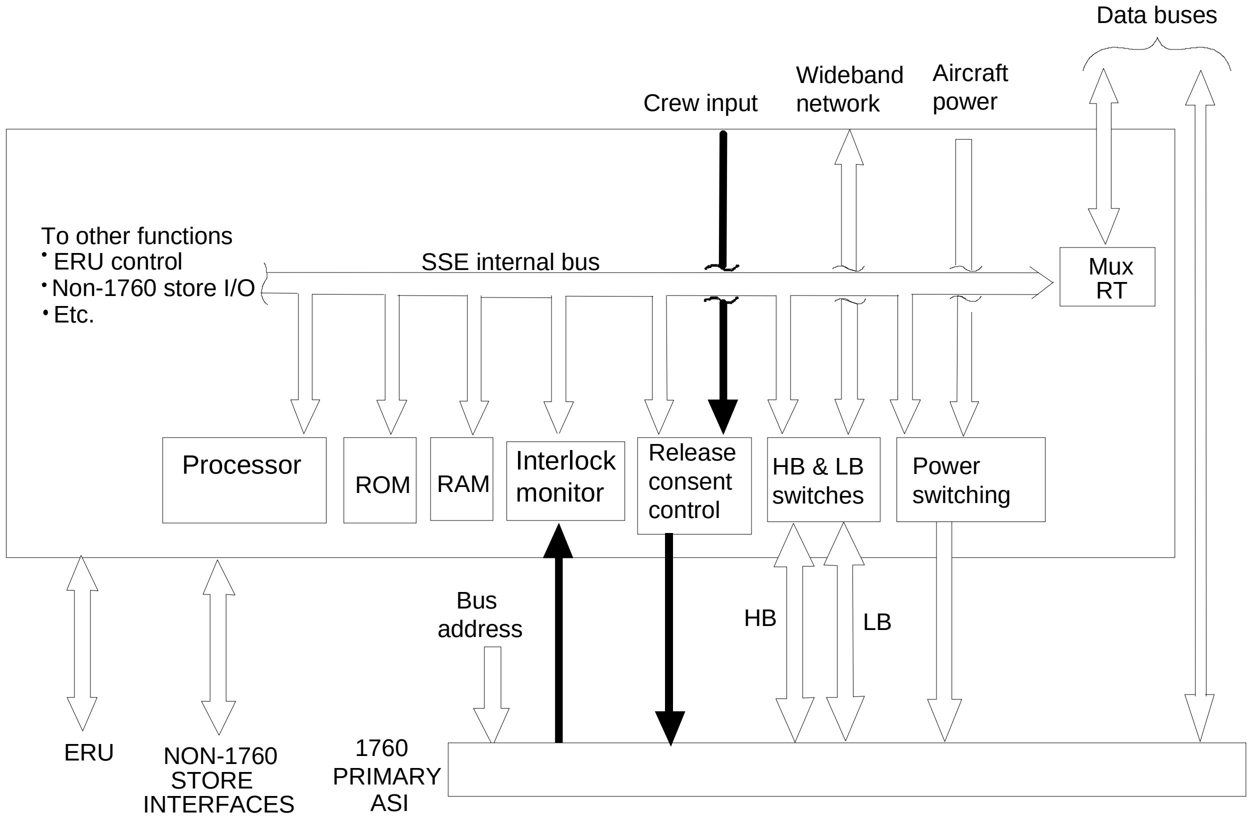


FIGURE 9. Representative SSIU configuration.

The SSIUs act under command of the SMP via a data bus connection to control and monitor MIL-STD-1760 power, discrete, high bandwidth and low bandwidth signals, as shown in the figure. Additional functionality for S&RE control/monitoring and non-1760 store interfacing is also incorporated, as required. One possible variation to the illustrated approach is that a localized MIL-STD-1553 bus controller could be contained in the SSIU to service the data bus interface(s) of the associated MIL-STD-1760 ASI(s). This local bus controller would effectively provide a bridge to the data bus controlled by the SMP. However, for cost reasons, the ASI data bus connections are usually separately derived from a more global data bus controlled directly by the SMP. Use of local bus controllers in the SSIU would also increase the number of hierarchical levels in the bus architecture, with a potentially negative impact on latencies and uncertainties of time sensitive data transfers.

Though the diagram shows SSIU interfacing to a single store station, multi-station units may be appropriate for sets of closely grouped store stations, as in an internal weapon bay. Such multi-station implementations permit economies to be achieved through commonality of processing, data bus interfacing, and packaging for servicing a group of stations. The specific platform physical arrangement and cabling provisions will dictate the optimum grouping of stations versus SSIUs for a particular implementation. (Compatibility with existing SSIU equipment to avoid development costs and simplify logistics may be an additional consideration at the programmatic level.)

5.2.3.3 Digital multiplex data network.

The Digital Multiplex Data Network consists of one or more serial digital data buses for providing communications between the distributed system hardware units and providing interconnectivity between the system and the data bus connections of the store station ASIs. The store data bus connections are required by MIL-STD-1760 to be compatible with MIL-STD-1553. MIL-STD-1553 is also generally used for interconnection of the distributed SMS components, though newer higher performance buses may be used for this purpose in some future systems. For systems that use a MIL-STD-1553 bus for this purpose, it may be combined with the store MIL-STD-1553 data bus if addressing limitations are not exceeded and the composite data throughput requirements (including protocol overhead) do not exceed the bandwidth of the bus. A maximum of 31 distinct terminal addresses is available for use on any one bus. Systems with large numbers of store stations and/or unusually high instantaneous data throughput requirements may consequently require that multiple MIL-STD-1553 data buses be employed, with store stations (and possibly SMS equipment items) distributed among them. The concurrency and throughput rates of required bus communications should be considered in determination of the system bus structure. It is desirable that bus throughput capacity for any individual bus not be loaded greater than forty to fifty percent in the initial system implementation, to allow a reasonable margin for future growth.

A detailed discussion of MIL-STD-1553 bus implementation issues is provided in section 6.

5.2.3.4 Wideband signal network.

A wideband signal network with an associated wideband network controller is required for providing high bandwidth and low bandwidth signal paths and related switching between AEIS store stations and aircraft avionics subsystems. The HB and LB interface requirements in the standard were designed to accommodate analog signals, but this network could be used to transfer digitized data, as long as the signal fits within the available bandwidth. The architecture and complexity of this network for any given system will be dependent on the number and class of store stations and the specific signal interconnectivity requirements. Detailed discussions of high bandwidth and low bandwidth network design along with network capacity considerations are provided in sections 8 and 9, respectively. Note that all or some of the network controller functionality may be physically incorporated into the SMP and/or the SSIUs in some implementations, as opposed to a separate physical enclosure. Where there is a physically separate network controller, it typically operates under control of the SMP, either via the data bus or via dedicated discrete control signals.

5.2.3.5 Critical discrete signal network.

Distributed SMS implementations also normally route certain critical function discrete signals among the system hardware components on dedicated signal paths. These signals typically include such things as master arm (from the associated cockpit switch) for safety critical output interlocking and emergency jettison for initiating fail-safe ejection of externally mounted stores under emergency conditions. Though they may not be considered critical, power enable discretes may also be routed from the SMP to remote subsystems to enable basic powering of the units from local aircraft power sources.

5.2.4 Store initialization and control procedures.

The ultimate purpose of the AEIS interfaces is to facilitate initialization and control of the attached stores by the SMS. The MIL-STD-1760 Logical Definition, further discussed in section 17, imposes certain rules regarding data bus message formats and high level interface control procedures. Detailed interface control procedures are store- and aircraft-dependent and are generally described in an Interface Control Document for any particular aircraft/store combination. The logic of the initialization and control procedures for employment of a given store type is normally stored and executed in the SMP as a store control algorithm. (Depending on the specific system architecture and associated functional partitioning, some elements of the store control algorithm could be executed in an avionics mission computer or an SSIU.) The control algorithms for MIL-STD-1760 stores can be described as a sequence of store control states, for ease of understanding. A representative state sequence and the associated interface control actions is subsequently described at a top level for a generic MIL-STD-1760 air-to-ground store.

Off State - The Off State is the initial un-powered state of the store. Upon selection of the store for initial conditioning and verification of interlock continuity (store presence) at the store station, thermal conditioning power (if required) is activated to the store interface. This results in transition of the store to the Standby State.

Standby State - Application of thermal conditioning power to the store interface is maintained during the Standby State for environmental conditioning of certain store subsystems (not applicable to all stores). Upon selection of the store for release preparation, initialization power is activated to the store interface. This causes the interface to transition to the Initialization State.

Initialization State - The remaining store subsystems (except those associated with certain irreversible functions) are powered up in the Initialization State, and the store is conditioned for release by the SMS. A Store Identification message may initially be requested over the data bus and compared against loaded inventory information. The store may subsequently be commanded to perform an Interruptive Built-In-Test (IBIT), if desired. After an IBIT is commanded, the bus controller will periodically poll for weapon status to determine when IBIT is complete. Any IBIT detected anomalies will be reported to the operator.

Following IBIT (if performed), initialization data sets required by the store will be transferred via the data bus. These data sets include such information as GPS initialization data, inertial navigation system initialization data, mission planning (including targeting) data, etc. The data sets are normally transferred using the MIL-STD-1760 Mass Data Transfer protocol, though elements of the data sets may subsequently be changed via individual messages. Once all required initialization data sets have been transferred to the store, the inertial transfer alignment process is initiated. Periodic transfer alignment messages are continuously transmitted to the store and alignment status is monitored through interleaved status polling. When the store is sufficiently aligned for employment and other conditions required for release are true, this condition is indicated in the returned status information and the system transitions to the Ready State.

Ready State - The store is maintained in a ready condition awaiting launch sequence initiation in the Ready State. Thermal conditioning and initialization power remains activated to the station in this state, and the ongoing periodic transfer alignment message transmission and status polling processes continue. If the ready status indication becomes not true, then the store will revert to Initialization State. Launch acceptability region information may also be periodically requested from those stores that have the capability to supply it, and used to determine the store release point. Upon launch initiation (through operator command), the system transitions to Launch State.

Launch State - Upon entry into the Launch State, safety critical power (28V DC Power 2) and the Release Consent discrete signal are activated to the store interface. After a required delay, a Commit to Separate command will be sent to the store in a safety critical message. This will initiate or enable irreversible actions in preparation for store release. A Committed to Store Separation status indication will then be polled for from the store. When this condition is detected as true, power to the store interface will be deadfaced, and the station release equipment will be activated to release the store. Verification of store separation will then be monitored for via the interface Interlock signal and possibly other indications such as ejector rack switch status. If separation cannot be verified within a designated time period, a hung store condition will be determined to exist and the system will transition to the Abort State.

Abort State - The system enters the Abort State if any unsafe store conditions are detected in other states, and/or if any abnormal conditions that preclude completion of the normal initialization and release sequence occur. An Abort command is issued to the store over the data bus, and all station power is subsequently removed (if still applied). The store will enter a safe condition, and the SMS will not attempt to release the store except in a jettison mode unless power cycling or reversion to an earlier state resolves the abnormal condition. If transition to the Abort State occurs after the Launch State has been entered (and irreversible functions have been initiated), power is removed from the store interface and no further attempts to operate the store are conducted during the ongoing mission.

5.3 Store design considerations.

This section was not yet written at time of publication.

5.3.1 Interface class compatibility.

This section was not yet written at time of publication.

5.3.2 Power source selection.

This section was not yet written at time of publication.

5.4 System safety provisions.

This section was not yet written at time of publication.

5.5 Interface design/documentation process.

This section was not yet written at time of publication.

5.6 Future trends and considerations.

This section was not yet written at time of publication.

6. DIGITAL DATA BUS INTERFACE.

The application of MIL-STD-1553 to the electrical interface between aircraft and stores results in several peculiar design issues not directly addressed by the MIL-HDBK-1553 Multiplex Applications Handbook. These issues include the reconfiguration of the multiplex data bus in the aircraft. This reconfiguration results from different store loadouts for different missions and from periodic removal of remote terminals from the network as a direct result of store release during a mission. Other issues include: (1) concerns about "open data bus stubs" and how these unterminated stubs affect waveform quality from both reflections and electromagnetic interference susceptibility perspectives; (2) uncertainties on the impact of harsh store station environments on multiplex data link performance; and (3) unfamiliarity with the need to impose data link electrical characteristic requirements at the interface breakpoint (i.e. ASI and MSI) that is different from the control point (i.e. remote terminal interface) defined in MIL-STD-1553. The purpose of this section of the handbook is to supplement information in MIL-HDBK-1553 for those aircraft design issues that are unique to MIL-STD-1760. This section is not intended to replace or conflict with design issue discussions contained in MIL-HDBK-1553.

6.1 Overview of digital serial multiplex data bus applications to AEIS.

This section is not available this revision. The outline below is a tentative list for inclusion in future revisions.

6.2 Data communications and system control.

6.2.1 Communication roles.

6.2.2 Addressing modes.

6.2.3 Subaddress restrictions.

6.2.4 Communication redundancy.

6.3 Network reconfiguration.

6.3.1 Bus reflections.

6.3.2 Loading effects.

6.3.3 ASI output waveform.

6.4 Multiplex interface EMI considerations.

6.4.1 Shield grounding.

6.4.2 Twinaxial versus standard contacts.

6.4.3 Center tapped transformers.

6.5 Architectural considerations.

6.5.1 Carriage store functions.

6.5.2 Internal aircraft hierarchical bus.

6.5.3 Bus repeaters.

6.5.4 Bus branch.

6.6 Issues, guidance and rationale.

6.6.1 MIL-STD-1553 issues.

6.6.1.1 Bus topology.

6.6.1.1.1 Local or aircraft bus.

6.6.1.1.2 Single or multiple buses.

6.6.1.1.3 Shared use.

6.6.1.1.4 Linear bus or other topology.

6.6.1.2 Impact of critical signals.

6.6.1.3 Hardware/software partitioning.

6.6.1.4 Open circuit stubs.

6.6.1.5

7. DISCRETES

7.1 Release consent.

Release consent is implemented with a single wire through the interface (and referenced to power return). The signal has two defined states: “Enable”, which is nominally connected to a 28V DC power source, and “Inhibit” which is nominally an open circuit or ground.

In addition to the information in this section of the handbook, the rationale and guidance in 15.4.3.4, 15.5.1.4, 15.5.2.4, 15.5.3.4, and all subparagraphs should be consulted.

The name "release consent" is a carry-over from the original version of MIL-STD-1760 in 1981. Based on its application, a better name might be "Safety Critical Consent". While the release consent signal was originally established and named as an enable/inhibit safety interlock on the release of certain types of stores, the signal function has been broadened to include other irreversible or safety critical functions commanded of the store over the digital data bus.

The pilot has final control over the status of the release consent signal. If release consent is inhibited or has been removed by the pilot, the mission store must not act upon critical control commands received over the data bus. When the pilot has activated the appropriate “Arm” or “Fire” switch and other safety constraints are satisfied, the aircraft will enable release consent to the mission store and/or carriage store.

Due to the safety aspects of this signal, aircraft safety analysis should always include an evaluation of the circuit, to determine that probable failure modes do not produce an unintended release consent signal.

A store is not “armed” or “fuzed” by release consent. However, release consent (in addition to fuze mode data from the data bus) may be used to initiate an arming process. The arming process is then completed by the store having an arming wire pulled during separation, or by reaching a pre-determined acceleration, deceleration, position, time delay, etc, after it leaves the aircraft.

7.1.1 Purpose.

The purpose of the release consent interface is to provide a reversible, hardwired, logic signal to enable or inhibit store acceptance of safety critical commands.

The enable state is provided by the aircraft to the store to indicate consent to act on safety critical commands received over the data bus. When energized, release consent indicates aircraft (and pilot) consent for stores to initiate safety-critical functions, such as: (1) store release from a carriage store, (2) missile launch from a rail launcher, (3) rocket firing from a pod and (4) gun pod firing.

The data bus may have sufficient data integrity to perform this function without a separate discrete signal, but the release consent signal is required in the interface anyway. The use of a discrete signal on a separate wire, independent of the data bus and computers, makes safety analysis and verification much easier. It also provides easier compatibility with existing stores that required a discrete consent line.

7.1.2 Aircraft side of release consent interface.

The aircraft initiates the actual store release command over the data bus, or through other interfaces between the aircraft stores management system (SMS) and the store supension/ejection and release equipment (SS&RE). The release consent signal is not a firing signal. The release consent signal is not to be used for any discrete function, other than to grant consent by the aircraft for the store to initiate safety critical or irreversible functions. The return line for release consent is the 28V DC Power 2 return line.

7.1.2.1 Design requirements.

The release consent circuit is in the "enable" and "inhibit" states when the voltage levels at the ASI, contact 1 referenced to contact E, comply with figure 10. The voltage transition time between enable and inhibit states must not exceed 3 milliseconds under resistive load conditions.

When the release consent signal is in the enable state, the aircraft must be capable of supplying 100 milliamperes through the ASI. The aircraft must also be capable of supplying the required enable voltage levels when store loads ranging between 5 and 100 milliamperes are attached to the ASI.

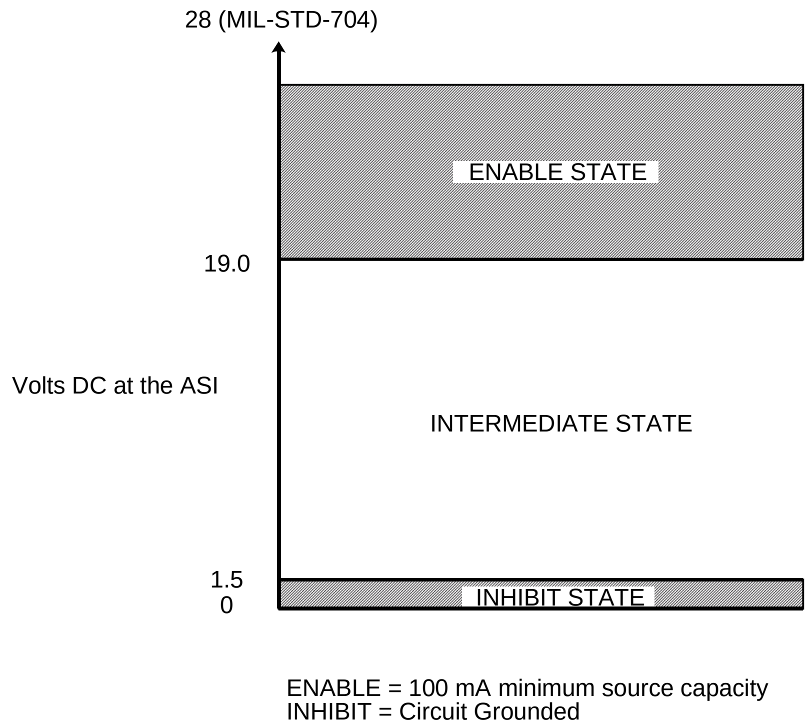


FIGURE 10. Aircraft voltage level requirements.

The final requirement on release consent in 5.1.4 of MIL-STD-1760C can be subject to misinterpretation. It states that when in the inhibit state, the release consent interface at an ASI must be electrically isolated (100 kilohms maximum at DC), from the release consent interface at all other ASIs. The intent of this requirement is that a fault in the release consent circuit of one station must not result in the release consent at other station(s) going to the enable state. The way the requirement is worded, however, can lead to a misinterpretation for the condition when several stations’ release consent signals are inhibited by being connected to ground. If several release consent signals are inhibited, then these lines may be connected to a common point (ground). It is not intended that a common connection to ground potential be interpreted as lack of electrical isolation.

7.1.2.2 Grounding in the inhibit state.

The standard does not require release content to be grounded in the inhibit state. Since there is a limit on both the voltage and current allowed, a medium-impedance connection to ground is implied. This connection should be chosen to ensure the 1.5-volt limit is not exceeded as a result of EMI pick-up, and insure the 5 mA current limit is not exceeded due to stray ground voltage difference. For solid state as well as electromechanical implementation, the output circuit must be pulled to ground when in the inhibit state to ensure the voltage to the store does not exceed 1.5 volts. As a further precaution against EMI, the output circuit may require filters and static discharge protection. The need is dependent upon circuit design employed.

7.1.2.3 Timing.

The standard requires that: (1) The aircraft must provide the enable state at least 20 milliseconds before a "store release" or "safety critical" command is sent to the store over the MIL-STD-1553 bus, and (2) the aircraft must provide the inhibit state at least 20 milliseconds before the aircraft wants the store to be inhibited.

7.1.2.4 Circuit design.

Figures 11 and 12 show typical aircraft circuits for the release consent function. Figure 11 is an electromechanical relay implementation and figure 12 is a solid state design. The current level limits of 5.0 milliamperes to 100 milliamperes allow a high degree of reliability to be achieved with the use of electromechanical relays since significant contact arcing is avoided. The release consent circuit is pulled to ground when operating in the inhibit state. This is required to ensure the 1.5-volt limit is not exceeded as a result of EMI pick-up.

The current level limits are also compatible with efficient solid state implementations. As shown in figure 12, transistor Q1 can operate in a current limit mode during a fault condition, thereby providing protection to the circuit wiring in addition to the drive transistor. Similar to the electromechanical implementation, the output circuit must be clamped to ground when in the inhibit state to ensure the voltage to the store does not exceed 1.5 volts. As a further precaution against EMI, the output circuit may require filters and static discharge protection. The need is dependent upon circuit design employed.

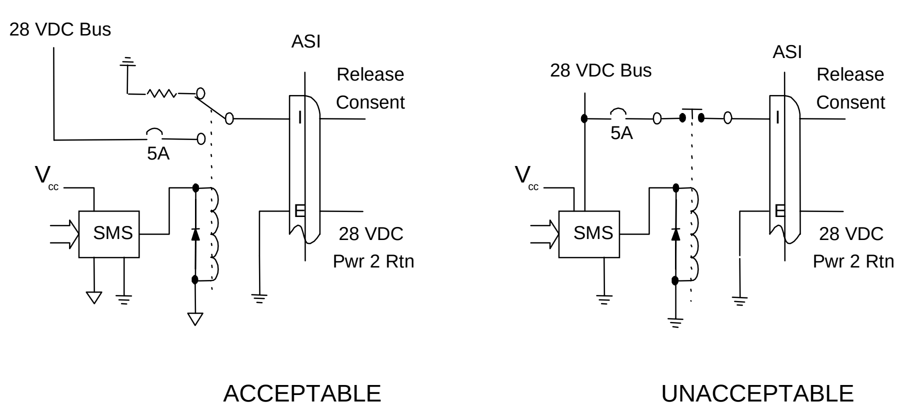


FIGURE 11. Aircraft release consent implementation examples – electromechanical relay.

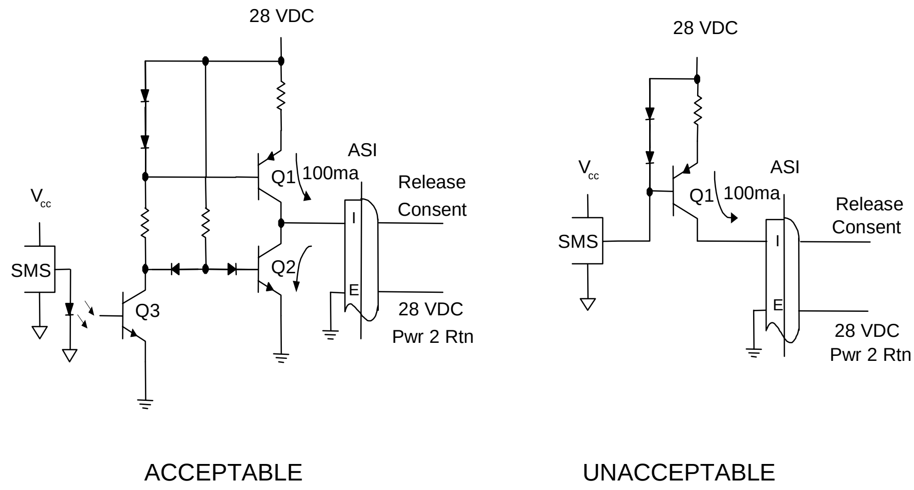


FIGURE 12. Aircraft release consent implementation examples – solid state.

7.1.2.5 Fault current.

There was a statement in Revision B of the standard requiring the aircraft to limit current through the release consent interface to the maximum overcurrent curve (figure 7 of Revision B of MIL-STD-1760) for the 28V DC 1 and 28V DC 2 sources. This is because the aircraft may be providing the release consent signal by connecting it to a 28V DC power source with 10 Amp rated load capability. This would be important under conditions of a low impedance fault at the ASI or below (i.e., release consent shorted to ground or power return). This abnormal condition may occur once during a flight or may never occur during the life of the aircraft. The statement limiting current to the maximum overcurrent of the 28 V dc power sources was deleted in Revision C of MIL-STD-1760 because it implied that release consent was a high power signal. Release consent should be treated as a logic signal, but the design should consider that the signal may be capable of high currents in a fault condition.

Since the release consent current demand is only 100 milliamperes, it is not necessary for the release consent circuit components (wire, relays, connectors, etc.) in a specific aircraft to be rated for 10.0 amperes if the aircraft limits the current to lower levels by design (e.g., as shown in figure 12. In the interest of saving weight, the aircraft designer should select the smallest gauge wire that will support the maximum load current expected for his design. A protective device should then be selected to protect this wire and other components. The circuit protective device trip characteristics must lie above the maximum release consent load current rating of 100 milliamperes and below the maximum overcurrent curve.

This overcurrent limit was imposed by the standard for the benefit of the connected mission store. This establishes an upper limit on fault currents which could be sourced into a store and which the store should safely withstand. A complication is that the allowed fault levels were defined to allow the aircraft to use the protection afforded one of the primary 28V DC power lines, 10 ampere rating, instead of installing an additional release consent circuit breaker or some other current limiter. This results in a very high "allowed" fault level compared to the 100 milliampere non-fault current capacity required of the release consent line.

Due to this low current level, it is in the interest of all aircraft, store and umbilical designers, that the current limiting on release consent be lowered considerably below the levels allowed in figure 17 of MIL-STD-1760C. Since the MIL-STD-1760 connector has a 20-gauge contact for the release consent function, an obvious implication exists that a 20 gauge or smaller wire will be used in the circuit. The required current level of 100 milliamperes can actually be provided through wire gauges smaller than can be installed in aerospace applications due to mechanical considerations. If the aircraft installs a 20 gauge, or smaller, wire, then the requirements imposed by aircraft system specifications will typically require that the aircraft protect the 20 gauge, or smaller, wire. Umbilicals and stores that use a 20-gauge wire for this function would then also be protected.

7.1.2.6 Ground reference.

The standard requires release consent to be referenced to 28V DC power 2 return. This reference was selected as a compromise to avoid increasing the interface connector size. The disadvantage of this selection is that it results in 28V DC power 2 return noise being injected into the release consent monitor circuit in the store. To some extent, the noise on 28 V DC power 2 return is noise generated by the store itself. Whatever the source of noise however, the store monitor circuit must attempt to isolate this noise from the store electronics and also account for 28V DC power noise levels in setting the release consent enable detection thresholds shown in figure 13.

Figure 98 of ASD-TR-87-5028 shows typical noise levels induced at the ASI by a 200-volt/meter field. These levels are comparable to the other discrete circuits. The noise level jumps to approximately 90 dB microvolt at frequencies below 10 kHz when MIL-STD-461 CEO1 limits are injected into the 28V DC power 2 line.

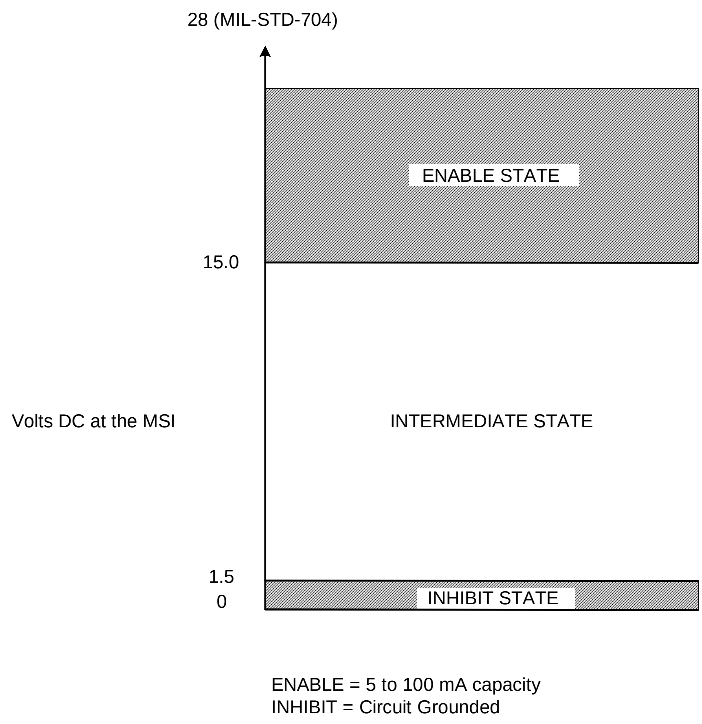


FIGURE 13. Store release consent voltage requirements.

7.1.2.7 Release Consent control function partitioning.

The release consent function should be distributed within the AEIS as switching of this safety critical signal should be as close to the ASI as possible to reduce the effects of electromagnetic pick up on the wiring to the ASI. For retrofit situations this function could probably be incorporated into existing equipment.

7.1.3 Mission Store release consent requirements.

7.1.3.1 Design requirements.

The release consent circuit is in the "enable" and "inhibit" states when the voltage levels at the MSI, contact 1 referenced to contact E, comply with figure 13. Note that the minimum “enable” voltage is 15, compared to the 19 required at the ASI, to allow for voltage drop in umbilicals, etc. The voltage transition time between enable and inhibit states may take up to 6 milliseconds.

7.1.3.2 Circuit design.

If the release consent line is used to provide an input to a solid state logic circuit, a pull-down resistor must be used as shown in figure 14b. The standard does not require the aircraft side of the circuit to have a low impedance path to ground when in the "inhibit" state; it allows the aircraft to provide an open circuit for the "inhibit" state. Therefore, the store must provide a circuit to pull a potentially open line to ground potential, or close to ground potential. The noise levels on the release consent input from the aircraft can be fairly high, e.g. 1 volt p-p spikes when in the inhibit state. The spikes seen in the enable state can approach the MIL-E-6051 limits for 28V DC systems, i.e. -42 volts to +42 volts. As a result, the circuits of figure 14b and figure 14c should include filtering, or transient suppressors, or both.

For applications where the store environment will permit the use of optical couplers, the circuit of figure 14c provides the distinct advantage of decoupling the release consent and its noisy return, 28V DC power 2 return, from the store's electronics power and signal ground. The use of Schmitt Trigger type buffers is also recommended to provide a "snap action" for the state transition.

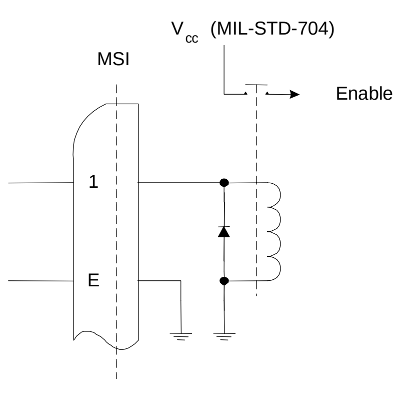


Figure 14a. Electromagnetic relay example

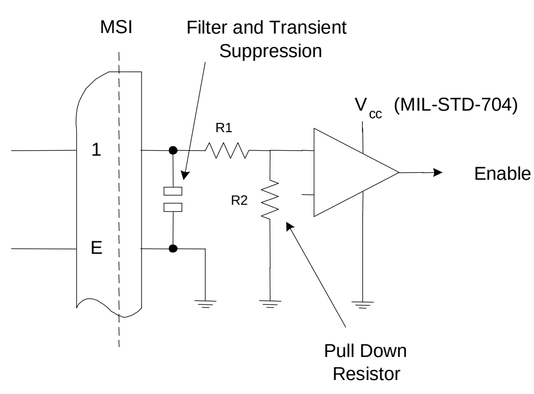


Figure 14b. Solid state example

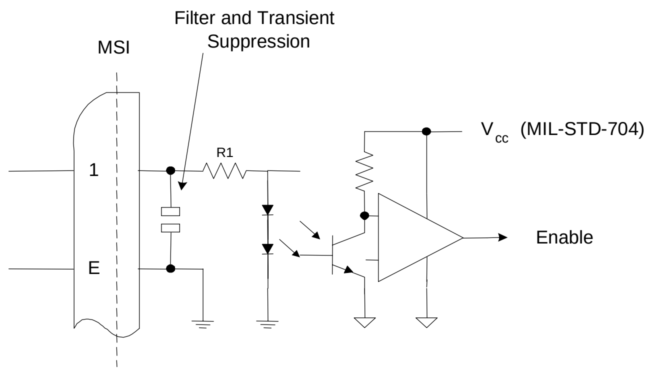


Figure 14c Optical coupler example

FIGURE 14. Store release consent circuit examples.

7.1.3.3 Timing.

The enable lead time and inhibit lead time requirements in the standard (10 ms each) establish when a mission store must accept or reject a safety-critical command based on the release consent signal.

7.1.3.4 Functions tied to release consent.

Interface Control Documents (ICDs) must define the store actions for which release consent must be enabled if there are any actions other than the ones required by the standard.

Since jettison is an S&RE function, release consent might not have any effect on jettison. Selective or Emergency jettison of a store should not require release consent to be enabled at the ASI and the enable or inhibit status of release consent must not prevent the store from being jettisoned. Stores may need processing time to erase software memory for security reasons before being jettisoned. In an application where this is the case, a message (e.g. 11R) to erase software memory can be sent by the aircraft to the store moments before the selective jettison command being sent to the S&RE to jettison the store on that station. In an emergency jettison condition, such commands should take precedence over any other command to the store.

The store is not allowed to use the transition to the enable state to activate any internal store function other than the internal store "functional state" which enables acting on safety critical commands from the data bus interface.

CAUTION
The mission store must not use the release consent signal to activate any internal store mode or function except those modes or functions required to accept or reject safety critical messages received by the store's remote terminal.

The standard defines which commands are to be interlocked with release consent. It is intended that safety related, or irreversible actions, are dependent on release consent. Examples include:

a. Firing commands sent to rail launched missiles, to ignite a rocket motor.

b. Fire command to a gun

c. The irreversible activation of a power source or function, e.g. electrical, pneumatic, thermal, etc. such that the life of the store is limited after activation. An example is firing a thermal battery.

d. Allow an emission, e.g. RF, laser, etc from the store which could increase the aircraft's "visibility" to other vehicles.

e. To carriage stores:

(1) Eject, fire or launch a mission store, submunition, etc.

(2) Activate release consent at a CSSI.

Whether or not the standard requires the store to implement the release consent interface is determined by the store system use of bits D8 and/or D10 of Word 04 of the Store Control message. The store may also require the use of release consent for other bits in the store control message, but the designer is warned regarding the extent to which the signal present time window is consequently extended.

7.1.3.5 Mission store circuit characteristics.

The release consent interface consists of a single discrete line for signal transmission and the 28V DC power 2 return line for signal return. The mission store must go to the appropriate enable or inhibit state when the voltages depicted in figure 13 above are provided at the MSI. The normal current demand by the store electronics is between 5.0 and 100 milliamperes, as required by the standard when an "enable" voltage is applied. Typical currents of 0 to 5 milliamperes result when an "inhibit" voltage is applied. If the mission store does not use the release consent function, the circuit, contacts 1 and E in the interface connector, must be left open. The 100 kilohms specified in the standard is meant to define an open circuit.

The mission store designer may choose to use the release consent line to activate an electromechanical device or provide an input to a logic circuit. Due to safety related applications of release consent in some stores, it may be desirable to use the line to cause a mechanical "break or make" function in the circuit rather than to provide a logic input. The line must not be used to directly fire an electro-explosive device (EED) since this would result in an irreversible action without a command via the data bus.

One practical use of release consent is to actuate electromechanical relays. Relays are readily available which are compatible with the current and voltage limits established by the standard. The relay in turn could be used to close a path to igniters, EEDs or similar loads, i.e. in effect Arm the EED circuit. Typical implementations are shown in figure 14.

If the release consent line is used to provide an input to a logic circuit, the current demand must not be less than 5.0 milliamperes at the minimum enable voltage. Ideally, this current level should be well above 5.0 milliamperes at this voltage, 15V DC, since this line may be switched by relays in the aircraft or carriage store. The selected current level must consider the broad range of allowed enable voltages, i.e. 15 volts up to the MIL-STD-704 28V DC upper limits.

7.1.3.6 Circuit protection.

The standard does not specifically mandate that the store safely withstand overcurrents associated with internal store release consent circuit faults. In contrast, such a requirement is mandated on the store for internal power circuit faults. However, it is the intent that, from a store safety perspective, the store not become unsafe if a fault occurs in the store's release consent circuit. It is also the intent that the store rely on aircraft protection devices to aid in safely withstanding these faults. In theory then, the store wiring should safely withstand store induced fault currents up to the current-time limits defined by the "maximum overcurrent" curves in figure 17 of the MIL-STD-1760. From a practical viewpoint, however, the wire size required to meet this overcurrent level may be too large for the size 20 contacts contained in the primary MSI connector for release consent. As previously discussed, in order to be compatible with the connector design constraints, the aircraft needs to provide fault protection levels compatible with 20 gauge or smaller diameter wire. Thus, the connector constraint becomes the driving element on allowed fault current levels sourced by the aircraft. Stores designed to safely withstand 20 gauge conductor fault levels should be adequately protected. Specific mission stores which require a higher level of safety can include additional fault protective devices within the store.

7.1.4 Carriage store release consent.

7.1.4.1 Design requirements.

Carriage stores are required to release mission stores although the release command is under the control of the aircraft Stores Management System (SMS). Consequently, the carriage store must provide a release consent signal at each CSSI in response to a similar signal provided at the ASI (and CSI via the umbilical cable). The standard requires the carriage store to be compatible with signal levels at the ASI and MSI as depicted in figure 15. It must be remembered that the carriage store design must make allowances for signal losses caused by the ASI-to-CSI and CSSI-to-MSI umbilical cables. That is, the maximum signal voltage drop allowed between the ASI and MSI is 4.0 volts. A minimum voltage drop of 0.5 volts should be allocated for the ASI-to-CSI and CSSI-to-MSI umbilical cables, leaving 3.0 volts to be dropped across the carriage store (CSI-to-CSSI).

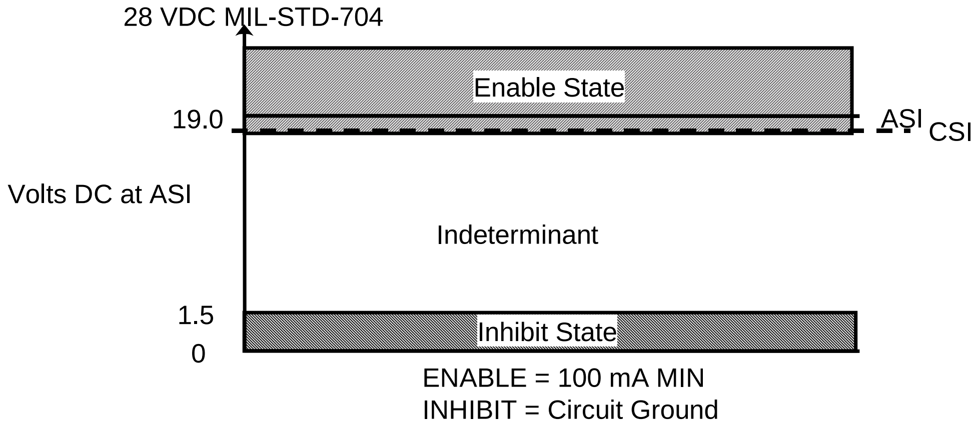


Figure 15a. Input to carriage store (measured at the ASI).

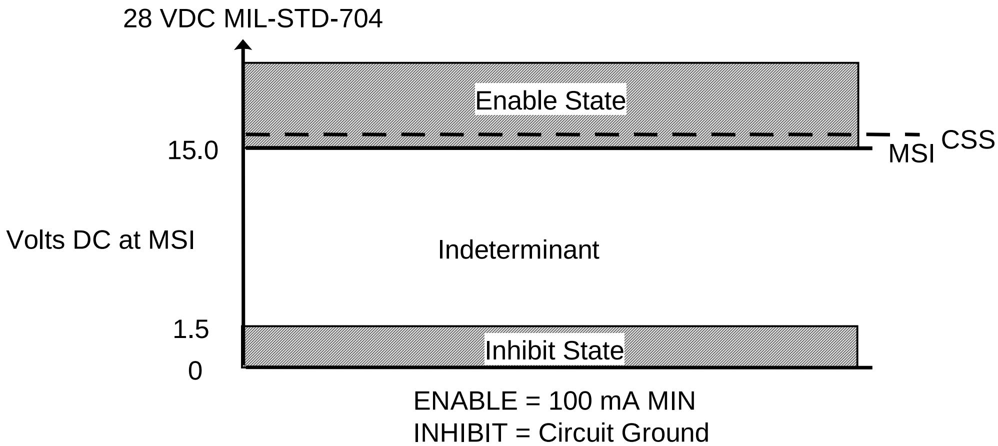


Figure 15b. Output from carriage store (measured at the MSI).

FIGURE 15. Carriage store release consent signal requirements.

7.1.4.2 Carriage store release consent circuit.

Typical carriage store designs for the release consent circuit are shown in figures 14 through 18. Figure 16 shows a direct connection between the CSI and CSSI interfaces. This implementation is applicable only when a single mission store is carried. All carriage stores having multiple mission store capabilities will require the release consent signal supplied at the ASI (and CSI) to be used for control only as shown in figures 17 and 18. This is true because each mission store is allowed to demand 100 milliamperes which is also the minimum that is guaranteed to be available from the ASI. Consequently, current amplification is required when more than one mission store on a carriage store is to be sourced a release consent signal simultaneously. Current amplification is obtained by using a separate power source (such as 28V DC power 2) as shown in figures 17 and 18. Relays requiring less than 100 milliamperes of coil current can be driven directly by the release consent signal; otherwise a transistor drive circuit is required. Figure 18 is an implementation similar to figure 17 except individual control of release consent fanout is provided based on commands received over the MIL-STD-1553 interface and solid state switches with current limiting are provided.

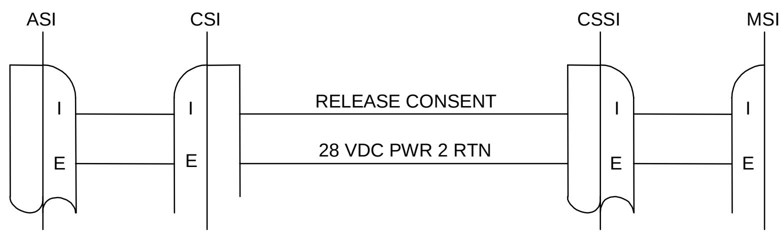


FIGURE 16. Carriage store release consent direct connection – one MSI only.

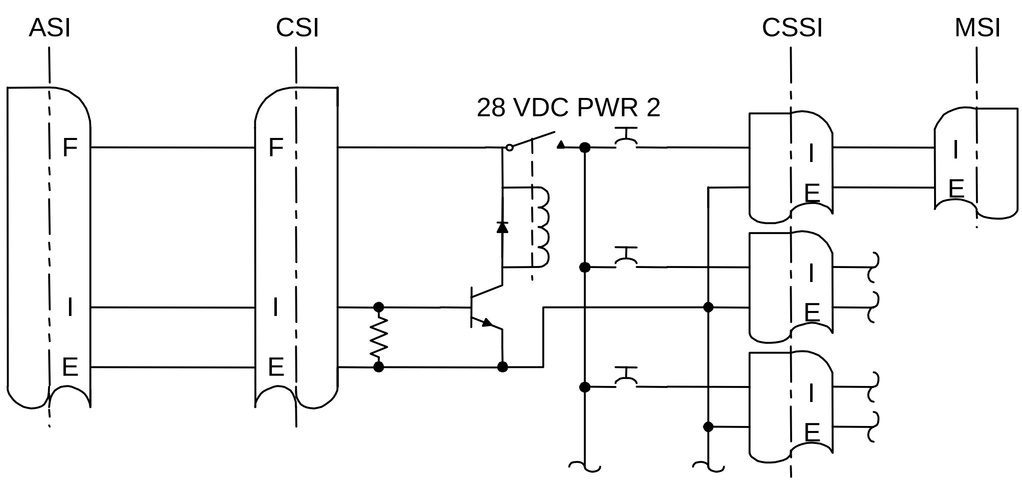


FIGURE 17. Carriage store release consent with separate 28V DC power source.

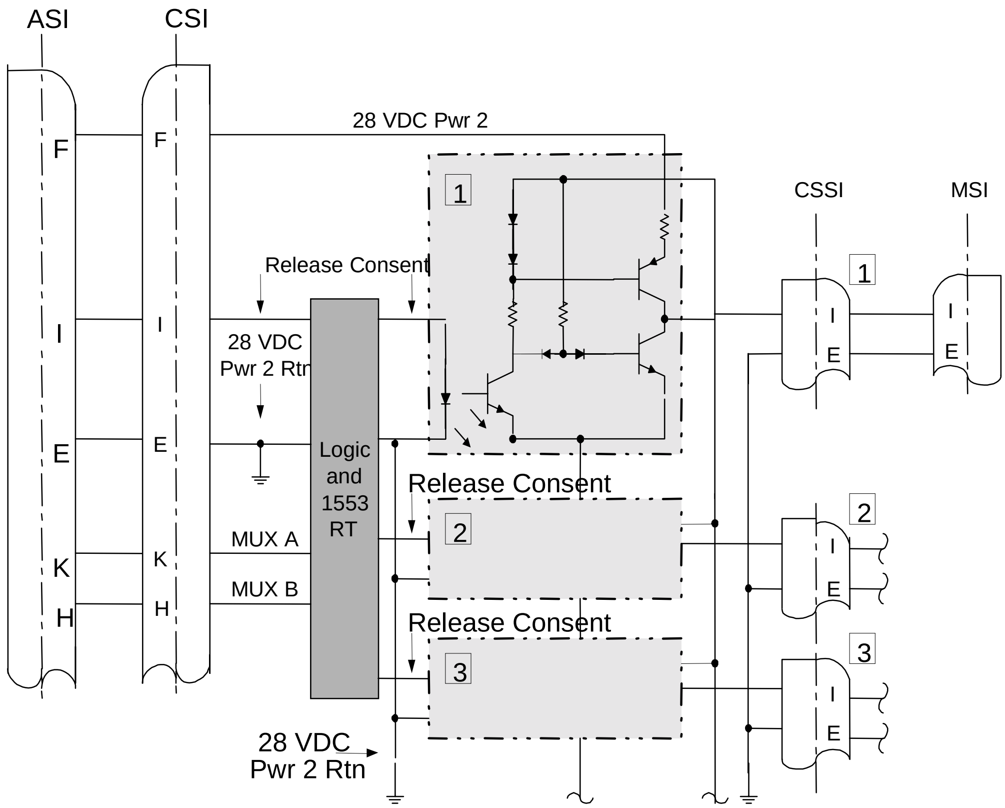


FIGURE 18. Carriage store release consent with three control circuits.

7.1.4.3 Circuit protection.

MIL-STD-1760 intended for carriage store wiring to be protected by the aircraft fault protection system to avoid the addition of protective devices in the carriage store. Revision B of MIL-STD-1760 required the release consent line to be protected to the same limits as the 28V dc power, which is actually much higher current than needed or desired. Therefore, as discussed above, it is highly recommended that a lower overcurrent limit (sufficient to protect 20 gauge wire) be provided by the aircraft for release consent.

While this lower overcurrent will benefit the carriage store on its release consent input protection, it could be a disadvantage in the release consent output circuit. The carriage store should include a series protective device between the 28V DC power (1 or 2) input at the CSI and the release consent output at the CSSI.

This series protection is required to maintain the "protected 20 gauge wire" recommendation. In contrast, if the carriage store implements this protection, then the current limiting shown in the figure can be sized to significantly limit fault currents (typically 100 ma) out the CSSI while still delivering the required 15 volt minimum signal to the MSI under fault-free conditions. Note that the fault-free load current is only 100 milliamperes maximum.

7.1.4.4 Test data.

The release consent circuit was implemented with 22 gauge wire in the test circuit. The worst case voltage drop (in environmentally fatigued harnesses) was less than 0.9 volts from ASI to

MSI for applications not requiring a carriage store and 3.4 volts in applications requiring a carriage store. (See Appendix A in ASD-TR-5028 for test configurations.)

7.1.5 Arming and fuzing.

Arming and fuzing of a store's warhead does not directly occur as a result of data or discrete signals sent through the MSI. Data or signals through the MSI may, however, influence the arming and fuzing process within well defined, controlled bounds.

A baseline condition or rule in store design is that a warhead is never armed while attached to the aircraft. Data or signals may be sent by the aircraft to the store through the MSI to enable, or disable, the arming process or to select arming and fuzing options. However, the actual arming occurs after the store leaves the aircraft and after some time, distance, acceleration duration, etc has transpired.

A typical arming operation for a missile might consist of the following steps. An "arming enable" command is sent to the store over the data bus, while the release consent signal is enabled. The store receives the command, verifies that the command is error-free, verifies that release consent is enabled and that the store subsystems are serviceable. If these checks pass, the store activates a mechanical lock that releases an acceleration sensor. If the missile is fired, acceleration from the missile results in the gradual movement of a device that was disrupting an explosive train. After the acceleration has continued for a predefined length of time, the explosive train will no longer be disrupted and the missile will be armed. This description is mechanically oriented. Similar arming sequence could occur using guidance computer integration of inertial sensor derived acceleration data, with a final command to align the explosive trains for an armed weapon.

With the explosive train aligned, the warhead can be detonated by the fuzing system initiating the explosive train. The fuzing system might detonate the warhead based on proximity sensors, optical sensors, high negative g-load due to impact, or a number of other exotic or simplistic target detection methods. As with arming commands and signals, fuzing "commands" might also be sent through the MSI. However, these commands will not result in weapon fuzing with the store attached to the aircraft. Instead the fuzing command contains data for selecting fuzing options such as fuze function delay time after impact, detonation altitude, target signature, etc.

The main point of this example is that fuzing and arming data is critical and should be well protected in its transfer over the data bus, including <u>possible</u> interlocking with release consent. That interlocking would necessitate a specific requirement to be added to the store ICD to use release consent with bit D7 of the “critical control 1” word. However, the data is not so critical that the store is actually being armed and fuzed while on the aircraft. Therefore, the data transfer can be sufficiently protected so that use of the AEIS for its transfer is a viable option over the use of mechanical arming wires and similar devices previously used.

7.1.6 EMI issues with release consent.

The release consent interface is required by the standard to use the 28V DC power 2 return as its reference. From an EMI perspective, selection of the power 2 return for the reference is not optimum. However, since release consent is characterized as a MIL-STD-704 power quality discrete, the mission store needs to treat the discrete as a "noisy" signal. A dedicated release consent return is not included in the MIL-STD-1760 interface connector because it would have increased the connector size. The chosen reference point does somewhat complicate the store's release consent monitor circuit by requiring the signal to be referenced to 28V DC power 2 return. Figure 14 illustrates several circuit solutions for this reference problem.

7.1.6.1 EMI test data.

In the testing reported in ASD-TR-87-5028, no problems were evident on the release consent lines when exposed to a 200-volt/meter field. See figure 98 therein for representative recorded noise levels at the ASI. Figure 103 therein illustrates representative spikes induced in the release consent interface when a total of 30 amperes of 28V DC is simultaneously switched through both primary and auxiliary interfaces. This switching was accomplished with electromechanical relays and no power line filtering. The spikes shown are sufficiently high to consider some filtering in aircraft circuitry. Measured levels of spikes varied considerably with different cable constructions, carriage configurations and measurement points. In several instances, the unfiltered spikes on the interlock exceeded 1.5 volts peak-peak.

Similar data is shown in figure 136 of ASD-TR-5028 for RSO3 induced levels in the standard EMI test cables and this illustrates induced noise measured at the MSI. The levels with the test cables are approximately 20 dB lower in magnitude compared to the ASI levels, measured with representative aircraft-store network configurations after adjusting for plotted units. The cables in all of these tests were constructed with the release consent line not twisted with the power 2 return. As a result, the release consent field induced noise levels are approximately 10 dB higher than similar tests on the 28V DC power 1 and power 2 interfaces. It is expected, however, that the noise levels induced into release consent during 28V DC power switching transient tests would have been higher than the levels shown in figure 98 of ASD-TR-87-5028 if the release consent line was twisted with the power 2 interface line set.

7.1.7 Safety analysis issues.

The standard contains no rules for the installation of release consent circuitry, only for the signal parameters across the interface. This is a 28V DC discrete using MIL-STD-704 characteristics and the return is via 28V DC power 2 return, with little else specified in terms of electrical characteristics. However, discussions over the years have indicated that when release consent is in use its implementation should be visible. This breaks down to "not software generated, only steered". Note that its initiation should be via a weapon release button or trigger, to keep the safety window as small as possible.

7.1.7.1 Why release consent is separate from the data bus.

Many people distrust the use of digital data for the transmission of safety critical commands and this actually includes the generation of such commands by the processor. Furthermore, although it can be shown that the risk of false generation of a safety critical message that passes all checking and is therefore acted upon, is very low, the assumptions the analysis is based upon are hard to verify and the analysis is generally mistrusted. In order that the flexibility of digital data can be retained, but that it becomes "safety related" not "safety critical", the use of a discrete, which must accompany such data, is mandated by the standard. That discrete is a nominal 28V DC line capable of a current drain up to 100 milliamperes, is called release consent and is mandated for use whenever bits D8 and/or D10 of the Critical Control 1 word (MIL-STD-1760C Table B.XXXII) are set to logic 1. Use at other times is at the discretion of the store, but the aircraft must be capable of complying with such a demand. This rationale leads to the guidance that release consent should not be software generated. Thus, the signal should not be transmitted on a data bus, but the signal may be software-steered. A data bus may be used for transmission of steering instructions, such as in a multi-rail launch store or carriage store.

7.1.7.2 Visibility of release consent circuitry.

As discussed earlier, the release consent implementation should be made visible. Therefore it is considered that generation should be a switching network activated from an arming, trigger, or weapon release switch and that only steering and/or final connection should be software controlled. The use of electromechanical switches is sometimes favored over solid state circuits because the signal connections and potential failure modes are more visible.

7.2 Interlock interface.

Interlock is implemented with two wires through the interface, operating in a discrete “open” or “connected” status.

In addition to the information in this section of the handbook, the rationale and guidance in 15.4.3.5, 15.5.1.5, 15.5.2.5, 15.5.3.5, and all subparagraphs should be consulted.

7.2.1 Purpose.

The purpose of the interlock circuit is to provide a means for aircraft to determine if the store is electrically mated to the aircraft. This discrete signal is similar to the "ground interlock" or "store present" discrete signal in many existing aircraft and stores. The aircraft has the option of using this discrete signal or not using it. If, however, the aircraft uses the discrete signal then the requirements in the standard apply to the aircraft.

7.2.2 Aircraft side of interlock interface.

The interlock circuit is equally applicable to the primary and auxiliary interfaces. The interlock circuit is not intended to be used as the sole indication of "store gone" since it cannot always determine the true status of the "mechanical" mating between the aircraft and store. Consequently, the following caution note is quoted from MIL-STD-1760C and must be heeded:

CAUTION
The interlock interface shall not be used as the sole criterion for functions which could result in an unsafe condition if the interlock circuit fails open.

The primary concern addressed by this caution note is that several failure modes exist in the interface which could result in an indication of "interface not mated". One obvious example is a broken wire or contaminated contact anywhere in the circuit path from the aircraft's sensor circuitry, probably in some SMS black box, to the ground or return connection for that sensor circuitry. The existence of continuity could lead to a reasonably valid conclusion that the interfacing connectors are mated. It follows then that lack of continuity could be interpreted as "no assurance that the interface is mated". This latter condition, however, is not equivalent to an indication that the store has physically separated from the aircraft. It is this physical separation sensing function that is the specific concern of the caution note. Some designs in the past have used the "ground interlock" signal as an input to the aircraft's SMS in ways that could result in safety problems under certain combinations of events. If the SMS uses the interlock as an input to determine store separation, a second input should be used as a confirmation of physical separation. The form of this second input can vary with different aircraft and different separation modes and is not addressed by MIL-STD-1760C. An example of a second input is a store presence switch, mechanical or proximity, in the suspension and release equipment.

There may be a large temptation for the aircraft designer to use the interlock interface to achieve a "hung store" detection, e.g., ejection command has been sent to station but continuity on interlock still exists. While the interlock provides a realistic indication that a store is hung, it does not provide a reliable indication that the store is not hung. This latter condition exists because failure modes in the interlock circuit could result in a "not mated", hence an implied "not hung", indication.

The aircraft designer can use the interlock interface as the first look at probable store separation in an effort to continue logic processing for the next store release. However, prior to releasing the "next critical store", the aircraft should verify separation by a second means such as S&RE store sensing switches. The term "next critical store" refers to the store which if released would result in unacceptable asymmetrical loading or in store collision. The aircraft designer can use the interlock interface to control deadfacing of power interfaces, as failure to correctly perform the deadfacing function is not likely to result in such catastrophic consequences.

7.2.2.1 Design requirements.

The aircraft is required to comply with a set of electrical characteristics (see 5.1.1.5 of MIL-STD-1760C) measurable at the ASI if the aircraft uses, i.e., monitors, the interlock interface.

The electrical characteristics in the standard can best be understood if the aircraft circuitry is viewed as an input to a logic gate with a pull-up resistor on the input. The gate input pull-up resistor can be tied to an aircraft voltage source that can range from as low as 4 volts DC to as high as the 28V DC levels defined by MIL-STD-704. Given the actual voltage source selected by a specific aircraft, the pull-up resistor is then sized to limit the short circuit current, assuming a short is applied at the ASI, to 100 milliamperes maximum and limit the current into a 2 ohm load at the ASI to 5.0 milliamperes minimum. The gate on/off thresholds can then be set to level(s) that ensures that:

a. An interface connected condition is detected for any impedance between 0 and 2 ohms connected on the store side of the ASI, and

b. An interface disconnected condition is detected for any impedance greater than 100 kilohms.

The actual impedance levels at which the aircraft circuit switches between connected and disconnected states can be at any point between these two values.

The 2-ohm and 100-kilohm impedance points are applicable for aircraft excitation voltages and currents over a frequency range from DC to 4 KHz. The 4 KHz frequency establishes an upper frequency limit for any aircraft circuit that uses excitation pulses, e.g., sampling, instead of continuous excitation, in an effort to reduce SMS power dissipation.

7.2.2.2 Grounding philosophy.

The ground connection for interlock return is not specified by MIL-STD-1760C. The standard requires the store to isolate all store circuitry from interlock and interlock return. The store simply provides a continuity link from interlock to interlock return on the store side of the MSI. This allows the aircraft to connect interlock return to any appropriate aircraft reference, e.g., power return, structure return, internal SMS signal return, etc.

One cautionary note, however, is that some stores designed prior to the release of MIL-STD-1760A may, in fact, have circuitry connected to interlock return and are expecting continuity between return and aircraft structure. This continuity to structure ground was required by the July 1981 release of MIL-STD-1760. The September 1985 release of MIL-STD-1760A removed this mandatory structure ground connection due to concerns with coupling structure ground noise into SMS and store electronic circuits. Aircraft which are required by system specification to be compatible with any of these earlier stores, e.g., AIM-120, still need to provide this ground connection.

To improve noise rejection, the aircraft should use a twisted wire pair for the interlock.

7.2.2.3 Circuit design.

The interlock interface is simply a continuity link on the store side of the MSI that is available to be monitored by the aircraft. Figure 19 illustrates this interface. Figure 19a shows the actual circuit from ASI into the mission store. Figure 19b defines the equivalent impedance looking into the MSI while figure 19c shows the resulting equivalent impedance that the aircraft circuitry sees looking out of the ASI towards the store.

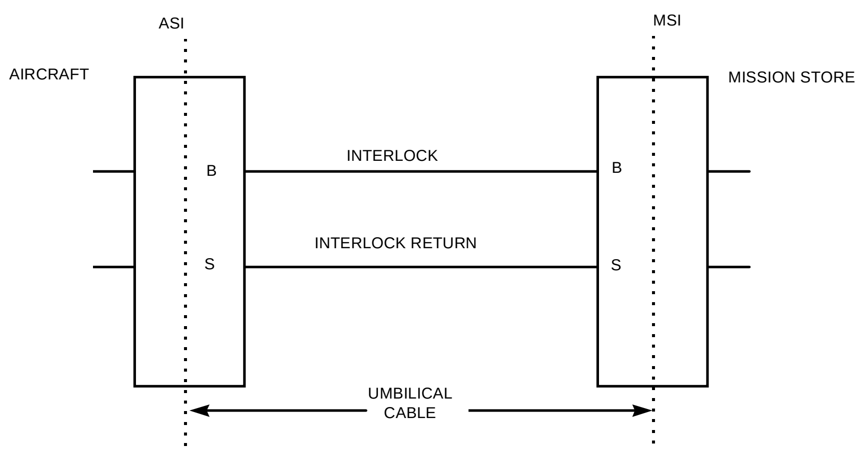


Figure 19a. Interlock circuit.

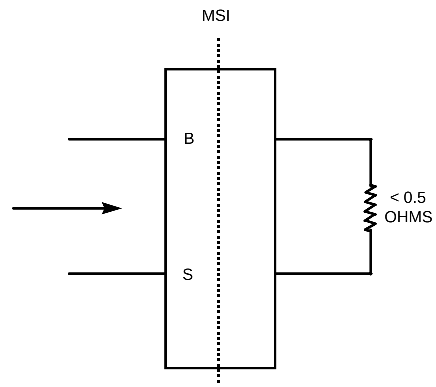


Figure 19b. MSI equivalent interlock circuit.

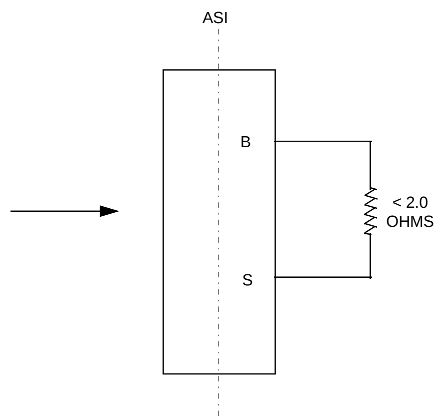


Figure 19c. ASI equivalent interlock circuit.

FIGURE 19. Interlock interface requirements.

The selection of equivalent impedance thresholds for the aircraft monitor circuit needs to consider the additional line losses between the monitor circuit and the ASI connector. These losses are dependent on the wire type and size selected, the wire length, cable bundling characteristics (such as twist rate) and on the excitation frequencies of interest to the monitor circuit.

Figure 20 shows three typical circuits for the interlock function. The Vcc for the solid state implementation (figure 20c) must be sufficiently high to provide a minimum voltage of 4.0V DC at the ASI connector contact B during an ASI unmated condition.

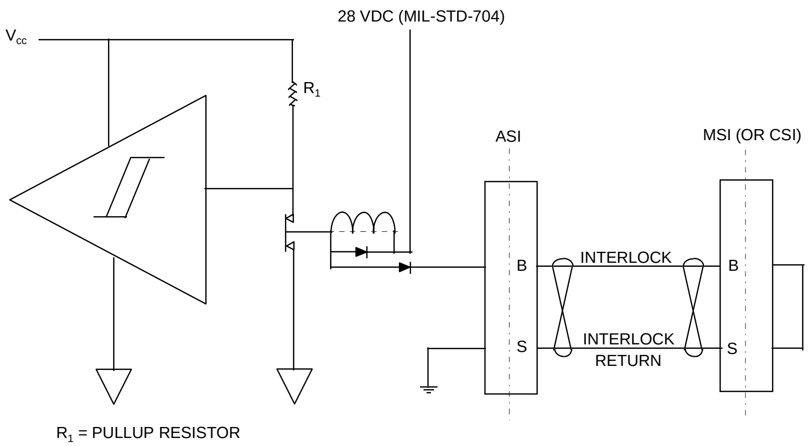


Figure 20a. Electromechanical relay.

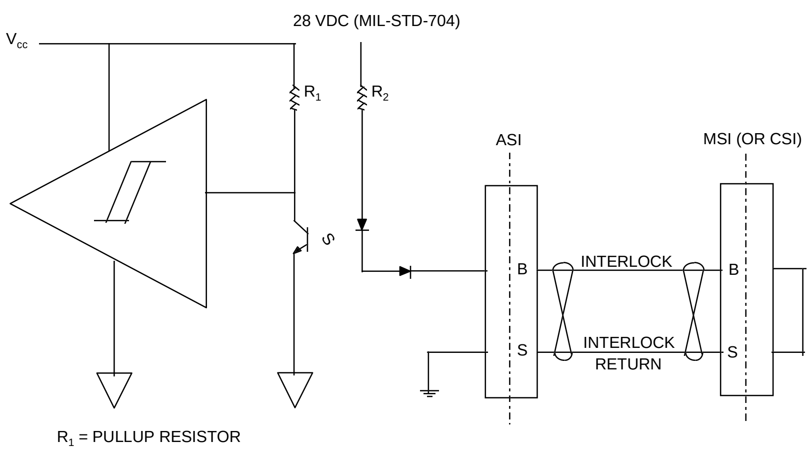


Figure 20b. Optical coupler (aircraft interlock circuit Implementation).

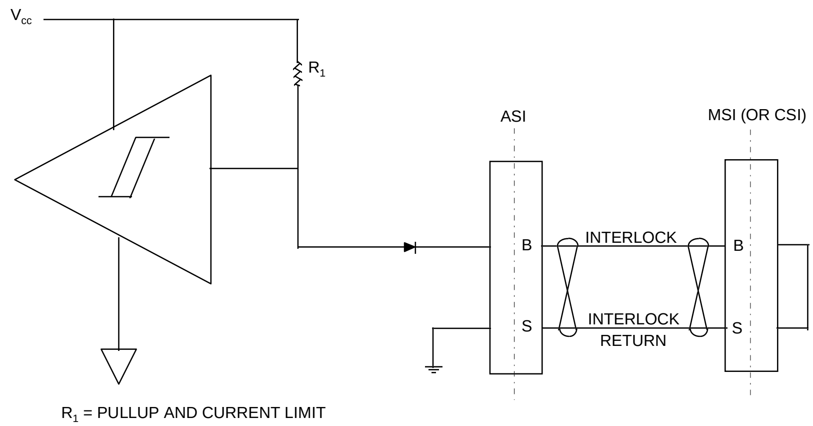


Figure 20c. Solid state aircraft interlock circuit implementation.

FIGURE 20. Typical circuits for the interlock function.

The circuits are current-limited to 100 milliamperes maximum, which is easily supported by 24 AWG or larger wire. The diode in the interlock line is used to protect the aircraft circuit against failure in the event power is applied at the interlock interface at the ASI connector as a result of a fault. In some applications, filters may also be installed on the input circuit to exclude EMI entry into the SMS electronic package. Static discharge protection from the outside environment may also be required on these inputs.

There is no requirement in MIL-STD-1760C for the aircraft to use the interlock signal, however, it is a convenient signal to assist in determining store presence. The designer should be aware of all of the requirements concerning the interlock interface especially if this interface is to be used to determine store presence. If this is the case, the designer should ensure that the response time of the monitoring circuit to changes of interlock status is acceptable for the overall system design and that all the voltage, current and threshold requirements of MIL-STD-1760C are met. The aircraft must provide other means of determining store presence as MIL-STD-1760C requires that the interlock interface not be used as the sole criteria for functions which could result in an unsafe condition if interlock circuit fails open. If the aircraft does use the interlock interface for any time critical functions, such as to help determine time of store release during a firing sequence, then the designer must ensure that the interlock monitoring circuit does not introduce excessive time delays.

7.2.2.4 Monitoring interlock.

It is recommended that the interlock signal be monitored close to the ASI to reduce aircraft wiring. If the interlock signal is monitored locally to the ASI in the associated store station equipment then the result can be transferred to other units using the internal data bus. This will minimize the aircraft wiring associated with the interlock signal, as dedicated wires are only required between the ASI and associated SSE, the data bus already being provided for other uses. The interlock signal may be used directly or indirectly to remove 115V AC power from the store for deadfacing the connector when the store is not present (may also be used to remove 28V DC if 28 V DC is deadfaced). If interlock is to be used for this, then it is recommended that the monitor circuit for this signal be close to the power switching elements for the particular ASI.

If this is the case, the power outputs can be disabled immediately after the interlock signal indicates store absence, otherwise delays will be introduced as the state of the interlock signal will have to be transferred over the data bus.

7.2.2.5 Auxiliary interlock monitoring.

The design of the auxiliary interlock circuitry should be similar to that used for the primary interlock signal. It is also recommended that the monitor circuit be located close to the ASI to reduce aircraft wiring. The designer should be aware that this monitor may be used directly or indirectly to remove auxiliary 115V AC power from an ASI to deadface the connector when store absence is detected.

7.2.2.6 Interlock line installation.

As discussed previously, it is intended that the interlock installation be derived from 28V DC using MIL-STD-704 characteristics. Interlock provision is required by MIL-STD-1760C. However, aircraft are not required to use it. If existing circuits, power or otherwise, are being added to provide the interlock requirement, then the wiring needs routing via the SMS or some means of communicating "interlock connected" status to the SMS. Interlock return isolation is dependent solely on the aircraft and SMS requirements. Originally, the return was to be connected directly to 28V DC Power 1 return, that is zero volts. However, this was modified to allow the aircraft/SMS to implement alternative approaches because of concern about monitor circuit susceptibility to zero volt noise and injection of noise into the LRU.

7.2.3 Mission store interlock interface.

7.2.3.1 Purpose.

The purpose of the interlock interface is to provide a means for the aircraft to determine if the store is electrically mated to the aircraft. The store circuit requirement is met by simply providing a continuity link between the interlock and interlock return connections at the MSI, contacts B and S on the store's primary receptacle (see figure 19) and contacts K and L on the store's auxiliary receptacle. The mission store is required to implement interlock and interlock return in each interface, primary and auxiliary, used by the store. The interlock signal is one of the few non-optional interface signals at the MSI. The only "option" associated with interlock is whether the primary or auxiliary interface is actually installed at the MSI.

7.2.3.2 Design requirements.

The closed circuit must have an impedance of 500 milliohms or less over the frequency range of DC to 4.0 kiloHertz when passing 5 to 100 mA current required by the standard. This requirement is met with the use of 22-gauge wire whose length is less than 6 meters assuming a high temperature environment. The circuit must be capable of supplying the 500-milliohm maximum equivalent resistance when currents ranging from 5 milliamperes to 100 milliamperes are passed through the interface. This length is more than adequate considering that the store should simply add a short, i.e., less than 150 mm, link between the interlock and interlock return contacts in the MSI receptacle.

Some past weapon system implementations of comparable interlock functions have routed the interlock signal through a number of internal store connectors. This variation, while possibly providing useful information to the aircraft, changes the meaning of the MSI interlock from "MSI mated" to a function which is more properly one small part of mission store BIT - i.e., all internal store subsystems are connected. The interlock signal is only intended to be an indication that electrical mating at the MSI exists.

The interlock and interlock return is the only function that the mission store is required to provide at an MSI, assuming, of course, that the mission store has an MSI. Furthermore, the mission store is required to provide this interface at both the primary and auxiliary MSI connectors installed on the mission store. The auxiliary MSI connector interlock and interlock return are independent and isolated from the primary MSI connector interlock and interlock return. As an example, the store circuit of figure 21a reflects the independent/isolated requirement while figure 21b is not a legal store implementation of interlock.

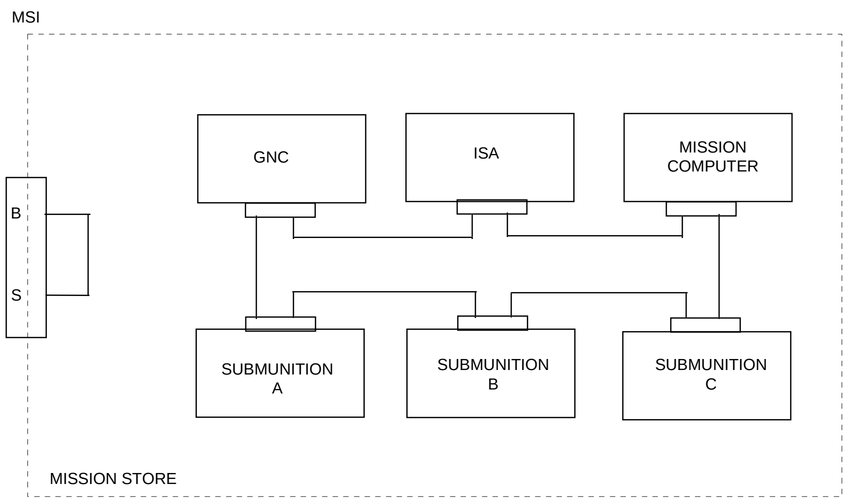


Figure 21a. Intended application.

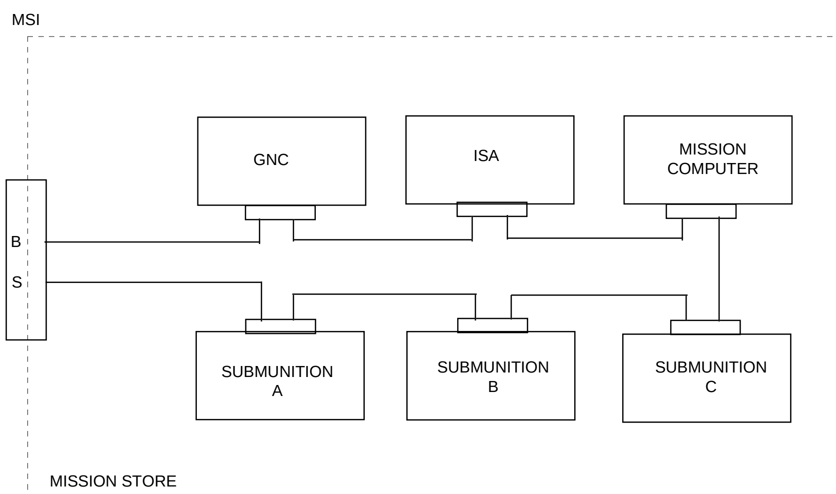


Figure 21b. Not intended.

FIGURE 21. Mission store interlock function.

7.2.3.3 Circuit design.

Figure 22 shows a correct and an incorrect implementation of the interlock function. The mission store is required to maintain 100 kilohms of electrical isolation between all mission store circuits including grounds and the interlock/interlock return connections. This isolation value applies over the range of DC to 4 KHz. This isolation effectively disallows the store from monitoring the interlock or interlock return for an indication of aircraft presence. This isolation requirement is a change in concept from what was allowed in the original MIL-STD-1760. That version required the aircraft to connect interlock return to structure ground and then allowed the store to monitor interlock return for continuity to structure ground. The requirement on the aircraft for a connection to structure was removed by Revision A MIL-STD-1760 and the store was banned from utilizing the interlock return line. This change was made due to the isolation problems when stores and aircraft connect their logic signal circuits together. As a result, mission stores that need an indication of aircraft mated status need to use the address interface (see 7.2.3) to determine such status.

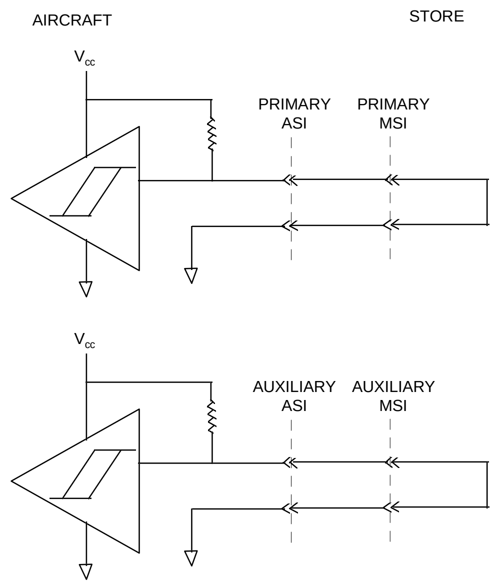


FIGURE. 22a . MIL-STD-1760C compliant.

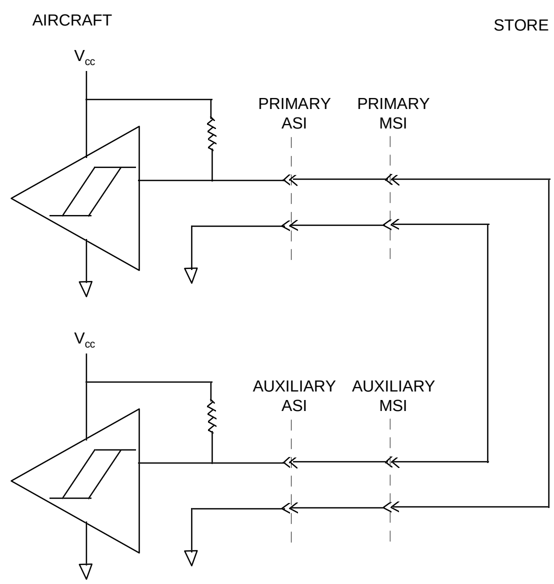


FIGURE 22b. Not MIL-STD-1760C compliant.

FIGURE 22. Primary and auxiliary interlocks.

7.2.3.4 Electromagnetic compatibility.

The store is only required to provide a link between the interlock and interlock return contacts on the store side of the MSI. As a result, the noise on the interlock interface from the aircraft can generally be kept out of the store electronics. The difference between MIL-STD-1760 and MIL-STD-1760C in the use of interlock by the store also helped minimize EMI concerns by the store on interlock. MIL-STD-1760 identified the use of interlock return referenced to structure ground as the mechanism for the store to determine "aircraft mated" status. MIL-STD-1760A through MIL-STD-1760C requires the store to be totally isolated from the interlock interface and to use the address discretes for "aircraft mated" status if required.

7.2.4 Carriage store interlock interface.

A carriage store must implement the interlock at the CSI just as a mission store must implement it at the MSI. A carriage store may use the interlock to determine connector mated status at CSSIs just as the aircraft uses it to determine connector mated status at the ASI.

7.2.5 Test data.

Test data on the interlock and interlock return lines implemented with 22 gauge wire show a typical resistance of less than 600 milliohms from the ASI to the mission store in applications not requiring a carriage store and 1.4 ohms in applications requiring an "extension cord" style carriage store.

7.3 Address interface.

The address interface is implemented with seven discrete wires through the interface.

In addition to the information in this section of the Handbook, the rationale and guidance in 15.4.3.6, 15.5.1.6, 15.5.2.6, 15.5.3.6, and all subparagraphs should be consulted.

7.3.1 Purpose.

The address interface provides a means for the aircraft to assign a data bus address to the MIL-STD-1553 compliant remote terminal in the mission store or carriage store as applicable.

7.3.2 Aircraft side of address interface.

The address transfer port consists of five address discrete lines with a binary coded weighting, one address parity discrete line and one discrete line for a common return. The nominal operating modes for these lines are an open circuit for Logic 1 and a short circuit for Logic 0 for each address line. The five binary coded address discretes are identified as Address Bit 0 (A_0) through Address Bit 4 (A_4). The address assignment is determined by:

$$\text{ADDRESS} = (A_4) \times 2^4 + (A_3) \times 2^3 + (A_2) \times 2^2 + (A_1) \times 2^1 + (A_0) \times 2^0$$

Where A_4 through A_0 are either logic 1 or logic 0.

One additional discrete, defined as address parity, is set to the proper logic state at the ASI to produce an odd number of Logic 1 states on the five address discretes and the one parity discrete. If the circuit uses an active address circuit (see 7.1.2.2), some additional rules apply.

The aircraft is required to provide a stable set of address discretes at an ASI prior to application of any interface power. Furthermore, the aircraft must not, intentionally, change the address assigned to any ASI after power has been applied to that interface. If power is later removed from the interface, e.g. due to internal store power changeover, the aircraft must still maintain the same address at the interface until this connected store has been released from the aircraft. It is strongly recommended that fixed addresses are used to identify the remote terminal address at all ASIs. If variable addresses are used it would degrade the safety of the system when considering the transfer of safety critical information on the MIL-STD-1553 Mux bus.

The wire lengths used for these links should be kept to a minimum. MIL-STD-1760C requires the aircraft to furnish an address to the store at all times. This address may change with different store loadouts, but there must always be a valid address at the MSI when a store is active. Since the address includes six logic bits with an odd parity check, there is always at least one line with continuity through the ASI and MSI. Consequently, a connector "electrically" mated status is provided whenever continuity is seen on any one of these address lines. It must be remembered that the store does not know which address it will be assigned and all address lines must be monitored to determine aircraft presence. Consequently, the following caution note must be heeded:

CAUTION
The Address interface must not be used as the sole criteria for establishing "aircraft mated" functions which could result in an unsafe condition if any one of the address lines fails open.

The address should be identified at any convenient point in the aircraft that is non-interchangeable. For example, if there is an ASI in a removable structure, the address determination circuitry should not be located in the structure itself, but the wiring should be routed through the structure to address determination circuitry located in the non-removable structure. This will prevent the possibility that simply by exchanging structures two different ASIs could be allocated the same RT address.

This "aircraft mated" detection function can be accomplished by simply monitoring the address lines for continuity. Electrical characteristics for the continuity circuit are discussed in 7.2.3.3, 7.3.2.2 and 7.3.3.3.

7.3.2.1 Design requirements - ASI.

In the simplistic form, the aircraft circuit is only a set of links on the aircraft side of the ASI. These links provide either a "short" or "open" circuit between each address and parity connection and the associated address return. However, the requirements in the standard were written to allow more complex implementations for cases where:

a. The address at a given ASI must be changed as a result of mission loadouts,

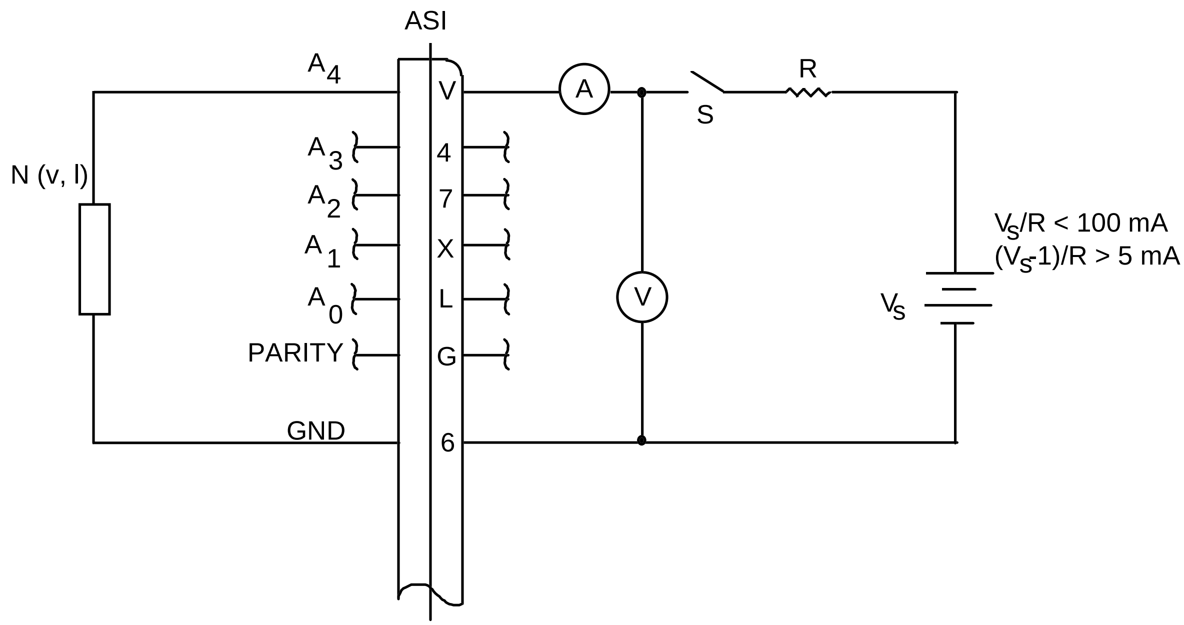
b. The address is provided by an electronic box, such as SSE, which is used at various stations and must therefore contain a programmable, changeable, address interface.

Some applications such as ASIs certified for nuclear store carriage may be prohibited from using software or electronic programmable addresses.

Figure 23 illustrates in a test circuit format, the electrical requirements imposed on the ASI. If a particular address line is in a Logic 1 state, then the aircraft circuit must be such that a current of less than 300 microamperes flows into the ASI connection when voltages between 3.5 and 31.5 volts DC are applied. Similarly, the aircraft must provide circuits for a Logic 0 state such that less than 1 volt is measured between the address connection and address return when currents ranging from 5 to 100 milliamperes are sourced into the ASI. The aircraft designer must also consider the effect, i.e. additional voltage drop in address return, on measured voltage when currents up to 100 milliamperes are sourced simultaneously into all Logic 0 set address lines at an ASI.

Furthermore, the aircraft is required to reach these required voltage/current levels within 10 milliseconds of address excitation application, i.e. closure of switch S in figure 23. This 10 millisecond response imposes some limits, though nothing significant, on any filtering or other circuitry which might be included in the aircraft address interface.

Finally, a sub-tier of paragraph 5.1.1.6.5 of MIL-STD-1760C requires that the aircraft isolate all address connections including the address return from all other aircraft circuits including grounds. This isolation level is specified at 100 kilohms minimum for frequencies up to 4 kHz. This isolation requirement primarily affects aircraft which use some active address concept.



LOGIC STATE	NOMINAL DESCRIPTION	V (VOLTS)	A (AMPERES)
1	N = OPEN	3.5 TO 31.5 (APPLIED)	$< 300 \times 10^{-6}$ (MEASURED)
0	N = CLOSED	< 1.0 (MEASURED)	$5 - 100 \times 10^{-3}$ (APPLIED)

FIGURE 23. ASI address electrical characteristics.

7.3.2.2 Circuit examples - ASI.

Examples of circuit implementations to meet these requirements are given in figure 24. Figure 24a shows a hard-wired, uncontrolled, implementation. Figure 24b shows an optical coupler design. The solid state device must be capable of conducting 100 milliamperes with a voltage drop of 1.0 volts maximum when closed and be capable of blocking 31.5 volts DC minimum when open. Figure 24c shows an electromechanical relay approach. Implementations that electrically isolate the address lines, including address return, from the aircraft control electronics are required. The implementations shown are compatible with both continuous and pulse-type excitation signals from the store. The circuit design should accommodate a "worst case" excitation signal condition which is a continuous signal of 100 milliamperes on each address line. Filtering and static discharge protection may be required for those designs which feed the address lines from the ASI back into some aircraft black box.

7.3.2.3 Grounding philosophy.

MIL-STD-1760C requires that the address lines, including return, be isolated from all aircraft power returns, isolated from structure ground and isolated from address circuits at other ASIs. This requires a totally isolated address set at each ASI using one of the techniques shown in figure 24.

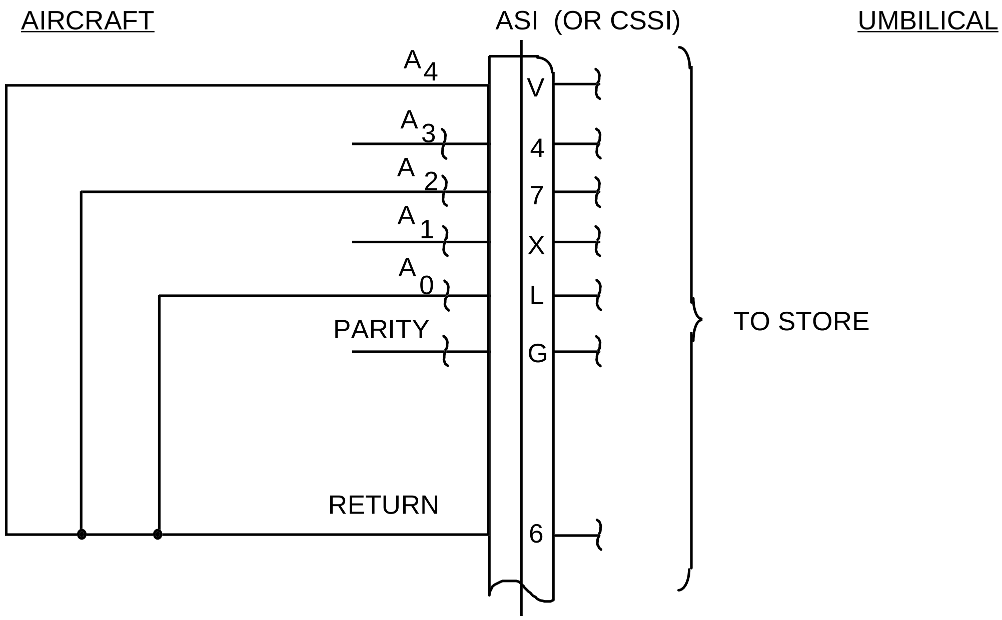


Figure 24a. Hardwired address.

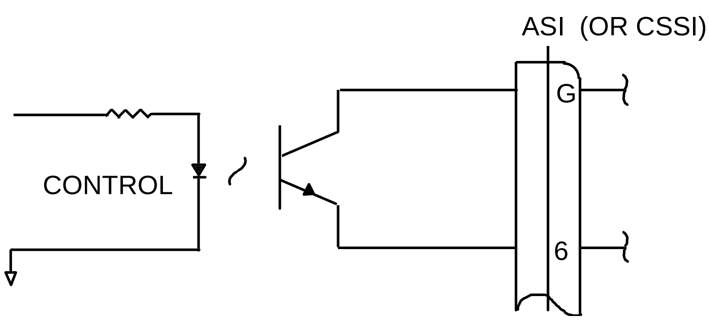


Figure 24b. Optical coupler.

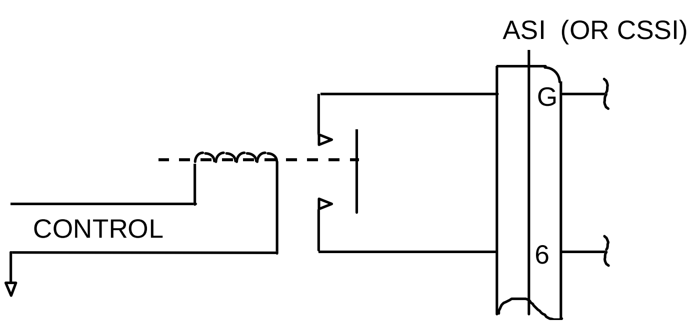


Figure 24c Electromechanical relay.

FIGURE 24. Aircraft address circuit examples.

7.3.3 Mission store address interface.

7.3.3.1 Purpose.

The address interface in the mission store provides a means for the store to detect the assigned store data bus address. If the mission store is required to determine the mated status at the MSI, it must also use the address lines for this purpose.

7.3.3.2 Interface requirements.

The address interface includes five binary encoded address bit connections: A0, A1, A2, A3 and A4, one address parity connection, and one common address return connection. The mission store monitors the five binary encoded address bit lines for Logic 0 and Logic 1 states. The remote terminal address is defined as:

Remote Terminal address = $(A_4) \times 2^4 + (A_3) \times 2^3 + (A_2) \times 2^2 + (A_1) \times 2^1 + (A_0) \times 2^0$

Where A_4 through A_0 are either logic 1 or logic 0

The mission store monitors the address parity line for Logic 0 and Logic 1 states and accepts the assigned address as a valid remote terminal address if the address parity logic state indicates odd parity. Odd parity is defined as an odd number of Logic 1 states on the five address bit lines and the address parity line.

> *NOTE. The store is required to conduct this parity check and not accept the address if parity fails.*

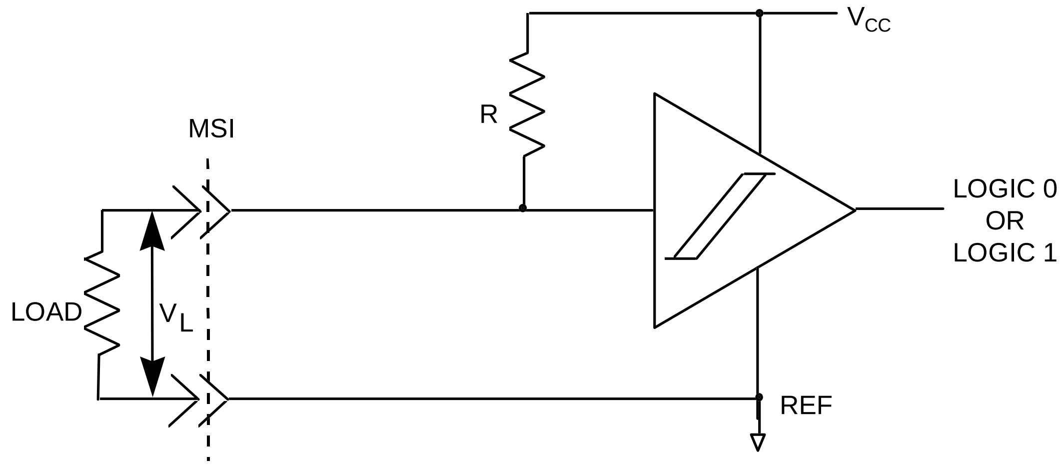
7.3.3.3 Design requirements - MSI.

The nominal operating mode of the five address bit connections and the address parity connection is for an "open circuit" (Logic 1) or "short circuit" (Logic 0) to be applied to the aircraft side of the MSI. Figure 25 defines the general signal characteristics for each address line. Figure 25a shows a simplified circuit diagram with limits on various characteristics. This diagram is shown for explanation purposes, not as a design. See 7.3.3.4 below for design examples. Figure 25b and figure 25c illustrate the logic transition voltages for circuits with and without hysteresis. MIL-STD-1760C does not mandate circuit hysteresis, but defines the Logic 1 and Logic 0 threshold limits such that hysteresis can be provided.

One of the main points in the figure is that the actual maximum detection threshold for the Logic 1 state is determined by the store circuit through the selection of the circuit's supply voltage (Vs) and the value of the pull-up resistor (R) or its equivalent. As will be seen in the examples of 7.3.3.4, MIL-STD-1760C allows a broad range of circuit implementations, with a range of voltage and current levels, for the address interface.

To allow for the effects of potential filtering and active circuitry in the aircraft's address discrete interface, the store must allow 10 milliseconds following application of the address excitation for the voltages and currents at the MSI to stabilize. If the store also includes filtering devices between the MSI and store circuitry, this stabilization time will increase based on the filter characteristics.

Finally, some store applications which may have significant thermal constraints or power dissipation constraints may opt for a more complex circuit that periodically pulses the address lines, possibly even one line at a time, to determine the assigned address. For example, a store that continuously sources 100 milliamperes with a 28V DC open circuit voltage through each address line dissipates more than 16.8 watts in the address monitor circuit. The limits in MIL-STD-1760C dictate 120 milliwatts minimum dissipation if continuous excitation of all address lines is used. Most circuits will probably select a value between these two power limits in order to provide a reasonable SNR for address detection. If the store designer selects address line pulsing, the rise and fall time limits of the excitation must be controlled. MIL-STD-1760C requires that the rise and fall time should not be longer than 10 milliseconds, but does not define minimum rise and fall times. Minimum times will be indirectly imposed in the store in order to meet specific EMC requirements of the store's system specification.



	LOGIC 1	LOGIC 0
NOMINAL LOAD	OPEN	SHORT
STORE SOURCED EXCITATION	4-31.5 VDC	5-100 mA
DETECTION THRESHOLD	≤ 300 mA	≤ 1.5 VDC

V_{CC} /R ≤ 100 mA
(V_{CC} - 1.5V)/R ≥ mA
V_{CC} = 4 + (R X 300 μA)
V_L ≤ V_{CC} < 31.5VDC
1.5V < REF ≤ V_{CC} - (R X 300 μA)

Figure 25a. General circuit description

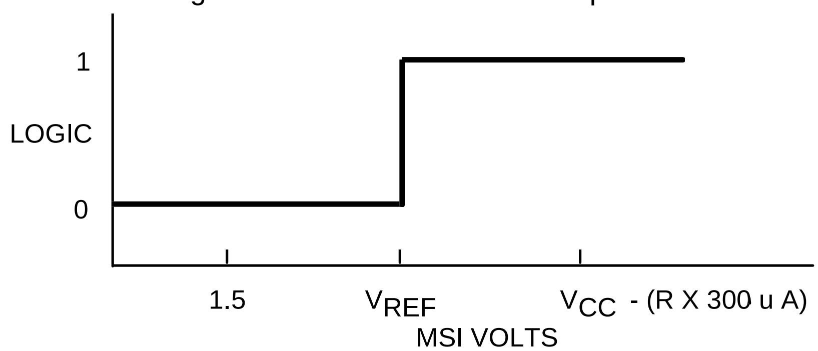


Figure 25b. Logic levels without hysteresis

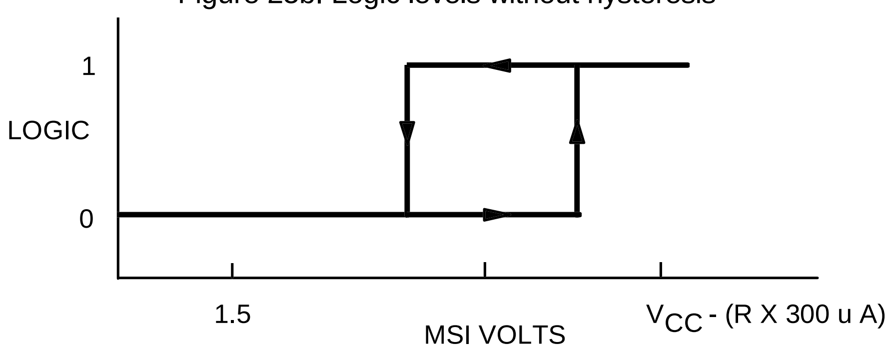


Figure25c. Logic levels with hysteresis

FIGURE 25. MSI address interface.

7.3.3.4 Circuit examples.

Examples of circuit implementations to meet these requirements are given in figure 26. The voltage supplied to the MSI, or CSI, by the store must not exceed 31.5 volts. If 28V DC (MIL-STD-704) power is used as the power source, the voltage above 31.5 volts must be suppressed with a Zener diode as shown in figure 26 or by some equivalent means. The diode in the address line is used to protect the store electronics in the event power is applied to the interface connector. MIL-STD-1760C defines address characteristics at the ASI and MSI such that a periodic pulsing/sampling option is available to the store designer. (See figure 27.) While, in general, a pulsing system requires more complex store circuitry, it may provide a viable option to reducing store circuit power dissipation. The main consideration in using pulse/sample method (figure 27a) is to allow enough time for the voltage/current characteristics to stabilize after the analog switch is advanced to the next address line. The store must allow at least 10 milliseconds at each line for stabilization of circuitry on the aircraft side of the MSI before accepting the output of the comparator as valid. Figure 27b illustrates an alternative where all address lines are powered, the address is read and stored in a register and then power is removed from the address lines. The duration that power is applied to the address lines is in the tens of milliseconds, resulting in very low average power dissipation.

Since the address and parity lines are current limited, no wire protection is required. It is only necessary that these lines be capable of sustaining these currents continuously. The address return wire must be capable of sustaining 600 milliamperes continuously. The detection threshold selected by the store needs to consider the address return line voltage when currents from all six address lines are flowing through the return.

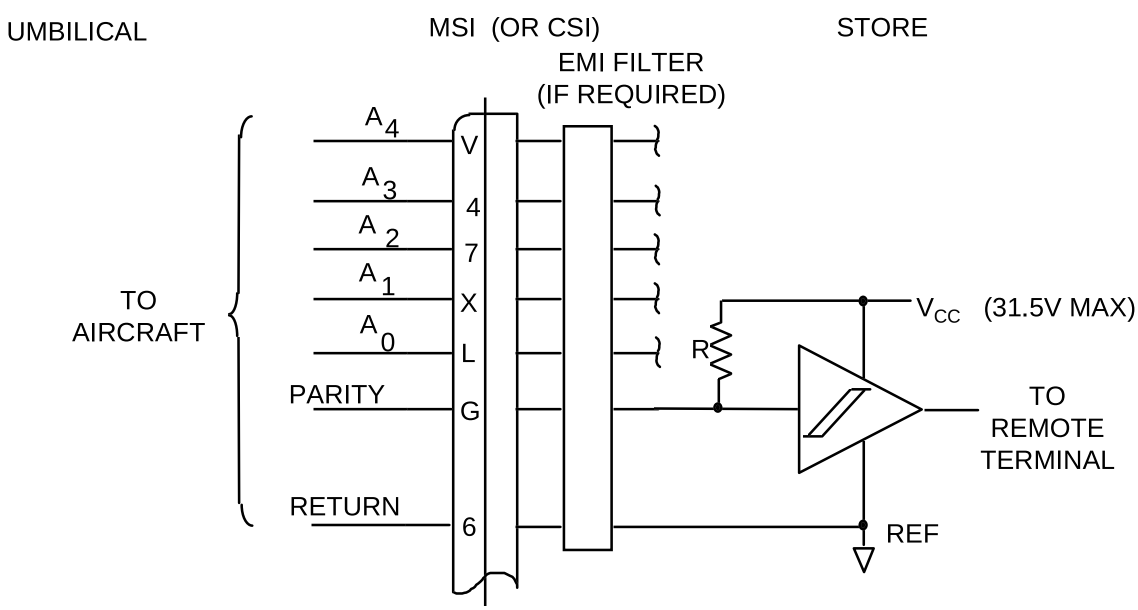


Figure 26a. Solid state.

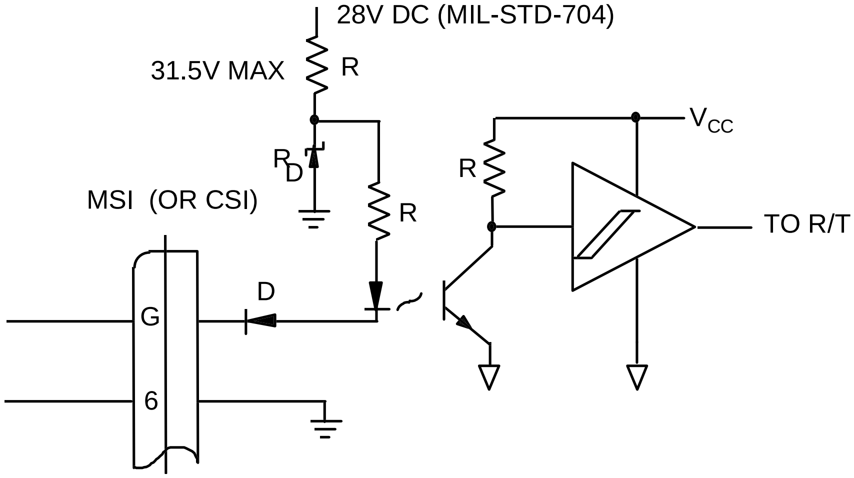


Figure 26b. Optical coupler.

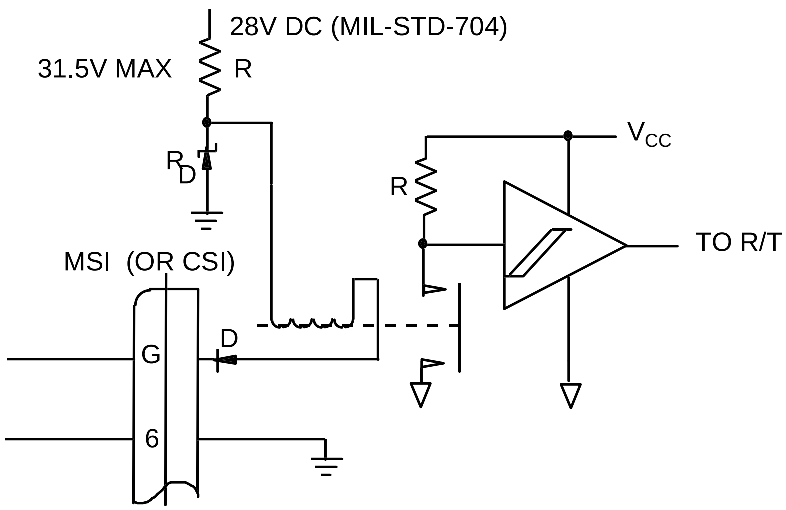


Figure 26c Electromechanical relay.

FIGURE 26. Store address circuits.

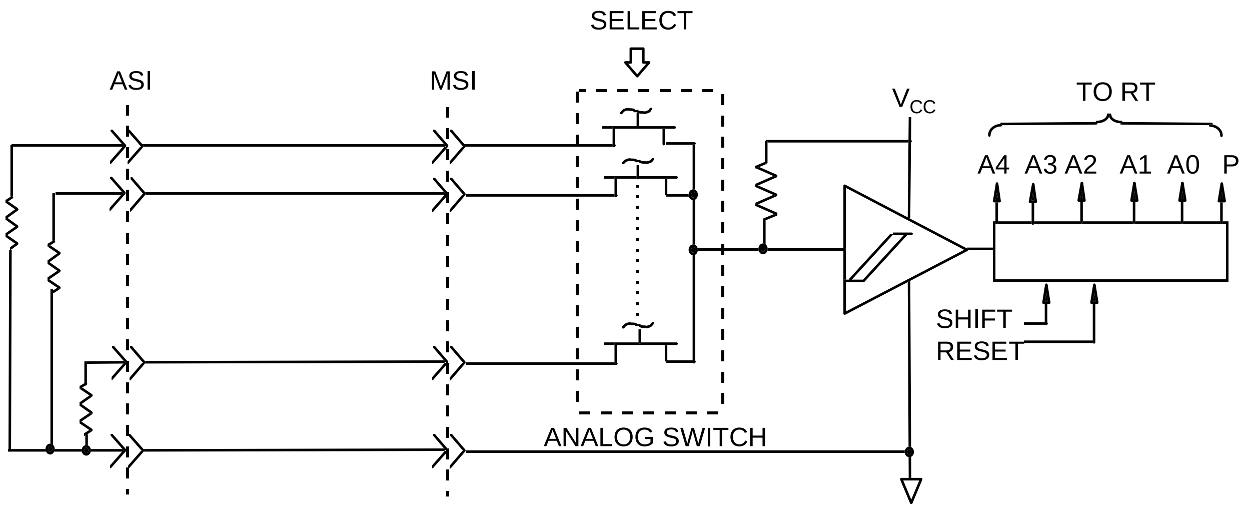


Figure 27a. Individual line pulse sample.

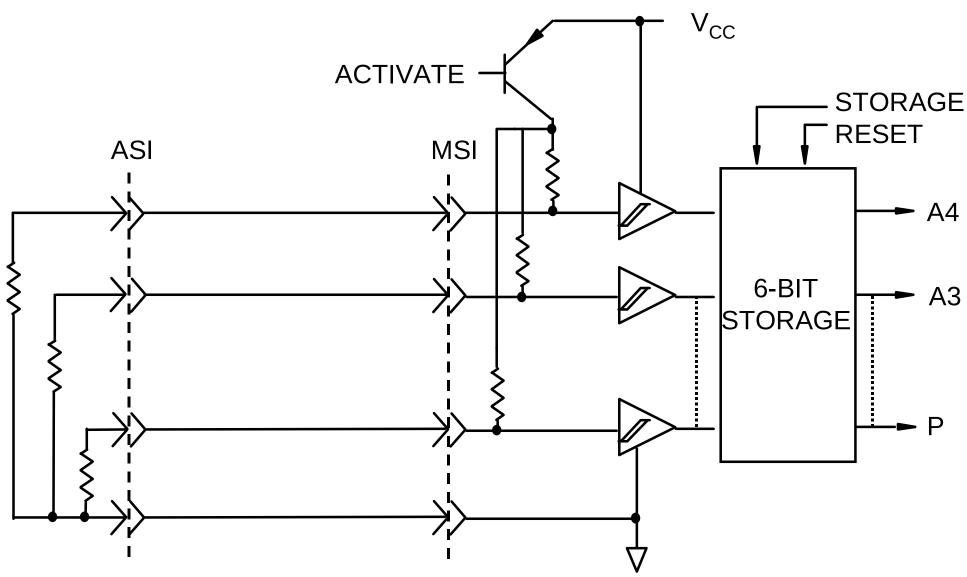


Figure 27b. Activate-strobe-deactivate.

FIGURE 27. Pulsed address circuits.

7.3.3.5 Electromagnetic compatibility.

MIL-STD-1760C requires that the aircraft isolate all aircraft circuitry, including grounds, from the address discretes. As a result, grounding of the address return occurs only in the store and at the ground point of the store's choosing, e.g. signal ground, power ground or structure ground. Even though the aircraft isolates the address discretes from aircraft power, signals and grounds, noise can still be injected onto the address lines due to electrostatic and electromagnetic coupling. Examples of typical induced levels for various aircraft-store configurations are presented in "Design Principles and Practices for Implementation of MIL-STD-1760 in Aircraft and Stores", ASD-TR-87-5028.

The data in the TR show the power switching induced spikes can get rather high, e.g. 1 volt p-p. It also shows the noise levels induced into the address lines under RSO3 field exposure with the standard test cables to range from -20 dB at around 500 kHz to +70 dB at frequencies above 500 MHz. In all of the cable configurations tested, the address discretes were twisted in the cables with the address return to cut down on electromagnetic coupling.

7.3.4 Carriage store address interface.

If a carriage store is provided, the carriage store must energize and monitor a set of six address discrete signal lines, plus a dedicated address return line, at the CSI in accordance with the requirements defined in 7.3.2.2. This set is used to assign the terminal address for the MIL-STD-1553 remote terminal in the carriage store. For conditions where the aircraft assigns terminal addresses to mission stores attached to the carriage store, the aircraft must accomplish this lower tier address assignment via the Mux bus. The carriage store would then need to contain circuitry, similar to figures 24b and 24c, to set-up address discretes at each CSSI based on these assigned lower tier addresses. For configurations where the carriage store determines the assigned terminal address for attached mission stores, any address except 31 may be assigned to any CSSI.

7.3.5 Test data.

Test data taken on address and address return lines (22 Gauge Wire) show a typical voltage drop of 0.11 volts on the aircraft side of the ASI. The voltage drop between the ASI and MSI was 0.025 volts with no carriage store and 0.11 volts with a carriage store. Test current was 100 milliamperes. MIL-STD-1760C allows a 1.0-volt drop on the aircraft side of the ASI and a 0.5-volt drop between the ASI and MSI.

7.3.5.1 Electromagnetic compatibility.

No problems were associated with either the low impedance Logic 0, or high impedance Logic 1, states of these signal lines in tests. Examples of typical induced noise levels for various aircraft-store configurations are presented in "Design Principles and Practices for Implementation of MIL-STD-1760 in Aircraft and Stores", ASD-TR-87-5028. Figure 97 therein illustrates induced noise from a 200 volt/meter field remained below 100 millivolts with typical in-band noise below 1 millivolt. Figure 110 of the TR illustrates typical power switching transient induced noise. These levels are sufficiently high to require filtering in the store address monitor circuit. The test results shown in the figures, however, were derived from an ASI address circuit where the address jumpers were located 35 feet from the ASI rather than directly at the ASI. This long wire length resulted in increased noise levels.

7.3.5.2 Electromagnetic interference.

Noise levels were measured on a representative interconnect system while exposed to a 200 volt/meter field, documented in "Design Principles and Practices for Implementation of MIL-STD-1760 in Aircraft and Stores", ASD-TR-87-5028. The data in the TR shows the noise levels induced into the address lines under RSO3 field exposure with the standard test cables to range from -20 dB at around 500 kHz to +70 dB at frequencies above 500 MHz. The address line set was twisted around the address return. The entire cable run was shielded with either a gross braid or with metallic structure. In the configuration tested, the address "jumpers" were installed approximately 35 feet from the ASI. When the jumpers are installed directly at the ASI, the noise levels drop 20 to 30 dB. The drop is frequency dependent.

8. HIGH BANDWIDTH INTERFACES.

MIL-STD-1760 provides for four high bandwidth (HB) lines to pass through the interface. These lines are used for functions such as transmission of a precision time reference pulse to a store, transmission of analog video from a store to the aircraft, or, more recently, transmission of GPS RF from the aircraft GPS antenna to a store.

In addition to the information in this section of the handbook, the rationale and guidance in 15.4.3.1, 15.5.1.1, 15.5.2.1 and 15.5.3.1 (and subparagraphs) should also be consulted.

8.1 General.

MIL-STD-1760 requires a high bandwidth signal routing network in the aircraft and in carriage stores, and provides for HB interfaces in mission stores. The HB network is intended to support the transfer of various high bandwidth (HB) signals between aircraft systems and mission stores or between one mission store and another. At each primary interface connector of the AEIS, four high bandwidth signal ports are defined (designated as HB1, HB2, HB3, and HB4). Each port provides a different signal transfer service.

The HB requirements were re-written between Revision B and Revision C of MIL-STD-1760. Although the basic network capability and bandwidth remains the same, the way it is specified, and the specific performance requirements, are different.

8.1.1 HB interface classes.

The aircraft routing network must support either a Class I or Class II interface at each primary ASI. The Class I primary interface requires all four signal-ports to be implemented. The Class II primary interface requires the implementation of HB1 and HB3 only. All AEIS umbilical cables and carriage stores should support the full Class I signal port set for compatibility with all possible aircraft and mission store interfaces. Each mission store interface may utilize any signal port in accordance with its signal transfer requirements within the constraints for hierarchical selection defined in 5.2.1 of MIL-STD-1760. At each port, the mission store may be either the signal source or signal sink.

8.1.2 HB interface types.

All aircraft and carriage store HB interfaces (HB1, HB2, HB3, and HB4) must provide a Type A interface. Type A interfaces must have a minimum transmission passband of 20 Hz to 20 MHz and be unbalanced, differential. For historical reasons, the source and sink impedance is 50 ohms for HB1 and HB2, and 75 ohms for HB3 and HB4. Presently, Type A interfaces are to be used for the following signal assignments only:

HB1 time correlation signals

HB2 time correlation signals

HB3 monochrome STANAG 3350 video

HB4 monochrome STANAG 3350 video

All aircraft and carriage store HB1 interfaces must additionally provide a Type B interface. It is not necessary to support the Type B interface at the same time as the Type A interface and therefore some mode switching mechanism may be used. Type B interfaces must have a minimum transmission passband of 20 MHz to 1600 MHz with the signal reference at ground potential. The source and sink impedance is 50 ohms. At present, there are no signal assignment restrictions for the Type B interface.

It is expected that as the Standard matures the list of approved HB signal assignments will be updated to include (or restrict) the transfer of further signal types on specific interfaces. To cater for this signal growth, aircraft and carriage store routing networks should be capable of transferring any signal that meets the general requirements of 4.3.1.1 and 4.3.1.2 of MIL-STD-1760 and not be limited by circuit design to the present signal functions.

Different functional and electrical requirements apply to the Type A and Type B interfaces, and therefore each interface type will be discussed separately.

8.1.3 HB Type A signal routing.

The Type A interfaces are intended to support a gamut of potential signal assignments, as discussed in 8.2.2. Each specific application signal may exhibit an amplitude or information content that is less than the required capabilities of the signal path and therefore the signal path cannot be characterized by signal measurements at the ASI alone. It is necessary to separate the waveform and noise characteristics of each signal utilizing the interface from the two-port transmission characteristics of the signal path itself. The system model for the Type A interface is therefore as shown in figure 28.

Type A signals may enter the AEIS at either the mission store MSI or the aircraft routing network RNASP interface. The RNASP interface is discussed in 8.2.6 of this Handbook. MIL-STD-1760 provides general electrical requirements for source signals entering the system at these points to ensure compatibility between the aircraft routing network and all MIL-STD-1760 stores that may be introduced in the future.

For each Type A signal transfer, a path is established between the source and sink equipment. For the purposes of the model, source and sink equipment is defined at the boundary of the AEIS; the aircraft (or mission store) may implement an additional transmission system above (or below) the AEIS but this is beyond the scope of MIL-STD-1760. The Type A signal path will consist of an aircraft routing network segment, one or a number of umbilical segments, and possibly one or (rarely) two carriage store routing network segments. Refer to figure 4, MIL-STD-1760.

MIL-STD-1760 considers the following types of signal transfer:

- Between a directly-carried mission store and aircraft system
- Between a mission store on a carriage store and aircraft system
- Between two directly-carried mission stores
- Between a directly-carried mission store and a mission store on a carriage store
- Between mission stores on different carriage stores.

The level of connectivity to be provided by the aircraft routing network is not controlled by the Standard. However, each ASI must support the simultaneous transfer of Type A signals on all of its implemented HB interfaces in any combination of source/sink mode.

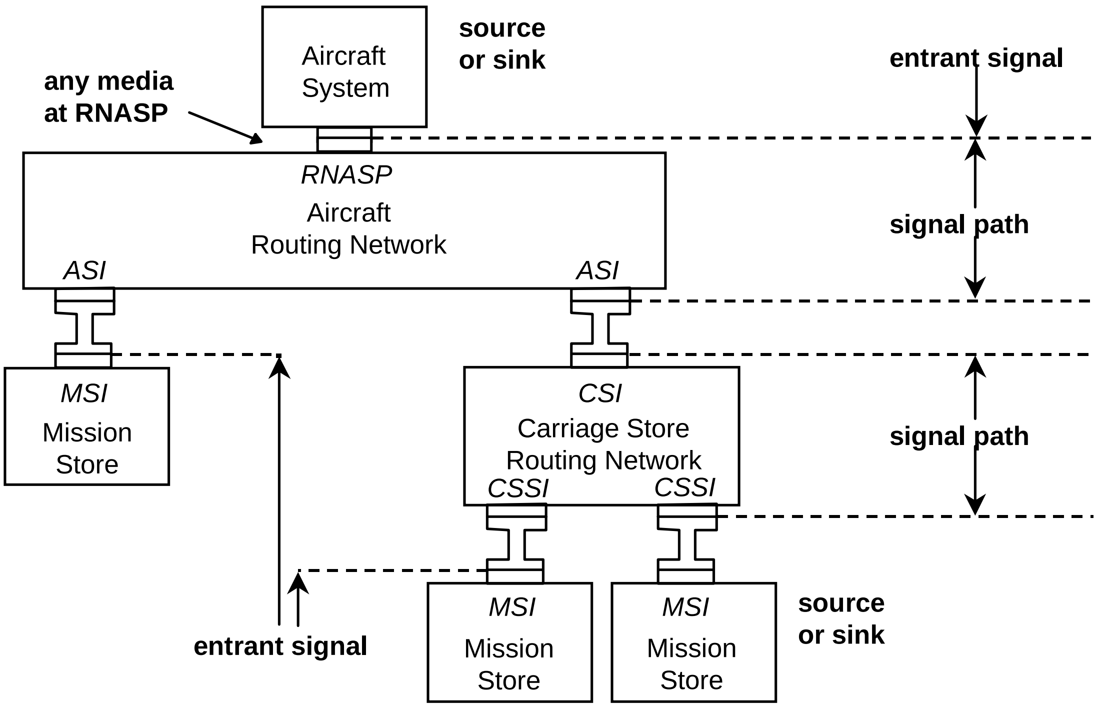


FIGURE 28. Model of type A signal routing system.

8.1.4 HB Type B signal routing.

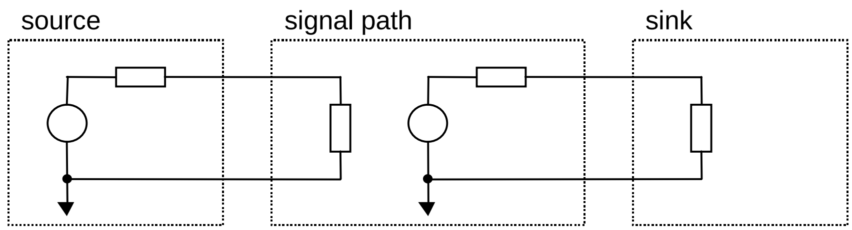
The Type B interface on HB1 is not defined in detail. However, it is expected that this will change as the Standard matures. The emerging requirement for the Type B interface is the transmission of GPS RF signals from the host aircraft antenna to GPS-aided mission stores. This may be necessary to overcome partial or full masking of the mission store antenna by the aircraft structure, however the need to utilize GPS RF while on the aircraft will depend on the store operational requirements and the store guidance system design.

Work is presently underway to explore a common approach to the different store GPS requirements within the interested countries, but note that the intent is also to utilize the Type B interface in future for other applications such as low latency, high information capacity or spread-spectrum signals.

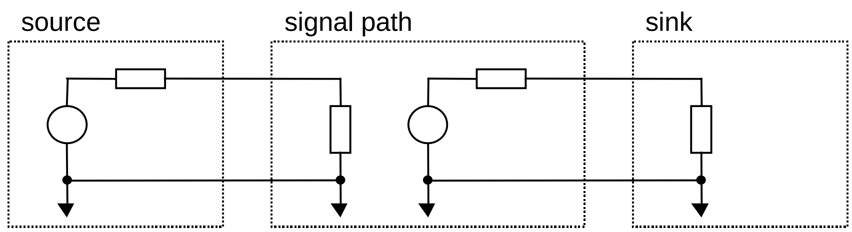
8.1.5 HB transmission circuit.

The required grounding scheme for Type B connections is different to that needed for Type A (see figure 29). Type B connections will require the signal reference (shield) to be at local ground potential at both the source and sink sides of the HB interface; in contrast, Type A transfers will be differential and therefore signal reference grounding will occur on the source side only. This arises from the different EMC practicalities at low and high frequencies. This, coupled with the divergent routing requirements, means in practice that common Type A and Type B signal path hardware will not be realized in the aircraft AEIS (see figure 30).

Because the HB1 signal path is required to handle both Type A and Type B signals, the designer needs to consider a multiplexing scheme similar to the functional schematic shown in figure 31.



(a) Type A Grounding Scheme



(b) Type B Grounding Scheme

FIGURE 29. HB grounding schemes (assuming active path).

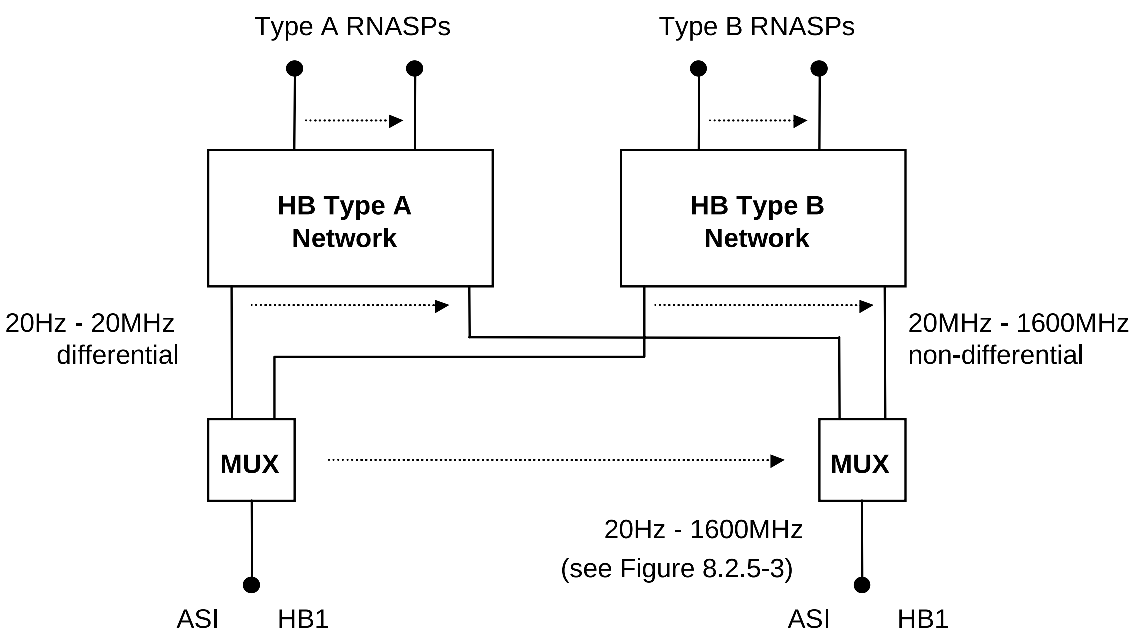


FIGURE 30. Recommended HB1 routing network architecture for aircraft.

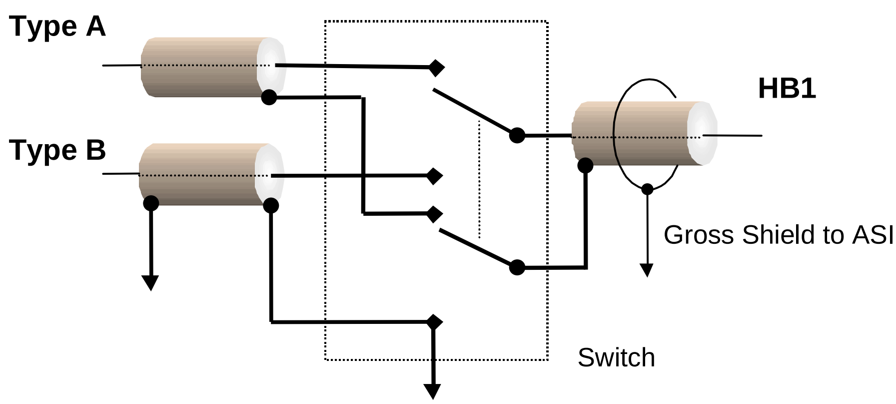


FIGURE 31. Suggested HB1 multiplexing scheme.

8.1.6 Routing network aircraft system port (RNASP).

One paradox of MIL-STD-1760 is that, although it is necessary to model each HB interface of the aircraft AEIS as a signal path, it is not the intent of the Standard to set out requirements for the internal design of the aircraft system at the RNASP

What is important is the transmission fidelity, or information capacity, of each implemented signal path, and not the chosen media of the RNASP. MIL-STD-1760 states the requirements of each implemented signal path between RNASP and ASI on the assumption that the RNASP media is identical to the nominal ASI. Requirements are framed as permitted deviations from a reference linear, unity gain, no delay, two-port network.

Other internal transmission schemes may be implemented by the AEIS, for example, where the signal at the RNASP is electrical or optical, modulated or base-band, amplified or attenuated, transmitted in analog format or as a serial bit stream. If the designer wishes to exploit this flexibility, compliance with the Standard must be demonstrated, by analytically or electrically converting each stimulus or measured perturbation at the RNASP into the format assumed by MIL-STD-1760 (or vice versa). The details of this process will require agreement between the supplier and the agency responsible for ensuring MIL-STD-1760 compliance before an interface specification and test method can be generated.

Note that the location of the RNASP is not explicitly defined in MIL-STD-1760; the RNASP may be an interface to specific signal utilization equipment, an interface to a further routing network or any other point chosen for the aircraft. A single RNASP is not required by the Standard to support both Type A and Type B signals or support bi-directional (simplex) signal transmission.

8.1.7 Carriage store HB interfaces.

The carriage store must be capable of implementing Type A and Type B signal paths between the HB interfaces at the CSI and the corresponding HB interfaces at each CSSI. As a minimum, it must be possible to simultaneously support point-to-point signal transfer on all implemented HB interfaces in any combination of source and sink to one CSSI. The Standard does not explicitly state whether the carriage store should provide a Class I, Class II, or other interface at the store stations. Of course, the greatest flexibility to carry a wide variety of stores is achieved if all stations are Class I.

The carriage store, in addition to providing a point-to-point signal capability, may also be required to support broadcast of HB Type B (HB1) and HB1 Type A (HB2) from the CSI to active CSSIs. The different grounding requirements for Type A and Type B signal paths may result in the HB1 routing network architecture shown in figure 32.

The introduction of a carriage store between the MSI and ASI will result in a quantified reduction in transmission fidelity for each signal application. The Standard sets out separate signal path requirements for the aircraft and carriage store and therefore the user of the Standard must calculate the probable or worst case performance for the chosen system configuration and application signal. General guidance on this is provided in 8.5 of this Handbook and specific guidance for video is provided in 8.6.

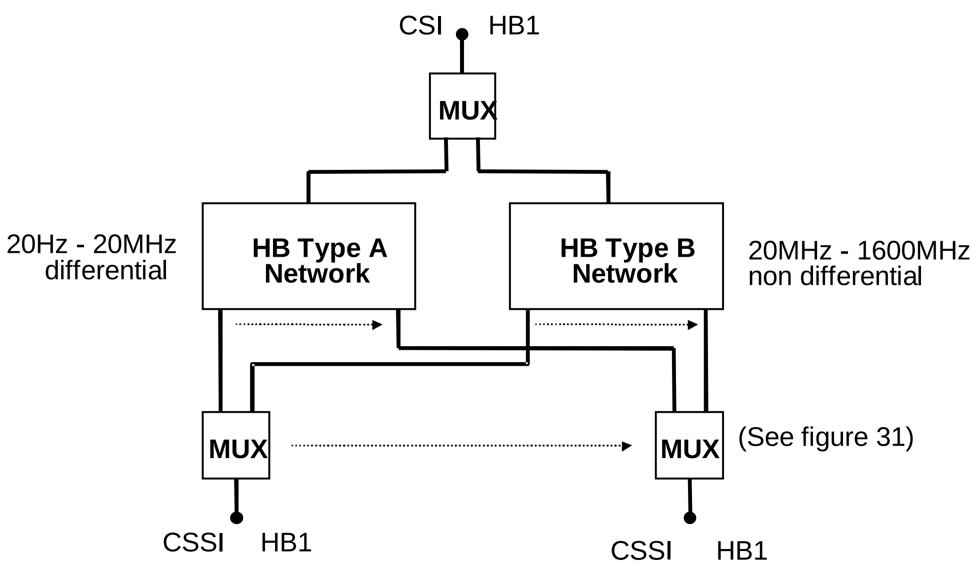


FIGURE 32. Recommended HB1 routing network architecture for carriage store.

8.2 Detailed discussion on HB requirements.

The Standard sets out source signal requirements and signal path requirements for the HB interfaces. The following material provides in-depth assistance on the interpretation and reasoning of each requirement.

8.2.1 HB signal requirements (Type A).

The source signal requirements in 4.3.1.1 of the Standard apply to any source signal (at the RNASP or MSI as applicable) which is intended for transfer across the HB interfaces. At any other AEIS interface, the signal may not comply with these requirements because of the possible insertion gain and distortion characteristics of the signal paths and umbilical cables. Refer to 8.2.6 of this Handbook for further remarks regarding the specification of RNASP entrant signals.

8.2.1.1 Signal voltage.

The maximum peak-to-peak signal voltage is restricted to 1.3V to ensure that the routing network requirements are practical and economic to implement. The requirement takes into consideration the voltage handling capabilities of video-bandwidth, DC-coupled amplifier circuits together with the requirement to deliver a linear, matched output over the necessary dynamic range across the full bandwidth at each AEIS output.

The 1.3Vpp limit permits the transfer of STANAG 3350 video and possibly an encoded color format at a later time. Historically, time correlation signals have been transmitted from a balanced-voltage, low impedance, non-linear source with consequently a higher voltage swing. Thus tailoring of source and sink equipment may be required to be compatible with the AEIS. The Standard no longer provides requirements for minimum signal amplitude, as it did in Revision B. This and other requirements (such as source output noise) must be defined for the particular application signal in the relevant mission store and/or internal aircraft system.

The peak-to-peak voltage requirement in 4.3.1.1 of the standard applies to an unrestricted bandwidth, i.e., includes spectral components below 20Hz and above 20MHz but does not include noise. Source signals may therefore include a DC component (both a useful DC-component associated with a base-band signal and a DC error component). The steady state voltage requirement of ±1.55V restricts this DC component to ensure compatibility of the source equipment with DC-coupled routing networks and sink equipment.

Alternatively, base-band signals may be internally AC-coupled within the source equipment (however the final output stage may still be DC-coupled and introduce a DC error). The steady state voltage range requirement therefore applies when the nominal base-band signal has a repetitive waveform with a period less than 50ms (i.e., 20 cycles per second). Long-time (i.e., low frequency) waveform distortion may occur if the signal has been internally AC-coupled and there is a shift in the useful DC component of the nominal base-band waveform (such as when the average picture level changes in video signals, or the mark-space ratio changes in a pulse train). The transient voltage range requirement in 4.3.1.1 of the standard controls the maximum temporary excursion of the signal to ensure compatibility with the dynamic range requirements of the routing networks and sink equipment. It should be noted, however, that signal paths might slightly compress or clip the signal peak under these conditions (see 5.1.1.2.6 and 5.3.1.2.6 of the Standard).

8.2.1.2 Transmission passband compatibility.

MIL-STD-1760 allows HB signals to have frequency components outside the minimum transmission pass band however this signal energy is not required to be transmitted by the AEIS (see 5.1.1.2.5 and 5.3.1.2.5 of the Standard).

8.2.1.3 Power spectral components above 20 MHz.

The slope of the power spectrum limit line in 4.3.1.1 of the standard may be compared with the eventual roll-off in the energy density function of the cosine-squared T signal. (See 5.1.1.2.2 and 5.3.1.2.2 of the Standard and 8.4.3.2 of this Handbook). Therefore, there is compatibility between the source signal and the routing network distortion requirements. For practical reasons the requirement is truncated at 200MHz, which is also the upper frequency of interest for the signal path out-of-band gain misequalization requirement (see 5.1.1.2.5 and 5.3.1.2.5 of the Standard).

8.2.1.4 Slew rate.

A slew rate requirement has been introduced to ensure compatibility of the source signal with the AEIS and aircraft-internal sink equipment. The maximum slew rate limits possible EMI and cross-talk problems caused by fast rising edges (such as induced spikes), and ensures that source signals can be handled by the AEIS signal path, without excessive transient response distortion.

The slew rate limit in 4.3.1.1 of the Standard corresponds with the peak slew rate of the cosine-squared T signal in figure 5a of the Standard, which is used to characterize the AEIS high-speed transient response (plus 5% to allow for a tolerance in the source equipment output voltage).

The slew rate requirement places additional restrictions on the source signal within the nominal transmission passband. The amplitude of monotonic signals for example is limited by figure 33 below.

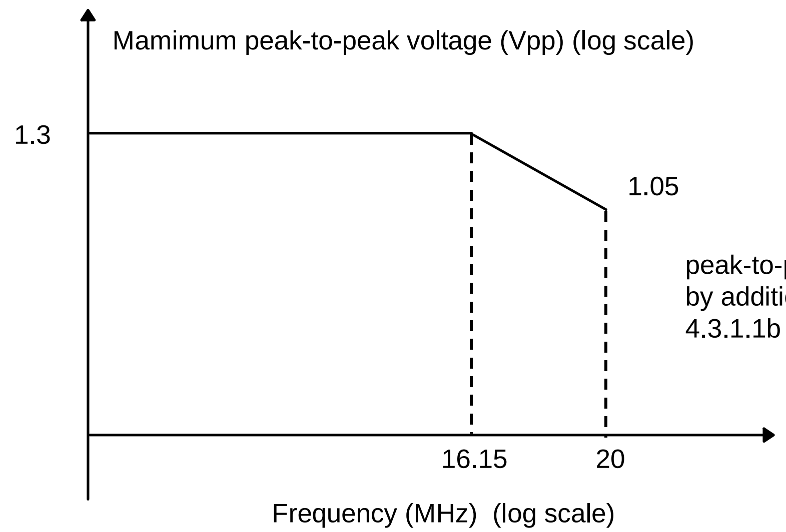


FIGURE 33. Effect of slew rate limit on maximum amplitude of monotonic signals.

8.2.2 HB signal requirements (Type B).

In 4.3.1.2 of the Standard, the signal peak envelope power has been restricted to ensure that the routing network requirements are practical and economic to implement. At present, MIL-STD-1760 does not address HB Type B requirements to the same detail as Type A. This situation may change in future revisions.

8.2.3 Nominal impedance.

The nominal impedance of the HB interfaces is defined in 4.3.1 of the Standard. The impedance is largely historical, i.e. 75 ohms is the traditional nominal impedance for video transmission and 50 ohms is the traditional nominal impedance for transmitting RF. The actual impedance over the applicable transmission passband is constrained by the return loss requirement (see 5.1.1.2.1, 5.2.1.2.1 and 5.3.1.2.1 of the Standard and the discussion in 8.2.5.2.1 of this Handbook).

8.2.4 HB signal assignment.

The utilization of the HB interfaces has been limited to the transfer of specific types of signal in 4.3.1.3 of the Standard. It is expected that as the Standard matures the paragraph will be updated to include the transfer of further signal types on specific interfaces. The intention is to control the growth of application signals that utilize the HB interfaces, so that the maximum level of interoperability is achieved in the future between aircraft and stores. To cater for signal growth, aircraft and carriage store routing networks should be capable of transferring any signal that meets the general requirements of 4.3.1.1 or 4.3.1.2 and not be limited by the signal path circuit design to the signal assignments in 4.3.1.3 of the Standard.

The following comments concern the signal assignments in 4.3.1.3.

a. It is recommended that the Type B interface is restricted to carrier-modulated signals only. One possible signal assignment is the transfer of received GPS RF to mission stores (i.e., L1 centered at 1575.42MHz and L2 centered at 1227.6MHz)

b. As yet, no standardized waveform has been developed for time correlation signals.

c. Because the U.S. Government had not ratified STANAG 3350 when Revision B was published, Revision B required video to comply with EIA-RS-170, EIA-RS-343, or STANAG 3350 (with modified signal levels). Revision C requires video to comply with STANAG 3350.

d. STANAG 3350 AVS provides requirements for three classes of video line standard, i.e.

Class A	875 lines at 30Hz
Class B	625 lines at 25Hz
Class C	525 lines at 30Hz

e. The aircraft capability to utilize all, some, or none of these video classes will depend on its operational requirements. MIL-STD-1760 does not provide for the transfer of color RGB video signals. Further guidance for routing STANAG 3350 video via the AEIS is provided in 8.6 herein.

8.2.5 Aircraft HB requirements.

8.2.5.1 HB network capacity.

The minimum transfer capacity requirement imposed on the aircraft is defined in 5.1.1.1 of the Standard. For any aircraft to meet its mission requirements, a higher level of HB network capacity may be needed. The actual capacity required (i.e., the number of simultaneous HB signals flowing through the aircraft routing network) will tend to vary with each aircraft and with each store load-out. As a goal, the aircraft should support the following minimum HB network capacity (see figure 34):

a. Simultaneous transfer through the 50 ohm network of one Type B signal (on HB1) and two Type A signals (on HB1 and HB2) between two ASIs and internal aircraft equipment plus one Type A signal (on HB1 and HB2) between any two ASIs.

b. Simultaneous transfer through the 75 ohm network of two Type A signals between the ASIs and internal aircraft equipment plus one Type A signal between any two ASIs.

Figure 35 illustrates this minimum aircraft capacity as a collection of HB paths that is transparent to the various technologies that could be used to implement the aircraft network. Figure 35 illustrates the same network capacity when implemented with a centralized "cross-point" style switching-matrix. It is not intended that figure 35 be interpreted as a required (or acceptable) design for the network but simply as an illustration of the recommended network capacity.

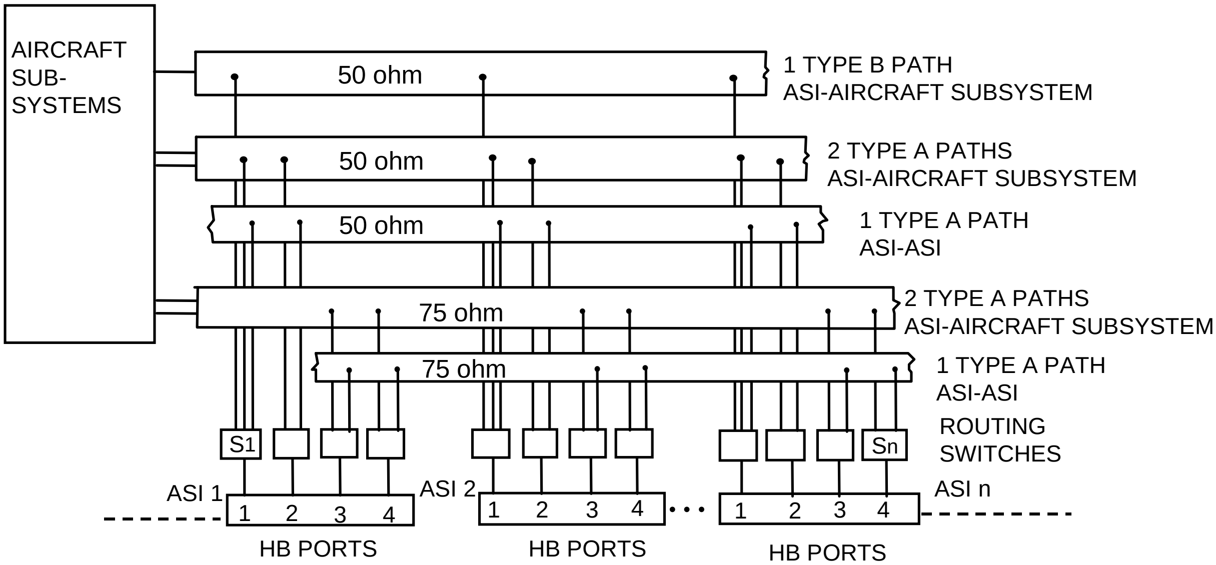


FIGURE 34. Recommended network capacity.

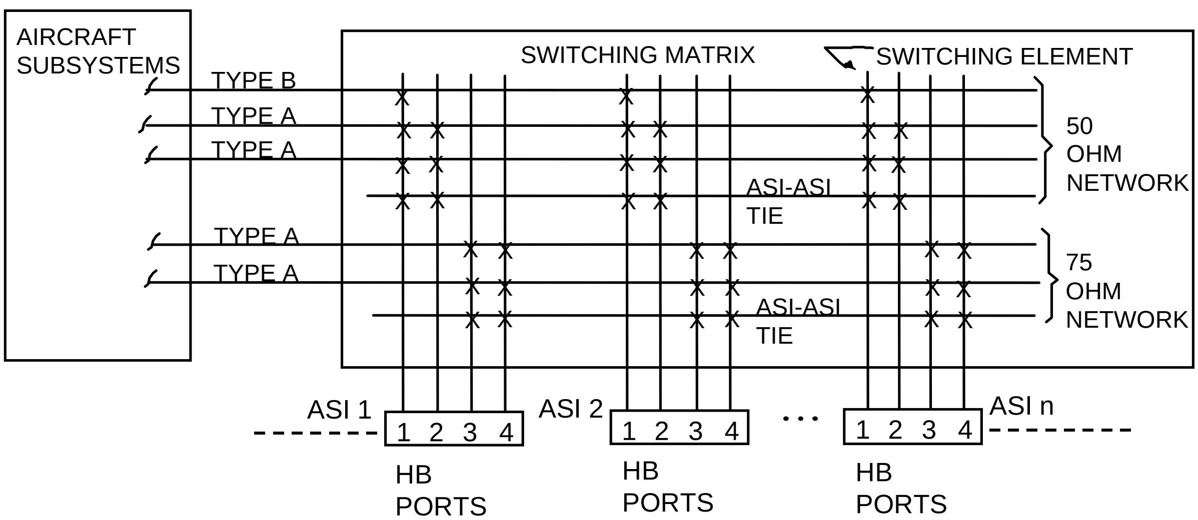


FIGURE 35. Centralized switching matrix example.

8.2.5.2 HB Type A signal path electrical requirements.

The transmission quality of each aircraft Type A signal path has been standardized to promote electrical interoperability between the aircraft AEIS and present and future mission stores. The requirements in 5.1.1.2 (and subparagraphs) of the Standard apply to all Type A signal paths implemented between an RNASP and ASI, and between one ASI and another.

For transfers between an RNASP and ASI, the performance requirements are couched in terms of deviations from a nominal linear, unity-gain, non-inverting signal path. Other transmission schemes may be implemented. When this is the case, equivalent transmission fidelity with that required by each subparagraph in 5.1.1.2 of the Standard must be achieved and demonstrated (see 8.1.6 of this Handbook).

8.2.5.2.1 Return loss requirements.

The HB interfaces must have the nominal impedance of 50 ohms for HB1 and HB2 and 75 ohms for HB3 and HB4. The nominal impedance applies to source equipment, routing networks and load equipment. In general, signal path requirements in the Standard apply when both the input and output are properly terminated by the applicable nominal impedance. However this does not give the whole story because the system will behave differently when the source and load are not exactly matched: i.e., when the signal path is connected between aircraft systems and stores instead of test equipment. When this happens, control of the signal path return loss is also important to the overall signal fidelity objective.

Return loss can add further distortion to the AEIS to that implied by considering purely the transmission performances of the individually tested signal path segments and combining them together. A mathematical examination of how return loss contributes to distortion at system level is offered in sections 8.4 and 8.5 herein.

A return loss of 20 dB corresponds with a VSWR of 1.22. The requirement in 5.1.1.2.1 of the Standard does not include the umbilical or test cable but does include the mating contact pair. The mating contact pair should not therefore be calibrated out of test data.

The signal path designer may find that transient response, insertion gain, representative pulse delay and equalization requirements can only be met by imposing a more stringent control on return loss at some (or all) frequencies than the minimum MIL-STD-1760 requirement. This really depends on the specific signal path design and in other cases return loss may not cause a problem at all. It appears that the effects of cable return loss are not as troublesome as return loss from many other sources.

It is general practice to impose tighter requirements on video source, sink, and signal path return loss than MIL-STD-1760. The CCIR, for example, recommends a minimum return loss of 30 dB for video transmission[1] and STANAG 3350 requires an impedance tolerance of ±5% over the video bandwidth (i.e., better than 32 dB). However this is not always feasible in an aircraft-store interconnection system where weight and space are restricted and the environment is harsh. The requirement of 20 dB in MIL-STD-1760 may still be difficult to achieve for long runs of subminiature cable. In general, HB3 and HB4 will be worse than HB1 and HB2 because of the larger characteristic impedance.

The build up of distortion will be worst when the mission store is suspended from a carriage store. The intent is to keep the K-rating to below 3% for an isolated store station as outlined in 8.4.2 of this Handbook.

8.2.5.2.2 Transient response and insertion gain.

Type A signal path distortion is controlled primarily in the time domain by means of transient response requirements. Transient response limits, rather than equalization limits, are preferred because of their immediacy in describing observable waveform distortion artifacts at the signal path output. Note however that testability and historical considerations render equalization requirements more useful for certain, limited types of distortion, and therefore the equalization requirement in paragraph 5.1.1.2.5 of the Standard complements the requirements established in the transient response paragraph. In addition to linear distortion, the transient response requirements are useful in controlling some types of non-linear distortion such as slew rate.

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[1]CCIR Recommendation 567-2 "Transmission Performance of Television Circuits Designed for Use in International Connections" [1978-1982-1986], D2.2.

Four different input waveforms are used in the Standard to characterize the signal path transient response: the cosine-squared T signal (figure 5a) and associated 2T bar signal (figure 7a), and the cosine-squared 2T signal (figure 6a) and associated 2T bar signal (figure 8a).

a. The 2T-bar signal response (figure 8b) is used to define the insertion gain (or loss) of the path (see 5.1.1.2.3 of the Standard) and the representative pulse delay (see 5.1.1.2.4 of the Standard). The 2T bar signal response in figure 8b is also used to determine the reference 100% level for the cosine-squared 2T signal response envelope and control the signal path "mid-time" tilt distortion. The magnitude of the tilt distortion is calculated by the maximum percentage departure in the instantaneous level of the bar top from the level at the center of the bar, $V'_{1.3}$. The first and last 1 µs are neglected to allow the "short-time" edge response to settle. The allowed tilt distortion for aircraft signal paths is therefore ±1.5 %.

Note that "long-time" tilt distortion (such as the tilt in the step response caused by possible low frequency roll-off below 200 Hz) is for historical reasons controlled by the equalization requirement in 5.1.1.2.5 of the Standard.

The 2T-bar signal response (figure 7b) is used to define the reduced 100% level for the cosine-squared T signal response envelope only. The figure 7b response is not used to control the insertion gain, representative pulse delay or mid-time tilt distortion.

b. The cosine-squared T signal and 2T signal responses (figures 5b and 6b) are used to characterize the "short-time" distortion of the signal path, where "T" denotes the half-period of the nominal upper cut-off frequency (i.e., 20MHz).

The 2T signal has negligible energy above 20MHz and therefore the high-speed transient response of the signal path is characterized without introducing significant out-of-band frequency components. The cosine-squared 2T shape represents the shortest pulse that can be transmitted with no appreciable distortion over the nominal pass-band of 1/2T. Two types of distortion artifact are controlled by the response envelope: reduction (or increase) in the peak amplitude of the "main lobe" and "side-lobes" (i.e., overshoot) on either side of it. The response envelope corresponds with a 3% K-rating as described in 8.4 of this Handbook.

The cosine-squared T signal is used to characterize the effective pulse-width resolution of the signal path. Note that the peak amplitude of the T signal is ±1 V to comply with the maximum slew rate requirement of paragraph 4.3.1.1c of the Standard. The signal energy spectrum is 6dB down at 20MHz with significant out-of-band energy up to 40MHz. Consequently, the T signal will be distorted by a rapid frequency response roll-off above the nominal transmission pass-band. The response envelope takes this into account and is based around the proposed acceptance test limits for a 3% K-rating as described in 8.4 of this Handbook.

Note that "long-time" side-lobe distortion, that is distortion artifacts such as echoes that occur outside the time coverage of the response envelope, is for practical reasons controlled by the equalization requirement in 5.1.1.2.5 of the Standard.

8.2.5.2.3 Transient response guidance.

Transient response requirements are, of course, much less convenient to work with than frequency response characteristics when multiple stages are cascaded (such as adding a carriage store to the AEIS) or when the response of the signal path to different input waveforms (such as application signals) must be determined.

For a linear system, it is a common misconception that frequency response limits and transient response limits can be interchanged via the Fourier transform relationship. There is a fundamental difference, which is due to the reciprocal nature of frequency and time. In general, a frequency response characteristic that has a large peak deviation from the ideal but over a small frequency range will correspond to a time domain (i.e., transient response) artifact that is relatively small in amplitude but dispersed in time. Conversely, an isolated distortion artifact in the transient response which is large in amplitude but for a short time only will correspond to a small frequency response deviation but spread over a large bandwidth. It can be seen from the transient response envelopes of figures 5b, 6b and 8b of the Standard that the duration of the distortion artifact is less important than its peak amplitude and displacement from the main response. Therefore it is less efficient (and less economic) to use frequency domain requirements to control the waveform distortion of the Type A signal paths.

The three response envelopes in figures 5b, 6b and 8b are loosely based on the K-rating system of specifying waveform distortion. The K-rating is a convenient method of applying equal weight to the effective impairment of various distortion artifacts that may be observed on an oscilloscope. In the case of MIL-STD-1760 however, certain adjustments have been made to the K-rating limits to take into account the particular application of the AEIS. The response envelopes in the Standard are a compromise between generality and simplicity: a more mathematically rigorous method could have been adopted for controlling every conceivable form of signal path distortion, but at the expense of understandability and convenience of testing.

Partly for historical reasons, the Standard defines the minimum signal path bandwidth (at the -3dB points) with a gain equalization requirement in paragraph 5.1.1.2.5 of the Standard. To avoid duplication, certain bandwidth-sensitive features of the transient response that would normally be controlled by the K-rating method are therefore omitted. However, there is an economic overhead in using the frequency domain to limit signal path distortion, as stated previously.

The following general points are made concerning the transient response requirement as a whole. Additional rationale and guidance on Type A signal path distortion is provided in 8.4 of this Handbook.

a. The peak voltage of each input signal may be either positive-going or negative-going. The amplitude is indicated by "V" in the applicable figure.

b. Because there is a roll-off in the gain misequalization envelope below 200 Hz (see 5.1.1.2.5 of the Standard) it may be necessary to test the signal path with input waveforms transmitted with a minimum repetition period of 5 ms (i.e., 1/ 200Hz) to avoid the introduction of "long-time" waveform distortion.

c. In contrast to the K-rating method, the transient response requirements in MIL-STD-1760 apply to an unrestricted measurement bandwidth (rather than one truncated at 20 MHz). This has the greatest effect on the T signal response, since the T signal has significant out-of-band energy. In practice, the measurement bandwidth must be at least 40 MHz.

(1) In figures 5b and 6b, the time-base alignment of the envelope may be adjusted to achieve the best fit. However, the zero time reference of the envelope must be stationary with respect to "sampling jitter" if the signal is transmitted digitally.

(2) The transient response requirement does not include noise. Signal path noise may be eliminated from the response measurement by analysis, or averaging over many sweeps.

(3) Compliance with the requirement may be tested directly by stimulating the signal path with the signals defined; however other methods of measurement, coupled with mathematical analysis, may be equally suitable at demonstrating compliance. For example, if

the signal path is known to be linear, information regarding the transient response may be extracted from a frequency response measurement followed by manipulation of the data.

8.2.5.2.4 Representative pulse delay.

For time correlation signal applications, the latency of the signal at the MSI may need to be known. One example of where the control of signal latency is important is the transference of precise time to the mission store. The signal delay between the RNASP and ASI (or between two ASIs) will contribute towards the latency error of the time correlation signal and is therefore carefully controlled by the Standard. The allowed delay consists of a bias component (up to 2 µs) and an uncertainty component (up to ±35 ns). The bias component may be added to other known delays within the AEIS (such as carriage store and umbilical delays) and used to calculate the latency of the Type A signal at the MSI for each time correlation signal application. This data may be provided to the mission store via the data bus interface and updated as necessary.

The representative pulse delay is a single delay value which is determined for a 2T bar signal (see 5.1.1.2.4 of the Standard). This signal provides a fast rising edge (48.2ns) without introducing energy outside the minimum transmission passband of 20MHz. It is possible to transmit a faster rising edge through the Type A signal path (as limited by 4.3.1.1 of the Standard) however there may be a difference between the representative pulse delay and the propagation delay of the specific application signal. The transient response requirements should ensure that the difference is small.

The variation in representative pulse delay is limited to ±35 ns (with respect to the anticipated bias component) over the signal path environmental envelope and operational life. The Standard does not limit the delay imbalance between two different signal paths at the same ASI or the delay imbalance at different ASIs.

8.2.5.2.5 Equalization requirements.

The permitted variance of steady-state gain with frequency (or "gain misequalization") for the Type A signal path is defined by the envelope in figure 9 of the Standard. The envelope is intended to control two types of signal path distortion:

a. The regions below 200 Hz and above 1.25 MHz ensure that the signal path is capable of transmitting all signals over the required frequency range of 20 Hz to 20 MHz (see 4.3.1 of the Standard). The -3dB level at the nominal lower and upper transmission frequencies traditionally defines the minimum "bandwidth" of the path. The signal path is not required to transmit any energy/power outside this bandwidth but may do so if desired. Compliance with the gain misequalization envelope may be achieved with a first-order (or higher) roll-off towards the lower and upper cut-off frequencies.

b. The mid-band region between 200 Hz and 1.25 MHz controls the amplitude of echoes (which could result in ghost images) in the transient response (see 5.1.1.2.2 of the Standard). The intention is to limit the amplitude of these distortion artifacts to ±3% (over the nominal transmission bandwidth).

The maximum gain above 20 MHz is controlled by 5.1.1.2.5 of the Standard to ensure that the signal path does not excessively amplify any out-of-band energy/power in the input signal. The zero-dB gain reference is the steady-state gain of the signal path at 20 kHz. This corresponds with twice the duration of the 2T-bar signal in figure 8a, which is used to define the nominal insertion gain (see 5.1.1.2.3 of the Standard).

8.2.5.2.6 Equalization guidance.

The gain misequalization envelope in figure 9 of the Standard defines the allowed variation in steady-state power gain (relative to the gain at 20 kHz) under the special condition that the source and load impedance is ideal. In general however, the return losses of the source and load will be finite and, therefore, the steady-state distortion at the signal path output will be determined by the gain misequalization, in concert with the source, load, and path return losses. For rationale and guidance on misequalization under these conditions, refer to 8.5.5 of this Handbook.

The equalization requirement is intended to control the linear distortion behavior of the path and therefore should apply to the small signal gain only. The large signal distortion performance is controlled by the transient response in (5.1.1.2.2), stimulated noise (5.1.1.2.8.4), and dynamic range (5.1.1.2.6) of the Standard. Note that Type A signal path delay misequalization is not explicitly restricted in MIL-STD-1760. This type of distortion is indirectly controlled by the transient response requirement.

Additional rationale and guidance on Type A signal path distortion is provided in 8.4 of this Handbook.

To satisfy the transient response requirements in 5.1.1.2.2 and 5.3.1.2.2 of the Standard, designers should consider the recommended gain misequalization and delay misequalization limits in figure 36 and figure 37 respectively.

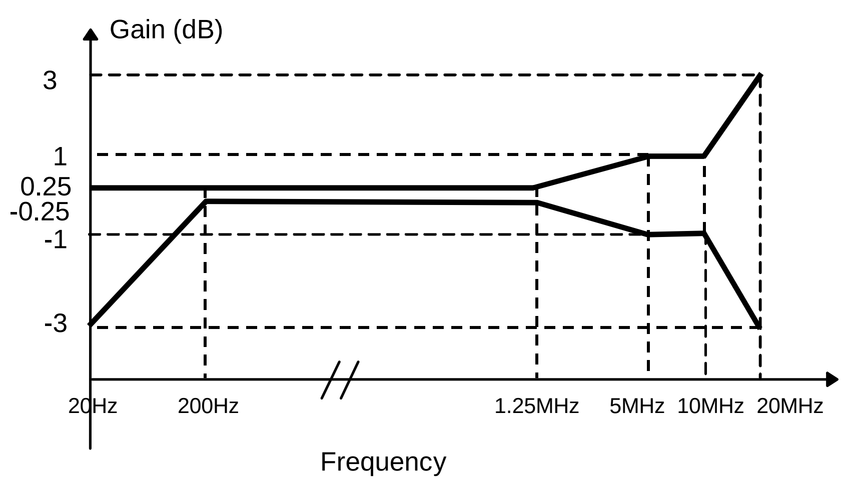


FIGURE 36. Recommended maximum gain misequalization envelope.

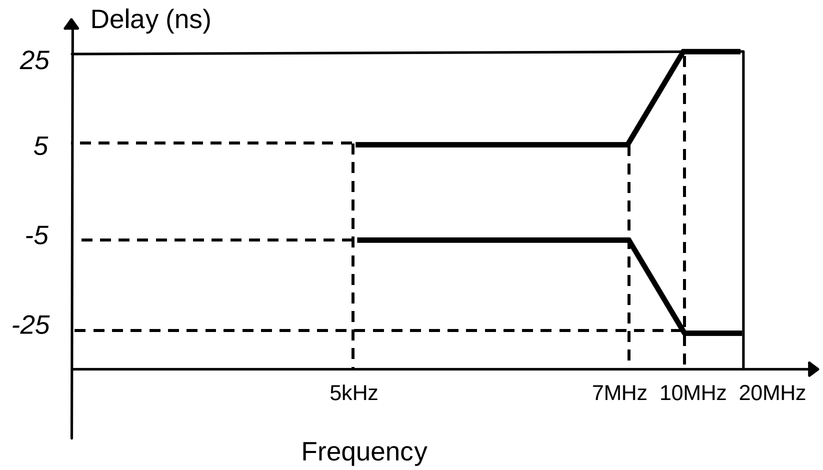


FIGURE 37. Recommended maximum group delay misequalization envelope.

8.2.5.2.7 Dynamic range.

The dynamic range requirement in 5.1.1.2.6 of the Standard ensures that the signal path is capable of handling Type A signals which have incurred maximal DC offset and/or AC-coupling in previous segments of the AEIS.

A full-amplitude source signal that is AC-coupled may bounce up to +1.75V or down to -1.75V (i.e. 3.5Vpp) if there is a sudden shift in its useful DC component, and the AC-coupling circuit has a large number of poles (see 8.4.4.1 of this Handbook and 5.1.1.2.6 of the Standard). In addition, the mission store and carriage store may each introduce a DC error of ±250mV (see 5.3.1.2.7 and 4.3.1.1 of the Standard). Under these extreme transient conditions, the Type A signal path may compress the waveform slightly at the output. The dynamic range requirement applies to a low frequency sinusoidal input to avoid the possible effects of transient non-linearity. Note that non-linear distortion under steady-state conditions is controlled by the stimulated noise requirement in 5.1.1.2.8.4 of the Standard.

8.2.5.2.8 Incidental phase modulation.

Incidental phase modulation is not covered in the Standard. However, consideration might be given to incidental phase modulation for growth applications such as encoded color video (e.g., NTSC, PAL, or SECAM). RGB color video, as defined in STANAG 3350, is not compatible with the MIL-STD-1760 AEIS because it would require three simultaneous signal paths with a very narrow gain and delay imbalance. Further, for certain applications, such as recording, encoded color is presently the only usable color format.

For this future application, the following specification for the signal path should be considered. When a 0.2Vpp sinusoid between 1 MHz and 15MHz (signal 1) is added to a 0.8Vpp sinusoid between 10kHz and 35kHz (signal 2) and applied to each signal path input, the peak-to-peak phase modulation of signal 1 at the output attributable to signal 2 must not exceed 5 degrees.

This additional specification would limit the inter-modulation between the luminance signal (i.e. signal 2) and the chrominance signal (i.e. signal 1). A limit of 5 degrees corresponds to CCIR Recommendation 567-2. Note that the associated incidental amplitude modulation requirement (sometimes known as differential gain) is controlled by the stimulated noise requirement in 5.1.1.2.8.4 of the Standard.

8.2.5.2.9 Noise requirements.

Signal path noise requirements were introduced in Revision C to ensure that the AEIS is capable of supporting an acceptable level of signal fidelity for present and future applications. The actual signal-to-noise ratio at the source is not controlled by the Standard. Only the noise introduced by the signal path is controlled. However, signal designers will be aware that, for interoperability, the AEIS noise limit (including carriage stores) will determine the maximum information capacity that should be expected for future application signals.

The actual signal-to-noise ratio delivered to the mission store or aircraft subsystem will be a function of both the AEIS and source equipment and therefore may be lower than that implied by MIL-STD-1760 alone. Further noise requirements must therefore be addressed in the aircraft-store system specification.

Signal path noise comprises random (or Gaussian) noise, periodic (or discrete frequency) noise, impulse (or spike) noise, and stimulated (or distortion) noise. The first three types of noise are determined under the same conditions, i.e. with the input terminated. Random noise and periodic noise are both stationary processes (i.e. continuous with time) and may be distinguished by spectral analysis of the output. Periodic noise will appear on a spectrum analyzer as a comb of discrete frequencies or possibly as a single frequency component. Random noise will appear as the non-coherent noise floor on a spectrum analyzer (proportional to the IF bandwidth of the instrument). Impulse noise is the random or cyclical occurrence of narrow spikes. Impulse noise may be observed on an oscilloscope but it is important to limit the measurement bandwidth to 20 MHz and exercise judgment over the rate of occurrence. The impulse noise requirement is not intended to control a one-off event. Stimulated noise is additional (stationary) noise power that may be generated when the input is driven rather than terminated. Depending on the design of the routing network and the frequency of the stimulus signal, stimulated noise may appear as pseudo-random or periodic. For simplicity, the MIL-STD-1760 requirement is not sensitive to the spectral behavior of stimulated noise.

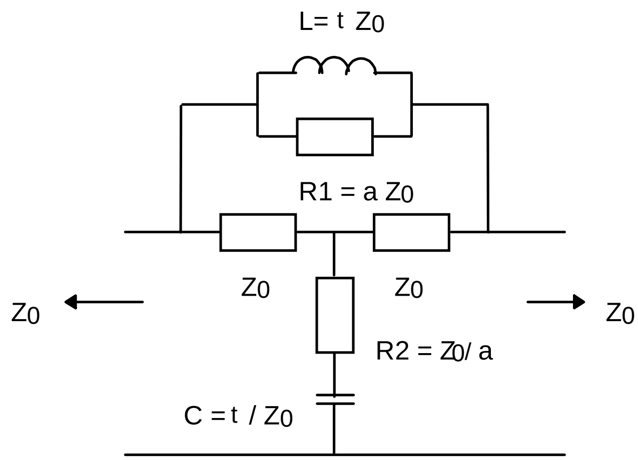
The most stringent application for signal path noise is analog video. The random noise and periodic noise requirements therefore take into account the reduced sensitivity of the eye at higher frequencies.

Common mode noise is not actually signal noise because it is the RMS voltage measured between the signal reference (shield) and structure ground. Common mode noise may, therefore, be stopped by a receiver with a sufficiently large common mode rejection. In practice, common mode noise may be folded into signal noise by a non-ideal receiver and therefore should be limited. The common mode noise weighting function allows for a reduction in common mode rejection at higher frequencies, offset partly by the reduced sensitivity of the eye to higher frequency interference.

In the following noise paragraphs, the signal-to-noise ratios indicated are based on a nominal signal path gain of 0dB. The actual signal-to-noise ratios may therefore be degraded by a further 4 dB if the insertion gain is the lowest permitted by 5.1.1.2.3 of the Standard.

8.2.5.2.9.1 Random noise.

For monochrome composite video on HB3 and HB4, the requirement in 5.1.1.2.8.1 of the Standard corresponds to a peak white to RMS noise ratio of 53 dB for a reference 1 Vpp signal. The requirement follows CCIR Recommendation 567-2 except that the random noise weighting function has been frequency scaled from 5 MHz to 20 MHz. The weighting function in figure 10 of the Standard can be realized by the network in figure 41. This network can be used to filter the signal path output prior to examination by a spectrum analyzer.



Z_0 = the nominal impedance of the signal path, i.e., 50 ohms or 75 ohms

τ = 61.2 ns

a = 4.5

$$A = -10\log \frac{1 + \left[\left(1 + \frac{1}{a} \right) \omega\tau \right]^2}{1 + \left[\frac{1}{a} \omega\tau \right]^2} \quad \text{dB}$$

FIGURE 38. Random noise weighting network

In response to flat noise the weighting function attenuation is 7.4 dB and therefore the random noise requirement corresponds to an unweighted peak white to RMS noise ratio of approximately 45dB if the noise is uniformly distributed.

8.2.5.2.9.2 Periodic noise.

Requirement 5.1.1.2.8.2 of the Standard considers cross talk from stimulated high bandwidth and low bandwidth signal paths as a further contribution towards periodic noise. Cross talk is often the most troublesome source of periodic noise in switching networks and therefore it is general industry practice to establish separate requirements for cross talk to take advantage of knowledge of the cross-talking waveform. However, in the case of MIL-STD-1760, a range of different signal characteristics may be simultaneously supported by the AEIS and consequently a more generic periodic noise requirement is appropriate.

The Standard's figure 11 weighting function is based on a performance objective for single frequency interference on the Bell video transmission system[2] with the envelope smoothed to de-sensitize it from a specific video format and the shape modified to accommodate the larger bandwidth of the MIL-STD-1760 video assignment. The peak-to-peak periodic noise voltage is simply the RMS value plus 9dB (since the calculated noise is a summation of sinusoidal components at different frequencies). The weighted periodic noise requirement therefore corresponds with a peak white to peak-to-peak noise ratio of 50dB for reference 1Vpp composite video.

To determine the periodic noise performance of the signal path, it is first necessary to establish the spread of operational configurations that must be considered for simultaneous high bandwidth and low bandwidth signal transfer. Note that the level of cross talk is often dependent on the direction of the interfering signal as well as its routing. This particularly applies to cross talk between adjacent cables and circuit board tracks. The maximum amplitude of sinusoidal Type A signals is limited at the high frequency end by the slew rate requirement in 4.3.1.1c of the Standard.

8.2.5.2.9.3 Impulse noise.

Impulse noise is the random or cyclical occurrence of narrow spikes at the signal path output. This form of noise should not be confused with stationary periodic noise induced by fast edges in cross talking HB signals.

The measurement bandwidth in 5.1.1.2.8.3 of the Standard may be critical to the peak amplitude of the observed spikes and therefore care must be taken to ensure that the output is evaluated over a passband of DC to 20MHz. The impulse noise requirement is not expected to apply to single or infrequent events, i.e. occurring at an average rate of less than one per second.

8.2.5.2.9.4 Stimulated noise.

The signal path may generate additional noise when the input is driven by an excitation signal. Stimulated noise may result from non-linear distortion or sampling and quantization error. The requirement limits in-band harmonic distortion to 2.5%, which for video signals corresponds to a differential gain distortion of 10%. This follows CCIR Recommendation 567-2. Non-linear distortion will appear on a spectrum analyzer as a comb of discrete frequencies or possibly a single frequency component, in other words, as additional periodic noise.

If the signal is transmitted through the routing network as a sampled and quantized signal then quantization error will be present at the signal path output also. The appearance of this noise will depend on the relative frequencies of the excitation signal and the sample clock. Except when the two frequencies are synchronous, quantization noise will be pseudo-random in nature.

8.2.5.2.9.5 Common mode noise.

Common mode noise is measured between the signal reference (shield) and structure ground and is expected to be single frequency or cyclical in nature. Single events or infrequent bursts of noise are not intended to be included within the common mode noise requirement. Common mode noise is restricted by 5.1.1.2.8.5 of the Standard because differential signal receiver equipment may transfer some of the common mode noise onto the signal voltage. In practice, the common mode rejection of a differential amplifier circuit will decrease with increasing

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[2] "Transmission System for Communictions" Bell Telephone Laboratories, Fourth Edition, 1971.

frequency; however, at the same time the eye is less sensitive to high frequency periodic noise. Consequently, the weighting function in figure 12 of the Standard is based on the net result of these two factors, using specifications from a range of video-frequency amplifiers.

MIL-STD-1760 does not set out common mode rejection requirements for the signal path as, to a certain extent, this must be determined by the aircraft system EMC requirements and apply to out-of-band as well as in-band common mode interference. As a minimum, it is recommended that the signal path should accept the common mode noise levels identified in 5.1.1.2.8.5 of the Standard and not incur signal noise at the output greater than that identified in 5.1.1.2.8.4 of the Standard.

8.2.5.3 Aircraft system electrical characteristics at the RNASP (Type A).

The Standard does not impose requirements on the "aircraft side" of the RNASP interface. However, the aircraft RNASP can affect the performance of the signal path if not correctly designed. The designer will want to set out specific requirements that are tailored to the choice of media (see 8.2.6 of this Handbook).

In digital systems, the designer will be concerned with the bit error rate associated with the interface; in analog systems, return loss will be the primary factor the designer will have to consider.

For implementations in which the RNASP signal format is base-band and analog, the designer is encouraged to limit the aircraft RNASP return loss to greater than 18dB in both sourcing and sinking mode. This figure is assumed in 8.6 of this Handbook for system-level performance budgeting (see also 8.5.5).

8.2.5.4 HB Type B signal path electrical requirements.

Presently, no performance requirements are provided by MIL-STD-1760 for HB Type B signal paths, however it is expected that detailed Type B requirements will emerge in a later revision or notice of the Standard.

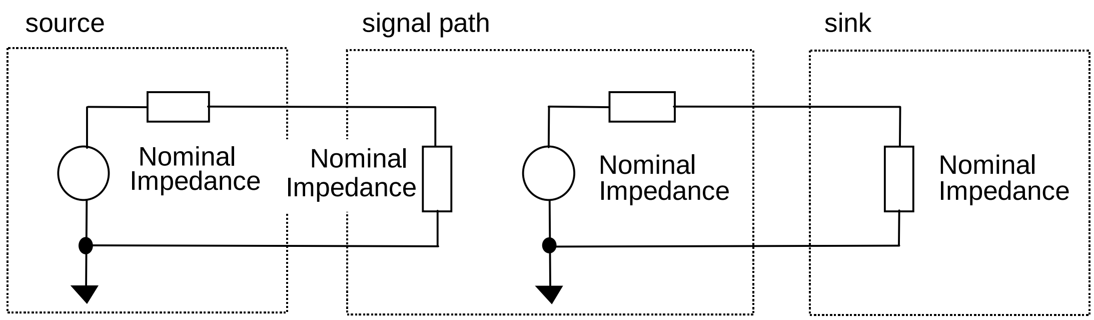
8.2.5.5 HB grounding scheme.

For Type A signal path implementations where the RNASP has similar characteristics to an ASI, the signal path ideal transmission circuits in figure 39 are recommended (RNASP to ASI and ASI to RNASP). In any case, the transmission circuits in figure 39 are mandated for Type A ASI to ASI transfers.

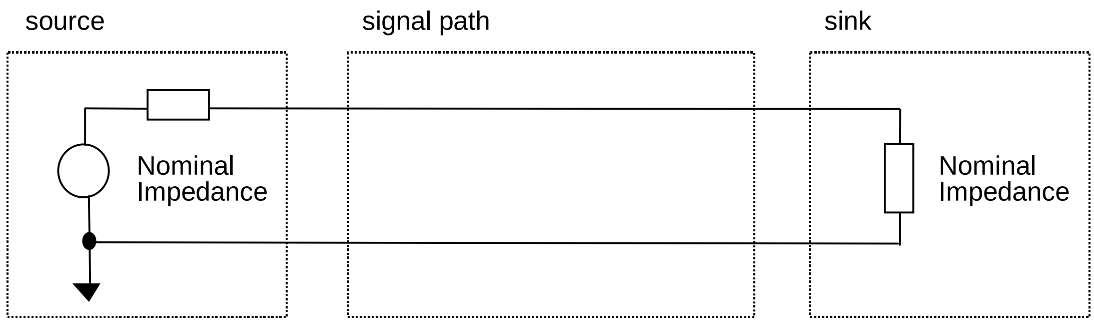
A differential, unbalanced transmission scheme was introduced into Revision C of the Standard for all Type A interfaces (see 5.1.1.4 of the Standard). This provides HB1 and HB2 with improved immunity to magnetic field interference compared with Revision B or earlier. At the signal path input, the designer should isolate the signal return (i.e. shield reference) from ground sufficiently to maintain adequate current balance and common mode rejection.

The Standard does not provide a common mode voltage requirement for the signal path input, however it is recommended that such a requirement is contained in the detailed specification for the aircraft routing network. For guidance, consideration may be given to the common mode voltage requirements for sink equipment in STANAG 3350 AVS. It is further recommended that the signal path common-mode noise rejection performance be related to its contribution to the stimulated noise requirement in 5.1.1.2.8.4 of the Standard. Note that an attached carriage store may introduce common mode noise at the ASI input. See 5.3.1.2.8.5 of the Standard.

To prevent the build up of return loss distortion through the AEIS it is recommended that the aircraft signal path specifically meet the requirements of figure 39(a) if carriage stores are to be used.



(a) Recommended Transmission Circuit for Active Signal Path (HB Type A)



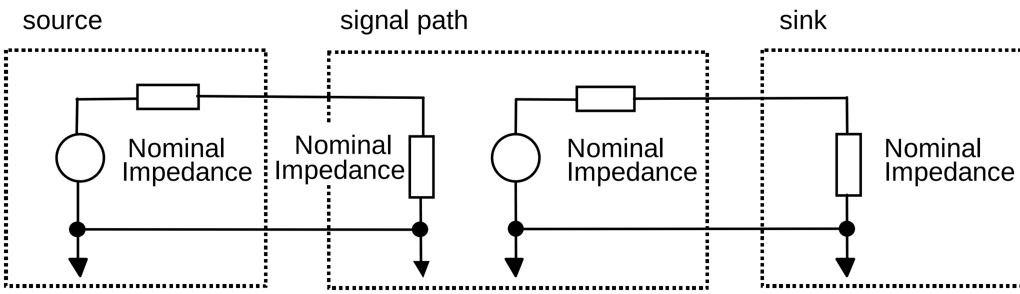
(b) Recommended Transmission Circuit for Passive Signal Path (HB Type A)

FIGURE 39. Type A transmission circuits (*assuming RNASP is similar to ASI).*

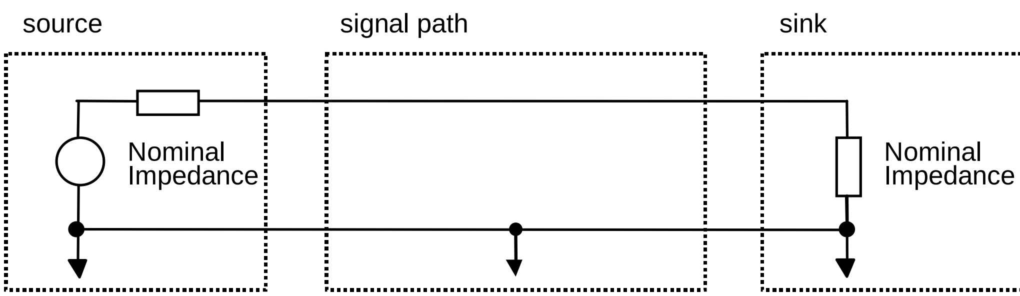
For Type B signal path implementations where the RNASP has similar characteristics to an ASI, the signal path ideal transmission circuits in figure 40 are recommended (RNASP to ASI and ASI to RNASP).

The Type B signal path must have a grounded signal reference (shield) at both the source and sink equipment. Further, it is recommended that the signal reference is connected to aircraft structure ground along the signal path where practical, consistent with meeting the signal reference grounding requirements for the Type A signal path. For HB1 Type A, the signal shield must be isolated from aircraft structure ground when the aircraft is in sinking mode or is transferring the signal to another ASI. For this reason the Type A / Type B switching scheme is recommended (see 8.2.5 of this Handbook, particularly figures 30 and 31).

For EMC, the designer is encouraged to use concentric triaxial cable or an additional shield between the ASI HB1 interface and the signal switching equipment. The outer shield should be grounded as often as possible to provide protection from high frequency electromagnetic field interference as the inner shield must be isolated from structure ground.



(a) Recommended Transmission Circuit for Active Signal Path (HB Type B)



(b) Recommended Transmission Circuit for Passive Signal Path (HB Type B)

FIGURE 40. Type B transmission circuits (*assuming RNASP is similar to ASI).*

8.2.6 Mission store HB interfaces.

The mission store will be compatible with a Class II primary interface if the utilization of the HB interfaces is restricted to HB1 and HB3. The addition of HB2 or HB4 (or both) will require a Class I primary interface at the store station. The mission store may source or sink HB signals at each interface. It is not recommended that a single interface be used in a "talk/listen" mode as the AEIS may not support rapid time-multiplex switching of signal direction. The HB1 interface may be utilized for either Type A signals or Type B signals. The AEIS is not required to support the transfer of both signals simultaneously but mode switching between Type A and Type B may be performed during a mission.

The capability of the AEIS to route HB signals from one MSI to another will depend on the aircraft system specification. If such a transfer is required, the same interface (i.e., HB1, HB2, HB3 or HB4) should be used throughout the AEIS if possible.

8.2.6.1 HB Type A interface electrical requirements.

The mission store source signal requirements in 4.3.1.1 of the Standard are limited to:

a. maximum instantaneous voltage excursion and full-scale peak-to-peak voltage

b. transmission passband compatibility

c. minimum roll-off of out-of-band power

d. maximum slew rate

These requirements are intended for electrical compatibility with the AEIS. At a sink MSI, the Type A signal might not comply with these requirements because of the possible insertion gain and distortion characteristics *en route*. The actual degradation should be calculated for the particular waveform of the application signal using the suggested error budgets set out in 8.5 of this Handbook.

It is expected that the mission store interface specification will set out additional source signal requirements which are application specific: such as waveform characteristics, signal amplitude, latency and noise.

8.2.6.1.1 Ground reference.

In 5.2.1.4 of the Standard, the mission store is required to support the differential (unbalanced) transmission of Type A signals through the AEIS. In Revision C, this now applies to HB1 (Type A only) and HB2 as well as HB3 and HB4. For sink equipment, the designer should isolate the signal return (i.e., shield reference) from the ground circuit sufficiently to maintain adequate current balance and common mode rejection.

The Standard does not provide a common mode voltage requirement for the MSI, however it is recommended that such a requirement is imposed within the mission store interface specification. For guidance, consideration may be given to the common mode voltage requirements for sink equipment in STANAG 3350 AVS, i.e.,

a. the common mode voltage range to be accommodated by sink equipment without causing degradation is ±5 V over the bandwidth DC to 2 MHz, and

b. the common mode voltage range to be accommodated without damage to the sink equipment is ±30 V over the bandwidth DC to 2 MHz.

8.2.6.1.2 Return loss requirements.

The required return loss of 25 dB in 5.2.1.2.1 of the Standard corresponds with a VSWR of 1.12, i.e. an impedance tolerance of ±12% over the Type A bandwidth. The requirement does not include the umbilical or test cable but does include the mating contact pair. Therefore, the mating pair should not be calibrated out.

For certain signal applications, the designer may wish to impose a more stringent return loss requirement. Note that STANAG 3350 requires an impedance tolerance of ±5 % over the video bandwidth (i.e. better than 32 dB) and therefore this specification is highly recommended as a goal for video source or sink equipment.

8.2.6.1.3 Dynamic range.

The dynamic range requirement of ±3.0 V in 5.2.1.2.2 of the Standard allows for possible AC-coupling distortion, insertion gain error and DC offset that may accrue through the AEIS. If the peak voltage of the signal waveform is sensitive to high frequency gain misequalization (see 5.1.1.2.5 and 5.3.1.2.5 of the Standard) then further dynamic range may also be required. A sink should accommodate the instantaneous voltage range without causing degradation. It is recommended that MSIs be designed to withstand, without damage, transient conditions an order of magnitude higher.

8.2.6.2 HB Type B interface electrical requirements.

Presently, few requirements are provided in MIL-STD-1760 for HB Type B interfaces. It is expected that detailed Type B requirements will emerge in a later revision or notice.

8.2.7 Carriage store HB interfaces.

The HB signal-routing capability of the carriage store should be as flexible as possible to support growth in the range of mission stores that the carriage store will be certified to carry. It is recommended that the carriage store should, as a minimum, support one Class I primary CSSI in any source/sink configuration for the four HB interfaces. The capability of the carriage store to simultaneously support multiple mission stores may depend on a number of factors, such as power management. However, it is recommended that the carriage store have the additional capability to transfer HB1 Type B and HB2 signals from the aircraft ASI to MSIs in broadcast (or multicast) mode. This mode may be used to provide a feed of GPS RF (HB1 Type B) and precise time correlation signals (HB2) to all powered stores. No operational requirement to support MSI to MSI signal transfers within the same carriage store has been identified. However the future requirement to support such a mode cannot be ruled out and, therefore, may be considered by the designer also.

8.2.7.1 HB Type A signal path electrical requirements.

The transmission quality of each carriage store Type A signal path has been standardized in 5.3.1.2 to promote interoperability between the AEIS and present and future mission stores. The requirements apply to all Type A signal paths implemented between the CSI and CSSI(s). Note that the signal path electrical characteristics must also meet the general requirements in 4.3.1.1 of the Standard. For the complete AEIS, i.e. comprising the aircraft routing network, umbilical cables and one or two carriage store routing networks, performance budget calculations may be found in 8.5 of this Handbook.

8.2.7.1.1 Ground reference.

To provide HB1 (Type A) and HB2 with improved immunity to magnetic field interference, a differential, unbalanced transmission scheme is required for all Type A signal paths in 5.3.1.4. The Standard does not impose a common mode voltage requirement for the signal path input, however it is recommended that such a requirement is provided within the detailed carriage store specification. For guidance, designers may consider the common-mode voltage requirements of STANAG 3350 AVS for sink equipment. It is also recommended that the common mode noise rejection performance of the signal path is specified. Consideration may be given to adding a common mode voltage input to the stimulated noise requirement in 5.3.1.2.8.4. Note that the aircraft routing network is permitted to introduce common mode noise at the CSI. See 5.1.1.2.8.5 of the Standard.

At the signal path input, the designer should sufficiently isolate the signal return (i.e., shield reference) from ground to maintain the necessary current balance and common mode rejection performance.

8.2.7.1.2 Return loss requirements.

See discussion in 8.2.5.2.1. The return loss requirement of 20 dB for the carriage store (MIL-STD-1760 5.3.1.2.1) corresponds with a VSWR of 1.22. The requirement does not include a test cable or either of the umbilical cables but does include the mating contact pair. Therefore, the mating contact pair should not be calibrated out. The carriage store return loss requirement is intended to achieve the overall return loss K-rating for different AEIS configurations as set out in table VIII of this Handbook.

8.2.7.1.3 Transient response.

See discussion in 8.2.5.2.2. The carriage store transient response requirements in 5.3.1.2.2 of the Standard are intended to achieve the overall performance budgets for different AEIS configurations as set out in 8.6.3 of this Handbook.

8.2.7.1.4 Insertion gain.

The insertion gain requirement in 5.3.1.2.3 of the Standard is intended to achieve the overall performance budget for different AEIS configurations as set out in table XIII of this Handbook.

8.2.7.1.5 Representative pulse delay

See discussion in 8.3.5.6 of the Standard. The representative pulse delay requirements in 5.3.1.2.4 of the Standard are intended to achieve the overall performance budget for different AEIS configurations as set out in table XIV of this Handbook.

8.2.7.1.6 Equalization

See discussion in 8.2.5.2.5. The gain misequalization requirements of 5.3.1.2.5 of the Standard are intended to achieve the overall performance budget for different AEIS configurations as set out in table XV of this Handbook.

8.2.7.1.7 Dynamic range.

See discussion in 8.2.5.2.7.

8.2.7.1.8 Incidental phase modulation.

See discussion in 8.2.5.2.8. Consideration might be given to the same specification for carriage-store incidental phase modulation that is recommended for the aircraft in 8.2.5.2.8. This specification is intended to achieve the overall performance budget for different AEIS configurations as set out in table XVI of this Handbook.

8.2.7.1.9 Noise.

See discussion in 8.2.5.2.9. The noise requirements of 5.3.1.2.8 (and subparagraphs) of the Standard are intended to achieve the overall performance budget for different AEIS configurations as set out in table XVII of this Handbook. The resultant signal to noise ratio is also affected by the insertion gain of the AEIS.

8.2.7.2 HB Type B signal path electrical requirements.

Presently, no performance requirements are provided by MIL-STD-1760 for HB Type B signal paths, however it is expected that detailed Type B requirements will emerge in a later revision or notice of the Standard.

8.2.7.2.1 Ground reference.

In 5.3.1.5 of the Standard, the Type B signal path is required to have a grounded signal reference (shield) at both the source and sink equipment. It is recommended that the signal reference is connected to carriage store structure ground where practical, consistent with meeting the signal reference grounding requirements for the Type A signal path (see 8.2.5.5). For HB1 Type A, the signal shield is required to be isolated from carriage store structure ground at the signal path input. For this reason the Type A / Type B switching scheme is recommended. See 8.2.5.

For EMC, the designer is encouraged to use concentric triaxial cable or an additional shield between the ASI HB1 interface (at both CSI and CSSI) and the signal switching equipment. The outer shield should be grounded as often as possible to provide protection from high frequency electromagnetic field interference as the inner shield must be isolated from structure ground.

8.2.8 Primary umbilical HB interfaces.

At aircraft stations intended to support carriage stores and at carriage store stations the maximum recommended length is 2 meters for each umbilical cable. At aircraft stations where a carriage store cannot be carried (such as in a bay or at a wingtip) the cable length within the umbilical may be longer, however care should be exercised in controlling insertion loss over the Type B transmission passband.

The present recommendation of a 2-meter limit is based on return loss considerations for Type A signals. The intent is to restrict the return loss contribution of each umbilical cable to greater than 30 dB over the transmission pass band 20 Hz to 20 MHz (not including the mated contacts at each end).

Isolation of the signal returns (contact shields) is recommended for compatibility with differential signal transmission over the Type A transmission pass band.

8.3 Cable selection for HB interfaces.

The use of concentric triaxial cable for implementing the HB interfaces is highly recommended. Aircraft implementations have shown improved HB Type A signal quality when triaxial cable is used instead of coaxial cable. These improvements are due to the protection afforded by the triaxial cable from electromagnetic field interference.

The interface definition in the standard allows the use of triaxial cable even though only a coaxial style contact is contained within each AEIS interface connector. This apparent connector limitation can be overcome by electrically terminating the outer shield of the triaxial cable to the conductive back-shell of the interface connectors. This termination can be made by means of a multi-shield device such as an inverted-cone contact ring or tag ring (or other techniques). The inner shield of the triaxial shield of the triaxial cable is used for the signal return of the high bandwidth signal.

8.4 HB Type A signal path linear distortion.

8.4.1 General.

For the high bandwidth Type A signal path, linear distortion is controlled by transient response requirements (MIL-STD-1760) (see 5.1.1.2.2 and 5.3.1.2.2), equalization requirements (see 5.1.1.2.5 and 5.3.1.2.5) and return loss requirements (see 5.1.1.2.1 and 5.3.1.2.1). This section provides a unified, mathematical examination of the signal path distortion issues and gives other information that may be of use to the design engineer. Section 8.5 herein provides the necessary performance budget for a signal path comprising an aircraft segment and a carriage store segment (or segments). This section concentrates on the performance of an aircraft signal path or carriage store signal path individually.

The central method of controlling linear distortion is transient response. Mathematically, all distortion requirements would be most efficiently described in this manner. However not all time-domain distortion artifacts are conveniently determined by practical testing and therefore the equalization requirement is included to augment the transient response requirement. Return loss introduces additional misequalization when source, signal path segments and sink equipment are cascaded. In MIL-STD-1760 a comparatively high level of misequalization (and therefore transient response distortion) can be introduced by return loss compared with industry practice. This is because high values of return loss may not be practical for an AEIS involving long lengths of cable or a passive carriage store routing network.

Each linear distortion requirement in MIL-STD-1760 will be analyzed in detail. But first, it is useful to establish a mathematical model for the distortion behavior of a signal path segment. The contribution of transient response, equalization and return loss may then be examined in a unified fashion.

8.4.2 Mathematical description of signal path linear distortion.

Initially, only signal path behavior within the nominal transmission passband of 20 Hz to 20 MHz will be analyzed. In practice, the distortion requirements in MIL-STD-1760 are inherently band-limited, except for the cosine-squared T signal response (see 5.1.1.1.2.3 and 5.3.1.1.2.3) which does have some out-of-band energy. Even here, the envelope takes into account the possible distortion created by abrupt frequency truncation at 20 MHz.

Any frequency-truncated signal may be precisely represented by a time-series of rectangular-filtered impulses, i.e.

$$f(t)\Big|_{filtered} = \sum_{n=-\infty}^{+\infty} b_n \frac{\sin\frac{\pi}{T}(t-nT)}{\frac{\pi}{T}(t-nT)} \qquad (8.4.2\text{-}1)$$

Where 2T is the inverse of the upper frequency of interest (i.e., 1/T is the Nyquist rate), b_n is the peak amplitude of the filtered impulse centered at time nT, and the sine-over-argument term is the shaping function for the rectangular-filtered impulse $\delta(t - nT)$, i.e.

$$\delta(t-nT)\Big|_{filtered} = \frac{\sin\frac{\pi}{T}(t-nT)}{\frac{\pi}{T}(t-nT)} \qquad (8.4.2\text{-}2)$$

The zero time reference is arbitrary in that any number of time-series may be created to describe the same frequency-truncated signal. However, by inspection, the impulse response of a signal path can most usefully be expressed as a central term of amplitude b_0 centered at t = 0 (being the non distorting part of the impulse response) and a time-series of other impulses occurring at $t \neq 0$ which amounts to the distortion introduced by the path. Such an impulse response is sketched in figure 41.

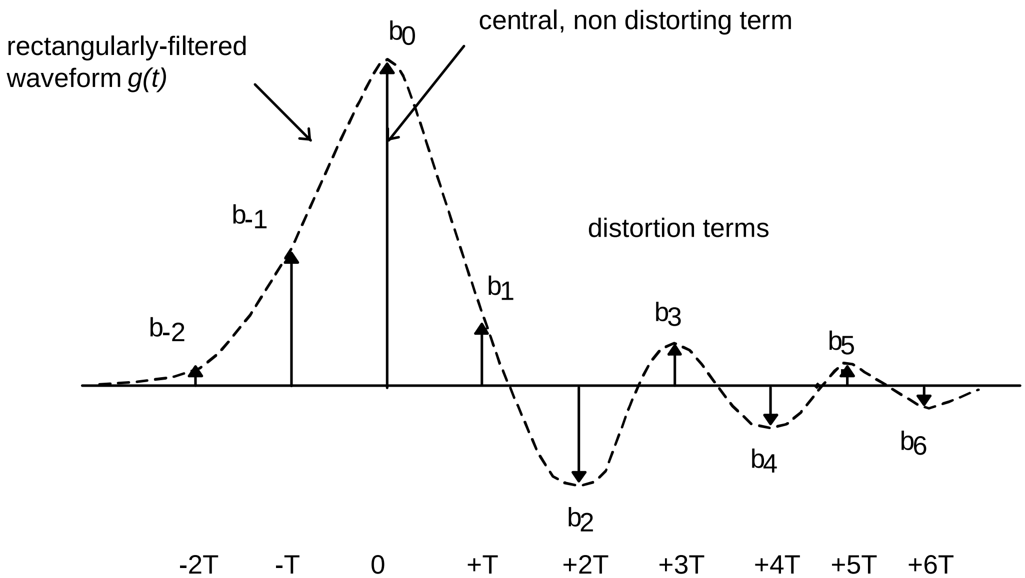


FIGURE 41. Example of signal path impulse response

The time-series of b_n (at interval T) would approximate to the cosine-squared T signal response of the signal path if the spectral activity above 20 MHz were removed. The non-exactness is because the energy spectrum of the T signal is not rectangular. Refer to the specific guidance on the T signal requirement later in this appendix. A fairly close model of the 2T signal response is the time-series of c_n (at interval T) where

$$c_n = {}^{1}\!/_{2}b_{n-1} + b_n + {}^{1}\!/_{2}b_{n+1} \qquad (8.4.2\text{-}3)$$

A suitable method for evaluating the qualitative distortion performance of a signal path is the K-rating system[3]. The K-rating system weights the importance of spurious impulse terms in the time-series according to their cumulative and individual amplitudes, and their displacement from the central, non distorting term b_0.

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[3]LEWIS, N.W. [1954] Waveform Responses of Television Links, Proc. IEE Vol 101, Part III, 258-270.

The K-rating is determined as the highest value of K1, K2, K3, K4 when b_0 is normalized so that $b_0 = 1$

$$K1 \geq \frac{1}{8}\left| n\frac{c_n}{c_0} \right| \quad -8 \leq n \leq -2,\ +2 \leq n \leq +8 \qquad (8.4.2\text{-}4)$$

$$K1 \geq \left| \frac{c_n}{c_0} \right| \quad n \leq -8,\ n \geq +8 \qquad (8.4.2\text{-}5)$$

The first requirement for K1 is intended to be met by the response envelope in figure 6b of the Standard between -200 ns and -50 ns and between +50 ns and +200 ns, where K1 is 3% for the aircraft signal path or carriage store signal path. The second requirement is outside the time covered by figure 6b (i.e., below -200 ns and above +200 ns) and therefore is not controlled by the transient response requirement. Instead, the equalization requirement is used to control K1 for large values of $|n|$. Refer to the specific guidance in this section.

$$K2 = \frac{1}{4}\left| \left(\frac{1}{c_0} \sum_{n=-8}^{+8} b_n \right) - 1 \right| \qquad (8.4.2\text{-}6)$$

$$K3 = \frac{1}{6}\left| \left(\sum_{n=-8}^{+8} b_n \right) - 1 \right| \qquad (8.4.2\text{-}7)$$

The time series summation in Equations 8.4.2-6 and 8.4.2-7 equates (approximately) to the amplitude of V′ in figure 7b or figure 8b of the Standard (and hence the 100% reference for figure 5b and figure 6b)[4]. K2 is intended to be met by the response envelope in figure 6b between -50 ns and +50 ns, and K3 is intended to be met by the response envelope in figure 5b between -25 ns and +25 ns, when energy above 20 MHz is rejected (remember that the time-series is normalized so that $b_0 = 1$). Both K2 and K3 are intended to be 3% for the aircraft signal path or carriage store signal path

$$K4 = \frac{1}{20}\left\{ \left(\sum_{n=-8}^{+8} |b_n| \right) - 1 \right\} \qquad (8.4.2\text{-}8)$$

MIL-STD-1760 does not address K4 and therefore the requirement is provided for interest only.

Although mathematically possible, long-time and mid-time distortion is not conveniently controlled by impulse response test requirements, and therefore the 2T-bar requirement in figure 8b of the Standard and the low-frequency end of the gain misequalization requirement in figure 9 of the Standard are also brought into play. Refer to specific guidance in this section.

The return loss requirement controls the additional misequalization that could result from impedance mismatch at each store station. This may introduce further distortion to that already allowed by the signal path transient response and equalization requirements. The intent is to limit return loss distortion to a maximum additional K-rating of 3% for an isolated mission store, carriage store and aircraft interconnection. Refer to the specific guidance in this section.

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[4] i.e. the final value arising from the convolution of the impulse response with a unit step, ignoring mid-time and long-time distortion terms

8.4.3 Transient response.

(See 5.1.1.2.2 and 5.3.1.2.2 of MIL-STD-1760)

8.4.3.1 Guidance on 2T-bar signal.

The 2T-bar signal in figures 7a and 8a of the Standard is a 25 µs-duration rectangular pulse, convoluted with the cosine-squared 2T function to yield a carefully chosen edge. The purpose of the convolution is to remove virtually all energy above 20 MHz, but maintain the shortest practical rise-time/fall-time. The 2T-bar signal is couched as a convolution to provide implicit guidance on how such a signal could be generated: i.e., g(t), or more precisely $g(t-t_d)$, may be viewed as the impulse response of a pulse-shaping filter (t_d is the necessary time delay to render g(t) realizable).

If the zero time reference is set at the V/2 crossing point of the rising edge instead, then it may be useful to note that the instantaneous voltage of the 2T-bar signal is given by Equation 8.4.3.1.

$v(t) = 0$ for $t < -2T$

$$v(t) = \frac{V}{2}\left[\frac{1}{\pi}\sin\left(\frac{\pi . t}{2T}\right) + \frac{t}{2T} + 1\right] \quad \text{for } -2T \le t < +2T \qquad (8.4.3.1)$$

$v(t) = V$ for $+2T \le t <$ start of falling edge

The leading edge of the 2T-bar signal is shown in figure 42. The trailing edge is the mirror image.

In practice, the precise shape of the edge is not critical provided that the resultant short-time waveform distortion settles within 1 µs of the 50 % crossing point. The purpose of the bar top envelope (figure 8b of the Standard) is to control the mid-time tilt distortion of the signal path. Consequently, any distortion artifacts on the bar top not associated with tilt, such as ringing or short-duration disturbances, should be omitted from the assessment. These forms of distortion are controlled by the mid-frequency portion of the equalization requirement in paragraph 5.1.1.2.5 of the Standard.

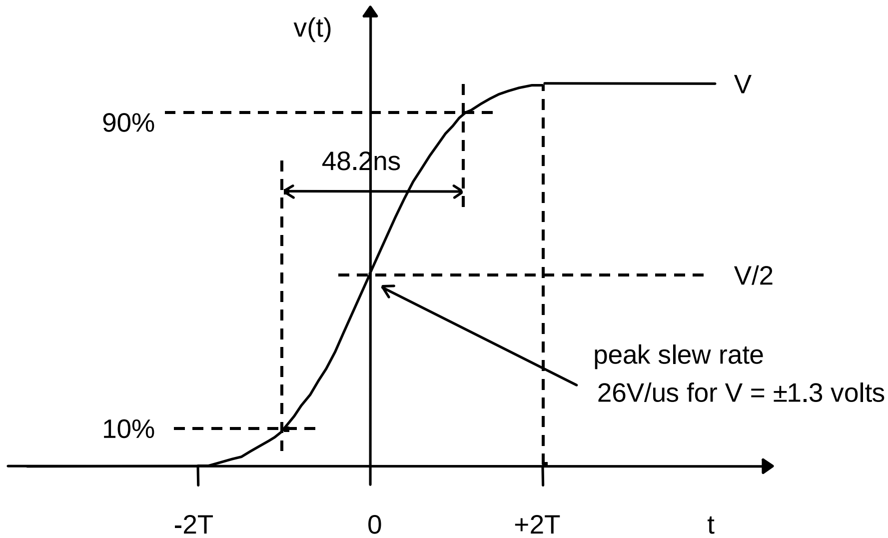


FIGURE 42. Detail of 2T-bar signal leading edge.

8.4.3.2 Guidance on T signal and 2T signal.

In contrast to mid-time distortion, the T signal and 2T signal are used to control the short-time waveform distortion of the signal path, i.e., the distortion activity that occurs within ±200 ns of the notional zero time reference of the response. The cosine-squared shape has similar properties to a band-limited impulse function but without the ringing which would reduce the dynamic range of the distortion measurement. The T signal and 2T signal therefore provide a lot of information about the behavior of the signal path over the full transmission pass-band.

The cosine-squared T signal, in contrast to the 2T-bar and 2T-signal, has significant energy above 20MHz, and consequently the response may be distorted by a signal path with a sharp cut-off above the nominal transmission pass-band. The one-sided spectral-density function of the T signal is illustrated in figure 43.

The mathematical model of the spectral-density function is

$$F(\omega) = \frac{\pi^2 V}{jT^3} \cdot \frac{\sin \omega T}{\omega\left(\frac{\pi^2}{T^2} - \omega^2\right)} \qquad (8.4.3.2\text{-}1)$$

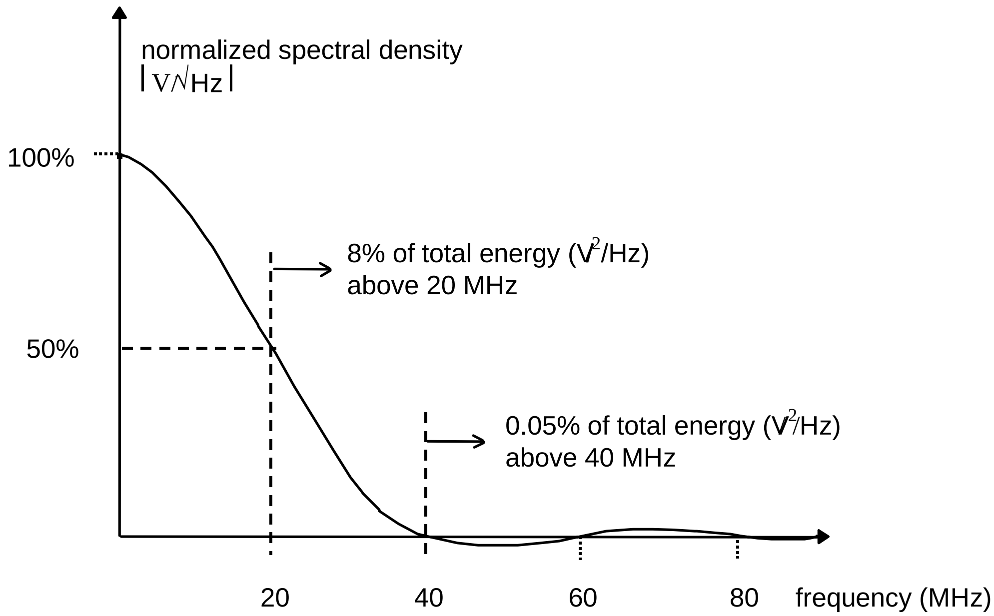


FIGURE 43. One-sided spectral-density function of cosine-squared T signal.

An example of a signal path T signal response is shown in figure 44.

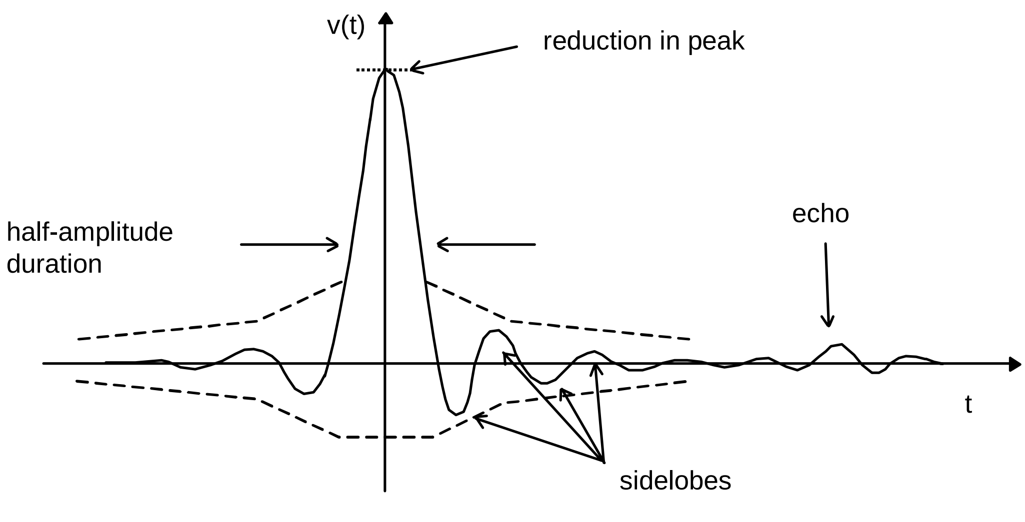


FIGURE 44. Example of cosine-squared T signal response.

In the figure, three distortion artifacts are shown: i) reduction in the peak amplitude of the main lobe, ii) side-lobes (or overshoot) close to the main lobe, iii) side-lobes (or echoes) a long time from the main lobe, and outside the period covered by the envelope. The amplitude of echoes a long time from the main lobe is not controlled by the transient response requirement because of possible tilt distortion difficulties. These artifacts are indirectly controlled by the mid-frequency part of the equalization requirement (refer to the guidance in 8.4.4). It may be noted however that the intent of the standard is to limit the peak amplitude of each echo to 3% outside ±200 ns (when the frequency response is truncated at 20 MHz).

If discernible side-lobes are present in the response (close to the main lobe) then it is probable that the signal path bandwidth is restricted compared with the wide Fourier spectrum of the input signal. The apparent signal path bandwidth may then be determined by inspection of the side-lobe "ringing" frequency. If it is less than 20MHz then the signal path roll-off may not comply with the equalization requirement of paragraph 5.1.1.2.5 of the Standard. The peak amplitude of the main lobe is also sensitive to roll-off and, additionally, slew rate problems. Generally, the half-amplitude duration of the main lobe will increase as the height decreases if the signal path is band-limited compared with the Fourier spectrum of the input signal.

Because the intent is to allow truncation of the signal path frequency response above 20MHz, the reference band-limited T signal response for the K-rating is not the same as the wide-band input signal, and has the characteristics shown in table III:

TABLE III. Reference (0% K-rating) T signal response.

reference characteristic	value
peak amplitude of main lobe	82%
half amplitude duration of main lobe	37ns
height of 1st (negative-going) side-lobe (leading or trailing)	8%
height of 2nd (positive-going) side-lobe (leading or trailing)	5%
side-lobe ringing frequency	20MHz

Note that the half-amplitude duration of the main lobe and the side-lobe ringing frequency are provided for interest only; these features are not restricted in MIL-STD-1760. The Standard defines a T signal response envelope which approximately corresponds with a 3% K-rating. Table IV defines the envelope for other K-rating values. It may be useful to quantify the actual signal path performance in terms of its K-rating.

TABLE IV. Variation of T signal response envelope with different K-ratings.

K-rating	0%	1%	2%	3%	4%	5%	6%
peak of main lobe	82%	78.8%	75.9%	73.2%	70.6%	68.3%	66.1%
envelope at ±100ns	±3.0%	±3.5%	±4.5%	±5.0%	±5.5%	±6.0%	±6.5%
envelope at ±50ns	±6%	±7%	±9%	±10%	±11%	±12%	±13%
envelope at ±25ns	±9%	±12%	±15%	±18%	±21%	±24%	±27%

The 2T-signal transient response requirement is similar to the T signal except that the energy spectrum is limited to 20 MHz (to 99.95 %). Consequently, the response envelope does not require an allowance for out-of-band linear distortion. For interest, table V shows the sensitivity of the envelope to other K-rating values.

TABLE V. Calculation of K-rating for 2T signal response envelope.

requirement	K-rating calculation
peak of main lobe	100% ± 4K
envelope at ±200ns (±8T)	± K
envelope at ±100ns (±4T)	± 2K
envelope at ±50ns (±2T)	± 4K

8.4.4 Equalization.

(MIL-STD-1760 5.1.1.2.5 and 5.3.1.2.5)

8.4.4.1 Guidance on low frequency roll-off.

The Type A signal path is not required to transmit energy or power below 20Hz. Therefore "long-time" waveform distortion may occur if there is a change in the near-DC (or low frequency) component of the input signal (see 8.2.1.1 of this Handbook). For example, consider figure 45. The near-DC component is affected by a shift in the "Average Picture Level" (APL) of the video signal (integrated over a complete frame period). In video signals, the difference between the blanking level and this near-DC component is referred to as the "useful DC component". Since the useful DC component may be removed by transmission through the AEIS, a DC-restoration circuit is needed at the MIL-STD-1760 video utilization equipment. A difference in the near-DC component would also result from a change in the duty cycle of a simple binary pulse train. Once again, some kind of DC-restoration circuit may be required at the utilization equipment to recover the undistorted waveform.

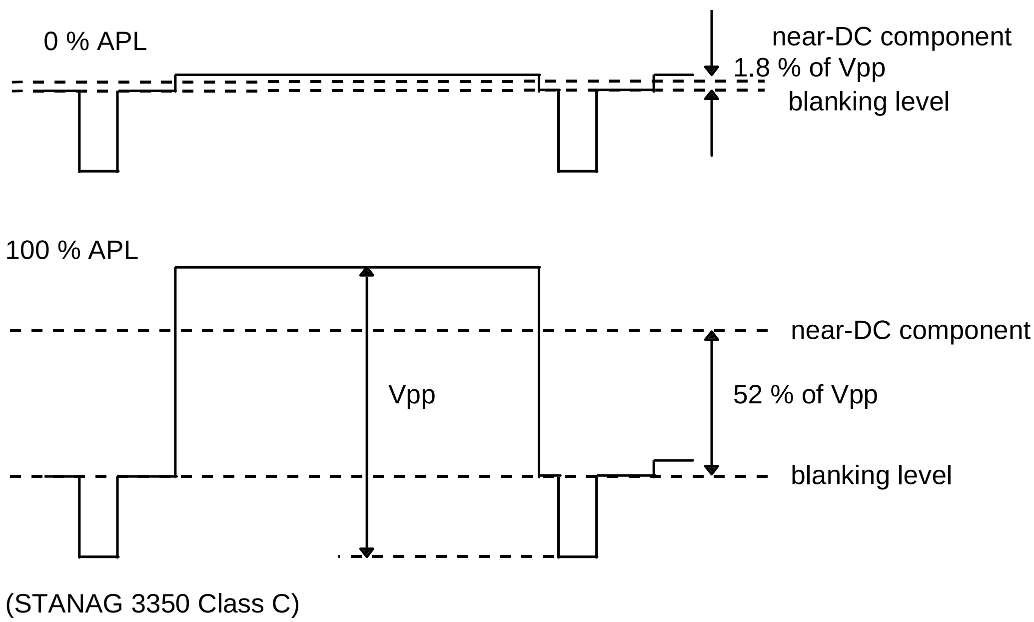
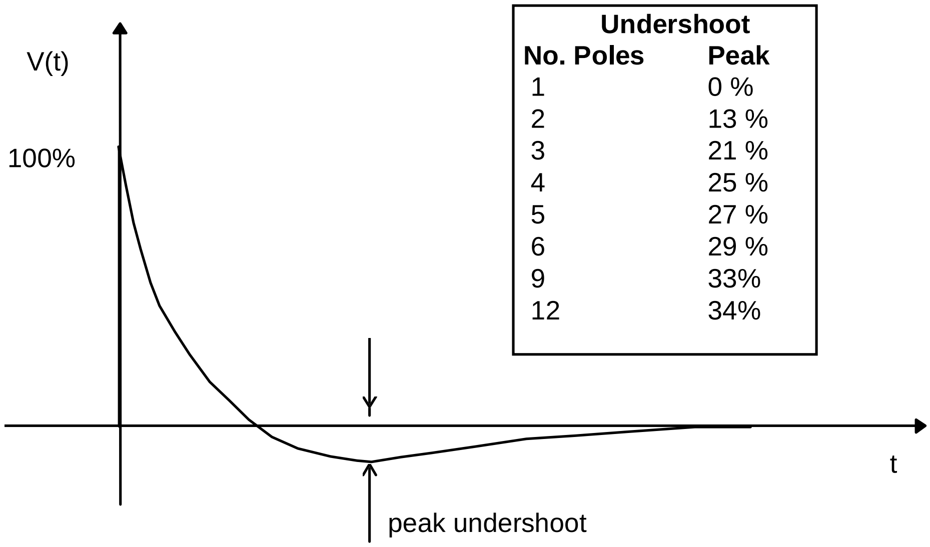


FIGURE 45. Useful DC component of video signal vs. APL.

The distortion caused by AC-coupling will depend on the actual cut-off frequency, the rate of roll-off, and the suddenness and magnitude of the shift in near-DC component. Figure 46 shows the Type A signal path response to a step in DC level from a settled condition. Under-shoot will occur if the signal path low-frequency roll-off is greater than first order. The relationship between the order (i.e., no of poles) and the percentage of under-shoot is shown in the figure also. It can be seen that an undershoot allowance of ±35% may be required as the order increases to a practical maximum. Of course, negative-going steps are equally likely, causing an output swing in the opposite direction. Therefore the "dynamic range" of the AEIS interfaces has to accommodate a much larger voltage excursion as a result of AC-coupling than the maximum settled peak-to-peak voltage of 1.3V defined in paragraph 4.3.1.1 of the Standard. Refer also to 8.2.5.2.7 herein for further guidance on dynamic range issues.



Undershoot	
No. Poles	**Peak**
1	0 %
2	13 %
3	21 %
4	25 %
5	27 %
6	29 %
9	33%
12	34%

FIGURE 46. AC-coupled output resulting from DC step at input.

Signals with significant power below 200 Hz, but above the nominal lower transmission frequency of 20 Hz, may also be affected by long-time waveform distortion. For example, figure 47 shows the "tilt" on a 20 cycle/second square-wave at the output of a signal path exhibiting a simple first-order roll-off and 20 Hz cut-off. Type A application signals must therefore be carefully designed to be compatible with an AC-coupled AEIS, allowing for considerable distortion below 200 Hz.

The gain misequalization envelope of figure 9 of the Standard may be satisfied by any first-order (or higher) filter with a 20 Hz (or lower) cut-off frequency. Although not explicitly stated in the Standard, it is assumed that the signal path gain misequalization below 20Hz does not exceed +0.25 dB/-∞ dB with respect to the mid-band zero-dB reference. Note that the bar top distortion in figure 8b of paragraph 5.1.1.2.2 of the Standard does not control the signal path performance below 200 Hz as it can be shown that the required 2T-bar response may be achieved with a 200 Hz cut-off and 7th order (Butterworth) roll-off. Conversely, the equalization requirement does not restrict the delay misequalization and therefore the 2T-bar response is not controlled by paragraph 5.1.1.2.5 of the Standard. Therefore, both the transient response and gain misequalization requirements are needed.

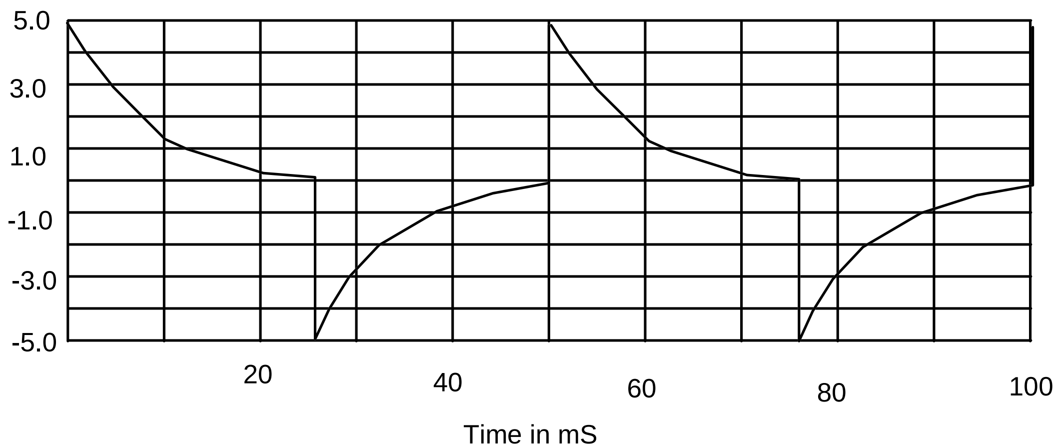


FIGURE 47. Tilt distortion caused by first order roll-off, with breakpoint at 20Hz.

8.4.4.2 Guidance on mid-band equalization.

The gain misequalization envelope between 200 Hz and 1.25 MHz is restricted to limit the magnitude of echoes which are displaced greater than ±200 ns from the center of the main lobe in the transient response (Equation 8.4.2-5). For guidance on this type of distortion artifact, refer to the earlier material in this section and figures 43 and 44 in particular. The detailed mathematical explanation of the gain misequalization envelope is complicated, however the following outline may be of interest and assist in understanding the requirement.

The vector frequency response of the signal path may be mapped to its impulse response (Equation 8.4.2-1) via the inverse Fourier transform (with re-scaling).

It is shown in 8.4.2 that the band-limited impulse response may be represented as a time-series of impulses of interval T, i.e.

$$f(t)\Big|_{filtered} = \sum_{n=-\infty}^{+\infty} b_n\,\delta(t-nT)\Big|_{filtered} \qquad (8.4.4.2\text{-}1)$$

Comprising: (i) a large, central impulse, $b_0\delta(t)$, associated with the main lobe of the response, and (ii) other smaller impulses, $b_n\delta(t-nT)$, which lead or lag the central term by nT (see figure 42). Note that band-limiting will give each impulse a sine-over-argument shape (Equation 8.4.2-2), and therefore the instantaneous voltage at time t will in general be a function of all the impulses in the time-series. The exception is at time nT where the instantaneous voltage is determined by b_n only. The central impulse may be seen as the non-distorting part of the signal path transient response, while the displaced impulses may be seen as the distorting part. It is these displaced impulses that cause the deviation from a flat gain-frequency characteristic.

The Fourier transform of the band-limited impulse response is

$$F(\omega)\Big|_{truncated} = \sum_{n=-\infty}^{+\infty} b_n e^{-j\omega nT}\Big|_{truncated} \qquad (8.4.4.2\text{-}2)$$

where each term, $b_n\delta(t-nT)$, is transformed to $b_n e^{-j\omega nT}$. A spurious impulse at time nT will therefore appear on the gain misequalization characteristic as a super-imposed ripple of frequency-interval 1/nT and amplitude $\pm b_n$. For example, a single impulse of amplitude 3%, displaced 200 ns from the main lobe, will have a normalized peak amplitude ±0.25 dB (with respect to the gain at 20 kHz) and a frequency-interval of 5 MHz. Impulses further out in time will have a closer frequency-interval.

The gain misequalization envelope to 1.25 MHz therefore limits the amplitude of impulses displaced by more than 200 ns (i.e., n is less than -8 or more than +8) because the Fourier transform of the spurious impulse must reach its first positive or negative peak before this frequency. The limit of ±0.25 dB meets the requirement of Equation 8.4.2-5 for a single spurious impulse (i.e., $c_n = b_n$)

Note that the gain misequalization envelope is not an efficient method of controlling the amplitude of transient response echoes. For example, divergence from the ideal response below 1.25 MHz may be caused by other distortion artifacts, or many small impulses may combine to produce a large composite ripple, and therefore the envelope may appear overly stringent in some implementations. Note however that further echo activity may be generated by the return losses of the path and interfacing equipment and therefore at system level the mid-band limit may be viewed as a compromise between rigor, understandability, economy of implementation, and testability.

8.4.5 Return Loss (5.1.1.2.1 and 5.3.1.2.1 of the Standard).

If the signal path were always presented with an ideal source and load impedance, such as under test conditions, the input and output return loss would not need to be controlled by the standard. Return loss is important to interoperability when two or more paths are cascaded or when a non-ideal source or load is connected instead of test equipment. In these circumstances, the return loss will add further transient response distortion, misequalization and gain error to the system and therefore needs to be controlled.

The AEIS may transfer Type A signals via a number of different signal path configurations as identified in figure 4 of the Standard. The worst permitted build up of distortion and loss would occur for an MSI to MSI transfer via two carriage stores when all path segments are low-loss and bi-directional. However such a situation may be unrealistic and therefore the effect of simpler configurations is initially considered here. Additional guidance on return loss build up for cascaded systems is provided in 8.5 herein.

Consideration must be given to the distortion created by return loss at a single store station where the MSI and ASI may be viewed as the source and load (in any order) and the carriage store routing network with umbilical cables is the effective signal path. Refer to figure 4 of the Standard. The performance of umbilical cables is discussed as a separate issue later in this section.

In general, a signal path with the scattering parameters S_{11}, S_{12}, S_{21} and S_{22} will generate the transmission vector

$$F(\omega) = \frac{S_{21}}{1 - S_{11}\Gamma_S - S_{22}\Gamma_L - S_{12}S_{21}\Gamma_S\Gamma_L + S_{11}S_{22}\Gamma_S\Gamma_L} \qquad (8.4.5\text{-}1)$$

Where:

a. The transmission vector $F(\omega)$ represents the gain and phase shift of the sinusoidal voltage developed across the load (at port 2) relative to the reference sinusoidal voltage that would have been developed by the source (at port 1) if its load had been ideal (i.e., a test load).

b. Γ_L denotes the reflection coefficient of the load equipment connected to port 2. Here the load may be either the MSI or ASI.

c. Γ_S denotes the reflection coefficient of the source equipment connected to port 2. Here the source may be either the MSI or ASI

The transmission vector may be modeled as the series of harmonically-related rotating vectors shown in Equation 8.4.4.2-2, where part of the behavior is determined by S_{21} (signal path gain and phase shift under ideal load and source conditions) and part is determined by the denominator which is due to return loss effects. The effect of return loss may be separated out if the signal path is assumed to add only delay but no distortion or loss when ideally terminated. That is

$$S_{21} = S_{12} = e^{-j\omega\tau} \qquad (8.4.5\text{-}2)$$

where τ is the (non dispersive) delay. If the reflection coefficients and remaining s-parameters in the denominator are small (less than 0.1 in magnitude) then Equation 8.4.5-1 may be re-written as

$$F(\omega)\Big|_{\tau} \approx 1 + S_{11}\Gamma_S + S_{22}\Gamma_L + e^{-j2\omega\tau}\Gamma_S\Gamma_L \qquad (8.4.5\text{-}3)$$

or

$$F(\omega)\Big|_{\tau} \approx 1 + \left|S_{11}\Gamma_S\right|\angle\phi_1 + \left|S_{22}\Gamma_L\right|\angle\phi_2 + \left|\Gamma_S\Gamma_L\right|\angle\phi_3 \qquad (8.4.5\text{-}4)$$

where the delay has been re-referenced to the output and the fourth order term has been neglected. Noting Equations 8.4.4.2-1 and 8.4.4.2-2, it would be possible to calculate the impulse distortion (and hence K-rating) arising from return loss if the polar behavior of the reflection products was known over the frequency range of interest. But MIL-STD-1760 can only control the return loss at each interface (i.e., the amplitude of the reflection terms) and consequently the distortion contribution can only be determined under worst case or statistical conditions. The worst case is: (i) the resulting vector will map to a single spurious impulse in the impulse response, and (ii) the spurious impulse will have a large (greater than ±8T) displacement from the non-distorting term. It can be shown that the specified return loss could introduce a spurious echo of 3%[5] under these conditions for an isolated connection of MSI to ASI via a carriage store and umbilical cables.

In most cases the hypothetical impulse response arising from return loss will be a grouping of impulses or an impulse closer in to the main term and therefore the implied 3% K-rating will be pessimistic for an isolated store station. A more probable situation would be a spurious impulse of 3% within ±2T, or a spread of impulses decreasing in amplitude in inverse proportion to further displacement, i.e., introducing a K-rating of perhaps one quarter of worst case. The balance of probability therefore is that the overall signal path K-rating for a cascaded aircraft and carriage store routing network will not be significantly degraded by return loss. See 8.5 herein for system level performance budgeting.

If the implementation of the aircraft routing network is passive then impedance loading at the second interface may translate into a lower return loss being observed at the first ASI. When this is the case, linear distortion will be increased through the AEIS.

The relationship between return loss, scattering parameter or reflection coefficient, and VSWR is shown in table VI for the AEIS interfaces.

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[5]Actually 3.1%

TABLE VI. Conversion of AEIS return loss requirements.

AEIS interface	return loss	$\lvert\Gamma\rvert$ or $\lvert S\rvert$	VSWR
ASI	20 dB	0.1	1.22
RNASP	20 dB	0.1	1.22
interface to RNASP	18 dB	0.126	1.29
MSI	25 dB	0.056	1.12
CSI	20 dB	0.1	1.22
CSSI	20 dB	0.1	1.22

The return loss requirements in MIL-STD-1760 are flat with frequency.

The return loss of the umbilical is not specified in MIL-STD-1760 because it is determined by the cable selection, length, and the choice of mating contacts. All of these factors are already controlled by the Standard. The effect of the mating contacts is included in the return loss requirement for each AEIS interface and therefore the umbilical may be seen as contributing electrical characteristics of the cable only. The assumed minimum return loss for each umbilical cable is 30 dB, although if this figure is degraded slightly with use, the effect at system level will not be significant. To ensure a cable return loss of greater than 30 dB, it is recommended that the maximum umbilical length is 2 meters.

8.5 HB Type A Signal Path System-Level Performance Budget.

8.5.1 General.

The Standard provides separate requirements for the aircraft routing network, the carriage store routing network and the umbilical cable. The overall electrical performance budget at system level will therefore have to be calculated for each signal path routing configuration. The applicable signal path electrical requirements are:

a. transient response

b. insertion gain

c. representative pulse delay

d. gain misequalization

e. incidental phase modulation

f. signal noise (random, periodic, impulse, stimulated)

g. common mode noise

Two sets of performance budgets are recommended in this Handbook for each electrical requirement. The first is based on a worst case analysis of the overall signal path[6]. This should be used when the achievement of a particular requirement is critical to system interoperability. The second set is based on a statistical analysis of the AEIS performance budget. The statistical budgeting process may contribute towards a more economic design of source and sink equipment for applications where the importance of achieving a particular requirement is subjective. One example is the routing of analog video on HB3 or HB4.

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[6] In fact, some practical considerations limit the realistic worst case contribution of return loss which affects some of the parameters.

For mission stores which cannot be suspended from a carriage store (because of physical, electrical or functional requirements), the designer can take advantage of the superior signal path performance provided by the aircraft routing network and umbilical with no carriage stores attached. However, in most other cases it is expected that the mission store will be designed to operate with up to one carriage store in the signal path. A signal path involving two carriage stores is also permitted by the Standard (see figure 8.4.2) and therefore some designers might wish to additionally consider this routing configuration. However it will be shown that the overall signal path behavior will be quite degraded, particularly in the worst case analysis.

The budget recommendations assume that the maximum cable length for each umbilical is 2 meters. An adjustment to the budget may therefore be required if longer cable lengths are to be used. For Type A signals, the primary effect of a longer umbilical is a reduction in return loss, although some noticeable gain misequalization may also be present in very long umbilical cables. Note that return loss is the only umbilical electrical parameter to be considered in the system-level budget calculations.

8.5.1.1 Summary of addition laws.

The addition laws in table VII are used to calculate the recommended system-level performance budgets. Each budget calculation is of the form

$$P_{AEIS}^{h} = P_{A}^{h} + nP_{CS}^{h} \qquad (8.5.1.1)$$

Where h is the addition law for which the aircraft performance budget, P_A , and n carriage store performance budgets, P_{CS} , may be combined to give the anticipated AEIS budget, P_{AEIS}.

In many cases, notably transient response, insertion gain error and gain misequalization, the return loss at each AEIS interface also contributes towards the performance budget calculation. The analysis of return loss is complicated and is handled separately in 8.5.2.

TABLE VII. Type A signal path addition laws.

Characteristic	P units	worst case h[1]	statistical h[1]	notes
T signal response envelope (figure 5 of MIL-STD-1760C)	K-rating[2]	1	1.5	Table 8.6.3-1
2T signal response envelope (figure 6 of MIL-STD-1760C)	K-rating[2]	1	1.5	Table 8.6.3-2
2T bar response envelope (figure 8 of MIL-STD-1760C)	% error	1	2	Table 8.6.3-3
insertion gain (error)	dB	1	2	Table 8.6.4
representative pulse delay	time	1	1.5	Table 8.6.5
representative pulse delay variation	time	1	1.5	Table 8.6.6
gain misequalization (figure 9 of MIL-STD-1760C)	dB	1	1.5	Table 8.6.7
incidental phase modulation	degrees	1	1.5	Table 8.6.8
random noise	V RMS	2	2	Table 8.6.8
periodic noise	V RMS	1	1.5	Table 8.6.8
impulse noise[3]	V	1	1	Table 8.6.8
stimulated noise[4]	V	1.5	1.5 or 2	Table 8.6.8
common mode noise	V	1	1.5	

Notes

1. The addition law does not take into account return loss. Where appropriate, the contribution of return loss must also be considered.
2. The K-rating system is discussed in 8.4 herein and elsewhere.
3. The build up of impulse noise may also occur as an increase in rate, rather than peak voltage, in many systems.
4. The addition law depends on the type of stimulated noise. If the noise is pseudo-random then the h = 2 law applies. If the noise is caused by non-linear distortion then the h = 1.5 law applies.

8.5.2 The contribution of return loss.

Non-ideal return loss behavior may result in the further build up of signal distortion when the different parts of the AEIS are inter-connected. This extra distortion must be added to the budget calculations described in 8.5.1.1.

The analysis of linear distortion arising from return loss is complicated by the choice of different signal path equivalent circuits (see figure 39), by the actual transmission characteristics of each signal path segment, and by the phase response of each impedance mismatch. It would be usual practice to obviate this uncertainty by imposing a stringent return loss requirement so that the effects of return loss could be ignored. However, in MIL-STD-1760 such an approach would be undesirable because it would prohibit the use of realistic lengths of subminiature cable or multiple cable breaks within the AEIS, and therefore a lower return loss performance must be tolerated. The penalty is greater complexity and less certainty in calculating the overall distortion limits.

Table VIII shows the K-rating budget arising from an isolated mismatch connection between the aircraft routing network and either the MSI or RNASP mating half. Both worst case and statistical values are provided. Table IX shows the overall K-rating budget for different AEIS configurations. Table IX is based on the assumption that the aircraft routing network is active[7], but the carriage store routing networks can be either active or passive. All path segments were assumed to be loss-less in arriving at these figures.

TABLE VIII. K-rating budget contribution of each aircraft signal path interface.

isolated interface	worst case K-rating	statistical K-rating
store station with no carriage store	±1.06 %	±0.265 %
store station with carriage store	±3.10 %	±0.775 %
RNASP	±1.26 %	±0.315 %

TABLE IX. Overall K-rating arising from return loss.

signal path configuration	worst case K-rating	statistical K-rating
RNASP to/from MSI with no carriage store	±2.32 %	±0.461 %
RNASP to/from MSI with carriage store	±4.35 %	±0.904 %
MSI to MSI with no carriage stores	±2.11 %	±0.421 %
MSI to MSI with one carriage store	±4.15 %	±0.875 %
MSI to MSI with two carriage stores	±6.19 %	±1.23 %

The worst case K-rating value is seen as contributing a flat percentage increase in the budget figures provided in tables X, XI, XII and XIII. This is because the time or frequency behavior of the extra distortion cannot be inferred in the worst case analysis. The statistical K-rating value on the other hand will contribute a true K-rating adjustment to the figures in tables X, XI, XII and XIII.

The budgeting procedure presented here is clearly a compromise between generality on one side and simplicity and practicality on the other. A more rigorous budgeting method is feasible, but at the expense of understandability and convenience for the general user of the Standard. However, in some circumstances the designer may wish to consider a more complex analysis. This might be necessary if:

a. The AEIS equivalent circuit is different from that recommended (i.e., a passive aircraft routing network is implemented).

b. The MSI or RNASP mating half return loss is chosen to be more stringent than MIL-STD-1760 to support a particular application signal

c. The return loss contribution of each umbilical cable (not including connectors) cannot be assumed to be 30 dB.

[7] That is, the return loss at one interface does not depend on the impedance match at the other ($S_{12} = 0$).

In analyzing the general case, consider equation 8.4.5-1 in 8.4 of this Handbook, which applies to a 2-port network with scattering parameters S_{11}, S_{12}, S_{21} and S_{22}. These scattering parameters may be arranged in a scattering matrix, i.e.

$$[S] = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \qquad (8.5.2\text{-}1)$$

For a 2-port network of n cascaded path segments, the scattering matrix may be expanded to

$$[S] = \begin{bmatrix} S_{11}^1 & S_{12}^1 \\ S_{21}^1 & S_{22}^1 \end{bmatrix} \begin{bmatrix} S_{11}^2 & S_{12}^2 \\ S_{21}^2 & S_{22}^2 \end{bmatrix} \cdots \begin{bmatrix} S_{11}^n & S_{12}^n \\ S_{21}^n & S_{22}^n \end{bmatrix} \qquad (8.5.2\text{-}2)$$

It can be seen that relating F(ω) in Equation 8.4.5-1 to a specific level of gain misequalization or transient response distortion, given no control of the phase or amplitude behavior of the reflection terms with frequency, would lead to difficulty in reconciling the practical and worst-case situations. This is left to the designer to resolve, who may be able to make simplifying assumptions about the specific application.

8.5.3 Transient response distortion.

It is recommended that the following performance budgets are considered for figures 5, 6 and 8 of the Standard. The budget includes the contribution of return loss and signal path transient response.

Table X is the recommended overall performance budget for the cosine-squared T signal. See figure 5b of the standard.

TABLE X. Overall performance budget for T signal response.

signal path configuration	min peak of response (%)	envelope at ±25 ns (%)	envelope at ±50 ns (%)	envelope at ±100 ns (%)
RNASP to/from MSI with no carriage store	72.9 (70.9)	18.4 (20.3)	10.1 (12.3)	5.1 (7.3)
RNASP to/from MSI with carriage store	68.3 (61.8)	24.0 (31.4)	12.0 (17.4)	6.0 (10.9)
MSI to MSI with no carriage stores	72.9 (71.1)	18.3 (20.1)	10.1 (12.1)	5.1 (7.1)
MSI to MSI with one carriage store	68.3 (61.9)	24.0 (31.2)	12.0 (17.2)	6.0 (10.7)
MSI to MSI with two carriage stores	64.8 (53.9)	28.8 (42.2)	13.6 (22.2)	6.8 (14.2)

Note that in this table the statistical addition is shown first and the worst case value is presented in parentheses. For video applications it is recommended that the designer assume the statistical values for establishing system requirements as some further unexpected degradation, although not desirable, may be tolerable for display applications. For time correlation signals, it is recommended that the worst case values are assumed, as inter-symbol interference could affect the usability of the system.

Table XI is the recommended overall performance budget for the 2T signal. See figure 6b of the standard.

TABLE XI. Overall performance budget for 2T signal response.

signal path configuration	min peak of response %	envelope at ±50 ns %	envelope at ±100 ns %	envelope at ±200 ns %
RNASP to/from MSI with no carriage store	87.5 (85.7)	12.5 (14.3)	6.2 (8.3)	3.1 (5.3)
RNASP to/from MSI with carriage store	79.9 (71.6)	20.1 (28.4)	10.0 (16.4)	5.0 (10.4)
MSI to MSI with no carriage stores	87.6 (85.9)	12.4 (14.1)	6.2 (8.1)	3.1 (5.1)
MSI to MSI with one carriage store	80.0 (71.8)	20.0 (28.2)	10.0 (16.2)	5.0 (10.2)
MSI to MSI with two carriage stores	73.6 (57.8)	26.4 (42.2)	13.2 (24.2)	6.6 (15.2)

Note that in this table the statistical addition is shown first and the worst case value is presented in parentheses. For video applications it is recommended that the designer assume the statistical values for establishing system requirements as some further unexpected degradation, although not desirable, may be tolerable for display applications. For time correlation signals, it is recommended that the worst case values are assumed, as inter-symbol interference could affect the usability of the system.

Table XII is the recommended overall performance budget for the 2T bar signal. See figure 8b of the Standard.

TABLE XII. Overall performance budget for 2T bar signal response.

signal path configuration	envelope tolerance
RNASP to/from MSI with no carriage store	±1.5 % (1.5)
RNASP to/from MSI with carriage store	±2.4 % (3.0)
MSI to MSI with no carriage stores	±1.5 % (3.0)
MSI to MSI with one carriage store	±2.4 % (3.0)
MSI to MSI with two carriage stores	±3.1 % (4.5)

Note that in this table the statistical addition is shown first and the worst case value is presented in parentheses. The calculations assume that the low frequency return loss performance is such that the distortion will have settled by the beginning of the envelope. For video applications it is recommended that the designer assume the statistical values for establishing system requirements as some further unexpected degradation, although not desirable, may be tolerable for display applications. For time correlation signals, it is recommended that the worst case values are assumed, as inter-symbol interference could affect the usability of the system.

8.5.4 Insertion Gain

The insertion gain budget in table XIII includes the contribution of signal path insertion gain and return loss[8].

TABLE XIII. Overall performance budget for insertion gain error.

signal path configuration	insertion gain tolerance (dB)
RNASP to/from MSI with no carriage store	+0.54, -4.0 (+0.7, -4.2)
RNASP to/from MSI with carriage store	+0.79, -4.2 (+1.4, -5.4)
MSI to MSI with no carriage stores	+0.54, -4.0 (+0.7, -4.2)
MSI to MSI with one carriage store	+0.78, -4.2 (+1.4, -5.4)
MSI to MSI with two carriage stores	+0.97, -4.3 (+2.0, -6.5)

Note that in this table the statistical addition is shown first and the worst case value is presented in parentheses. Because the insertion gain of the system can affect interoperability, it is probable that the designer will consider the worst case addition.

8.5.5 Representative pulse delay.

Table XIV. Overall performance budget for representative pulse delay and error.

signal path configuration	representative pulse delay
RNASP to/from MSI with no carriage store	2 µs ±35 ns
RNASP to/from MSI with carriage store	3 µs ± 70 ns (2.5 µs ±56 ns)
MSI to MSI with no carriage stores	2 µs ± 35 ns
MSI to MSI with one carriage store	3 µs ± 70 ns (2.5 µs ± 56 ns)
MSI to MSI with two carriage stores	4 µs ± 105 ns (2.9 µs ± 73 ns)

Note that in this table the statistical addition is shown first and the worst case value is presented in parentheses (if different). Because the pulse delay and pulse delay uncertainty of the system can affect interoperability, it is probable that the designer will consider the worst case addition only.

[8] The return loss impulse response is assumed to affect the 2T bar signal amplitude in accordance with the note for K2 and K3 in section 8.4 (with appropriate addition law).

8.5.6 Gain misequalization.

Table XV is the recommended budget for gain misequalization. See figure 9 of the Standard.

The budget calculation includes the effect of return loss as well as signal path gain misequalization (see 5.1.1.2.5 and 5.3.1.2.5 of the Standard).

TABLE XV. Overall performance budget for gain misequalization.

signal path configuration	envelope at 20 Hz (dB)	envelope at 0.2-1.25 kHz (dB)	envelope at 5-10 MHz (dB)	envelope at 20 MHz (dB)
RNASP to/from MSI with no carriage store	+0.26, -3.0 (+0.45, -3.2)	±0.26 (0.45)	±1.0 (1.2)	±3.0 (3.2)
RNASP to/from MSI with carriage store	+0.42, -4.8 (+0.87, -6.4)	±0.42 (0.87)	±1.6 (2.4)	±4.8 (6.4)
MSI to MSI with no carriage stores	+0.26, -3.0 (+0.43, -3.2)	±0.26 (0.43)	±1.0 (1.2)	±3.0 (3.2)
MSI to MSI with one carriage store	+0.42, -4.8 (+0.85, -6.4)	±0.42 (0.85)	±1.6 (2.4)	±4.8 (6.4)
MSI to MSI with two carriage stores	+0.55, -6.2 (+1.27, -9.5)	±0.55 (1.27)	±2.1 (3.5)	±6.2 (9.5)

Note that in this table the statistical addition is shown first and the worst case value is presented in parentheses. For video applications it is recommended that the designer assumes the statistical values for establishing system requirements as some further unexpected degradation, although not desirable, may be tolerable for display applications. For time correlation signals it is recommended that the worst case values are assumed, as inter-symbol interference and tilt could affect the usability of the system.

8.5.7 Incidental phase modulation.

Table XVI is the recommended overall performance budget for incidental phase modulation.

TABLE XVI. Overall performance budget for incidental phase modulation.

signal path configuration	incidental phase modulation
RNASP to/from MSI with no carriage store	5 degrees
RNASP to/from MSI with carriage store	8 degrees (10)
MSI to MSI with no carriage stores	5 degrees
MSI to MSI with one carriage store	8 degrees (10)
MSI to MSI with two carriage stores	10.5 degrees (15)

8.5.8 Signal noise.

Table XVII is the recommended overall performance budget for signal noise.

TABLE XVII. Overall performance budget for signal noise.

signal path configuration	random (dBm RMS)	periodic (mV RMS)	impulse (mV peak)	stimulated (dBm RMS)
RNASP to/from MSI with no carriage store	-45	0.8	40	-26
RNASP to/from MSI with carriage store	-42	1.06 (1.32)	50	-24.6 (-23.7)
MSI to MSI with no carriage stores	-45	0.8	40	-26
MSI to MSI with one carriage store	-42	1.06 (1.32)	50	-24.6 (-23.7)
MSI to MSI with two carriage stores	-40	1.29 (1.84)	60	-23.5 (-22.0)

Note that in this table the statistical addition is shown first and the worst case value is presented in parentheses (if different). The statistical stimulated noise budget will be the value in parentheses also if the noise is non-linear distortion rather than pseudo-random. For video applications it is recommended that the designer assume the statistical values for establishing system requirements as some further unexpected degradation, although not desirable, may be tolerable for display applications. For time correlation signals it is recommended that the worst case values be assumed.

8.5.9 Common mode noise.

The build up of common mode noise will depend on the common mode noise rejection (if any) of the signal paths. Worst case, the common mode noise at the output of a single carriage store and aircraft system is 400 mV RMS (600 mV RMS for a system with two carriage stores). The statistical budget is 320 mV RMS and 420 mV RMS if the designer is interested in the required common mode noise rejection performance of a signal-path or sink equipment.

8.6 Video signal path system-level performance.

8.6.1 General.

The transfer of analog monochrome video through the AEIS is permitted via the HB3 and HB4 interfaces. The applicable line standard is STANAG 3350 AVS, i.e.

- Class A 875 lines at 30 Hz
- Class B 625 lines at 25 Hz
- Class C 525 lines at 30 Hz

Video transfer is permitted to occur in either direction between the aircraft and store or between stores at different stations. However, the specific capability of the aircraft or store to utilize any line standard class or route HB3 or HB4 signals is system specific. The system model for MIL-STD-1760 analog video distribution is shown in figure 48.

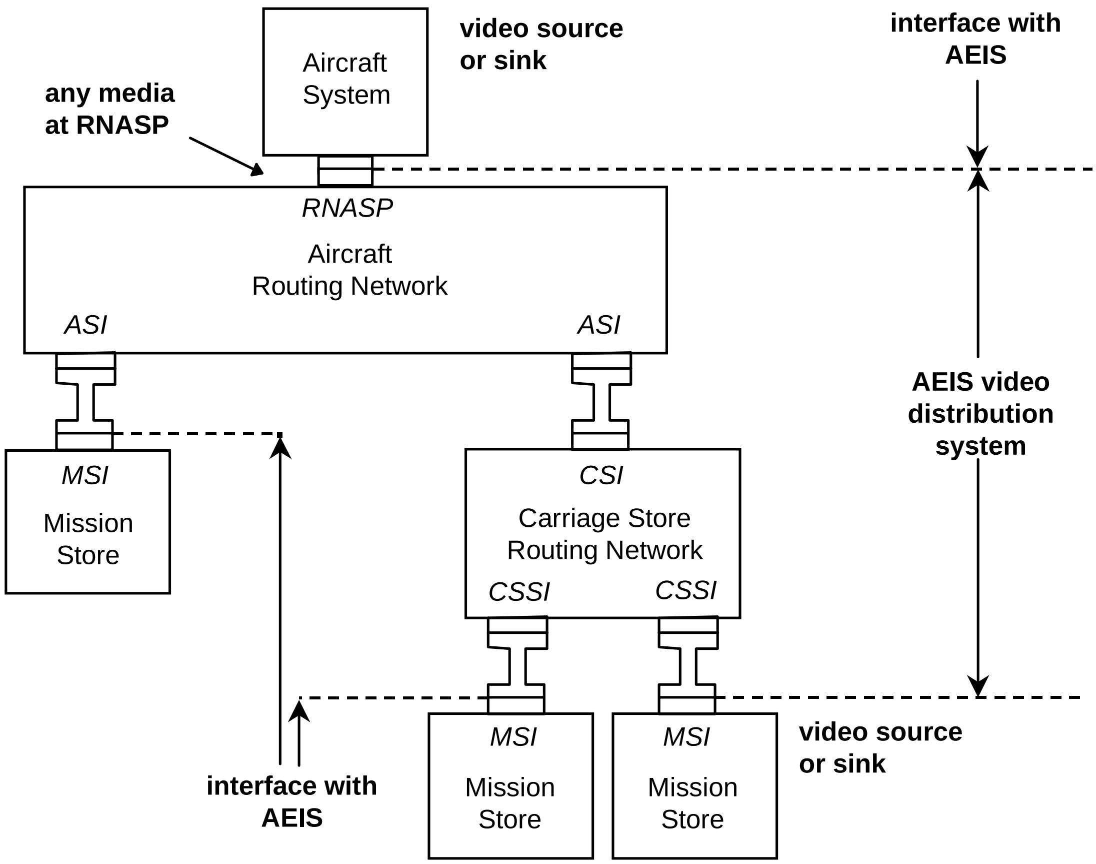


FIGURE 48. Model of AEIS video distribution system.

The chosen media of each RNASP and RNASP mating half is to be determined by the specific design of the aircraft. Thus, video signals may cross the RNASP in any digital or analog format using electrical or optical interfaces. However aircraft designs which diverge from STANAG 3350 AVS in this way will still be required to demonstrate equivalent fidelity and dynamic range to the requirements set out in MIL-STD-1760 and STANAG 3350 AVS as amended here. At the other AEIS interfaces, the literal requirements must be met for interoperability.

It is recommended that the RNASP mating half is located as near to the actual aircraft source or sink equipment as possible as further attenuation, distortion or noise would be undesirable. If the AEIS feeds into a further routing network, it might be prudent to apply the RNASP requirements directly to the utilization equipment interface rather than at the actual RNASP.

MIL-STD-1760 does not allow the AEIS routing network to carry out video-specific operations such as scan conversion, DC-restoration, sync pulse shaping or automatic gain control. This is because the HB3 and HB4 signal assignment may be enlarged in future to cater for other applications besides video.

8.6.2 Line standard characteristics.

The aircraft and mission store must be compliant with all of the line standard characteristics detailed in Table A of STANAG 3350 AVS for each implemented line standard class.

8.6.3 Source equipment.

Source equipment requirements are defined at the MSI for mission stores and at the RNASP mating half for aircraft systems. The source equipment must present a Thevenin equivalent circuit and source impedance tolerance as defined in MIL-STD-1760 paragraphs 4.3.1, 5.2.1.2.1 and 5.2.1.4 (for mission stores) or paragraphs 4.3.1, 5.1.1.2.1 and 5.1.1.4 (for aircraft equipment). This supersedes the STANAG 3350 AVS source equipment requirements, which are considered too severe for store applications.

Mission store video sources are not required to make provision for external synchronization unless warranted by the aircraft-store system design. If necessary, external synchronization may be provided using an appropriate composite video signal via the HB4 interface.

It is highly recommended that the designer consider the short circuit and signal transient handling requirements of STANAG 3350.

It is recommended that Table B of STANAG 3350 AVS is replaced with table XVIII below for MIL-STD-1760 applications.

TABLE XVIII. Video source signal requirements.

characteristic	class A	class B	class C
output voltage level (peak to peak) when terminated in 75 ohms	1 V ± 5%	1 V ±5%	1 V ±5%
maximum signal slew rate	65 V/µs	65 Vµs	65 V/µs
gamma	1	1	1
passband compatibility	20 Hz to 20 MHz	20 Hz to 20 MHz	20 Hz to 20 MHz

8.6.4 Sink equipment.

Sink equipment requirements are defined at the MSI for mission stores and at the RNASP mating half for aircraft systems. The sink must present a Thevenin equivalent circuit and sink impedance tolerance as defined in MIL-STD-1760 paragraphs 4.3.1, 5.2.1.2.1, and 5.2.1.4 (for mission stores) or paragraphs 4.3.1, 5.1.1.2.1, and 5.1.1.4 (for aircraft equipment). This supersedes the STANAG 3350 AVS sink equipment requirements, which are considered too severe for store applications.

It is highly recommended that the designer consider the signal transient and common mode handling requirements of STANAG 3350.

It is recommended that table C of STANAG 3350 AVS is replaced with table XIX for MIL-STD-1760 applications.

TABLE XIX. Video sink interface requirements.

characteristic	class A	class B	class C
input voltage level (peak to peak) for mission store[1]	0.45 to 1.3V ± 5%	0.45 to 1.3V ±5%	0.45 to 1.3V ±5%
input voltage level (peak to peak) for aircraft equipment[2]	0.5 to 1.2V ±5%	0.5 to 1.2V ±5%	0.5 to 1.2V ±5%
minimum signal to noise ratio	Table 8.7.5	Table 8.7.5	Table 8.7.5
gamma (nominal)	1	1	1
noise bandwidth	DC to 20 MHz	DC to 15 MHz	DC to 12 MHz

Notes

1. The input voltage level range for mission stores is based on a worst-case analysis of the AEIS insertion gain error when two carriage stores are in the signal path. This will be pessimistic for most mission store applications. See table XIII of 8.5 herein.
2. The input voltage level range for aircraft equipment is based on a worst case analysis of the AEIS insertion gain error when one carriage store is in the signal path. See Table XIII of 8.5 herein.

8.6.5 Signal distribution budget.

The video distribution system is the MIL-STD-1760 AEIS, including all equipment between the MSI mating half and RNASP (or second MSI mating half). For the MIL-STD-1760 application, Table D of STANAG 3350 AVS may be replaced with table XX below for all three line standard classes.

TABLE XX. Distribution budget.

characteristic	no carriage stores in path	one carriage store in path	two carriage stores in path
signal to self induced noise ratio[1,2]	37.2 dB	35.8 dB	34.7 dB
signal to noise ratio (random)[1,3]	48.8 dB	45.8 dB	44.0 dB
signal to noise ratio (periodic)[1,4]	54.4 dB	52.5 dB	50.7 dB
signal to noise ratio (impulse)[5]	28.0 dB	26.0 dB	24.4 dB
crosstalk rejection[6]	45.4 dB	43.5 dB	41.7 dB
differential signal delay[7]	not controlled	not controlled	not controlled
minimum -3 dB bandwidth referenced to gain at 20 kHz[8]	20 Hz to 20 MHz	51.6 Hz to 13.5 MHz	73.7 Hz to 11.6 MHz
gain measured at 20 kHz[9]	-4.2 dB to +0.7 dB	-5.4 dB to +1.4 dB	-6.5 dB to +2.0 dB
gamma (nominal)	1	1	1

Notes

1. The signal to noise ratio (self induced, random or periodic) is the ratio of the peak-to-peak reference video component (i.e.1Vpp) to the unweighted RMS noise. The signal to noise may be further reduced by the signal path insertion loss. For video distribution, the statistical values in table XVII herein are used for system budgeting.
2. That is, stimulated noise as defined in paragraph 3.1.11 of MIL-STD-1760.
3. This value assumes that the unweighted RMS random noise density is flat over the 20 Hz to 20 MHz transmission passband. Refer to the guidance and rationale associated with paragraph 5.1.1.8.1 of the standard, however note that the signal to noise values in the guidance and rationale are based on the CCIR definition as opposed to the STANAG 3350 AVS definition. Random noise is defined in paragraph 3.1.8 of the Standard.
4. Periodic noise is defined in paragraph 3.1.9 of the Standard. The signal to noise is based on the values in table XVII herein, but adjusted by 7 dB to take into account the flat part of the periodic noise weighting function as shown in figure 11 of the Standard. Refer to the rationale and guidance associated with paragraph 5.1.1.2.8.2 of the Standard.
5. Impulse noise is defined in paragraph 3.1.10 of the Standard. In contrast to self-induced, random or periodic noise, the impulse noise is quantified by its peak to peak value. Impulse noise is therefore not controlled by Table D of STANAG 3350. The signal to noise ratio is related to the peak-to-peak reference video component (i.e., 1Vpp). For video distribution, the statistical values in table XVII herein are used for system budgeting.
6. Cross-talk rejection is controlled by the periodic noise requirement. Refer to the guidance associated with paragraph 5.1.1.2.8.2 of the Standard. The cross-talk rejection is the ratio between the peak to peak cross-talk (i.e., periodic noise) and the peak to peak reference video component.
7. Differential signal delay, in the context of STANAG 3350 AVS, applies to the difference in propagation times between one path and another where two or more monochrome signals have to be mixed. It is not the intent of MIL-STD-1760 to control this parameter.
8. For video distribution, the statistical values in table XV herein are used for system budgeting.
9. The value in table XV is based on the worst case analysis of insertion gain error. Refer to table XIII herein.

8.6.6 Color video.

Facilities for RGB color video are not provided by MIL-STD-1760. The Standard does not demand the required channel matching to enable three lines from HB1, HB2, HB3 and HB4 to be used in concert for the transmission of RGB.

If the transmission of analog color video is required, the option is available to utilize an encoded color line standard such as NTSC or PAL.

8.7 Planned changes after MIL-STD-1760C Notice 1.

8.7.1 Relaxation of gain misequalization envelope.

It is planned to relax the gain misequalization envelope of MIL-STD-1760 figure 9 (ref. 5.1.1.2.5 and 5.3.1.2.5 of the Standard) and correspondingly tighten the allowed response envelope for the cosine-squared 2T signal of MIL-STD-1760 figure 6b (ref. 5.1.1.2.2 and 5.3.1.2.2 of the Standard).

This planned change arises from experience of using subminiature coaxial cables in MIL-STD-1760C aircraft. It is thought that the performance variability of such cables represents a risk to achieving the equalization requirements of the Standard.

The relaxation of MIL-STD-1760 figure 9 will be achieved while preserving the 3% K-rating of the aircraft and carriage store signal paths. For guidance on K-ratings refer to 8.5 of this Handbook. The K-rating will be preserved by extending the allowed response envelope of figure 6b from ±200ns to ±400ns.

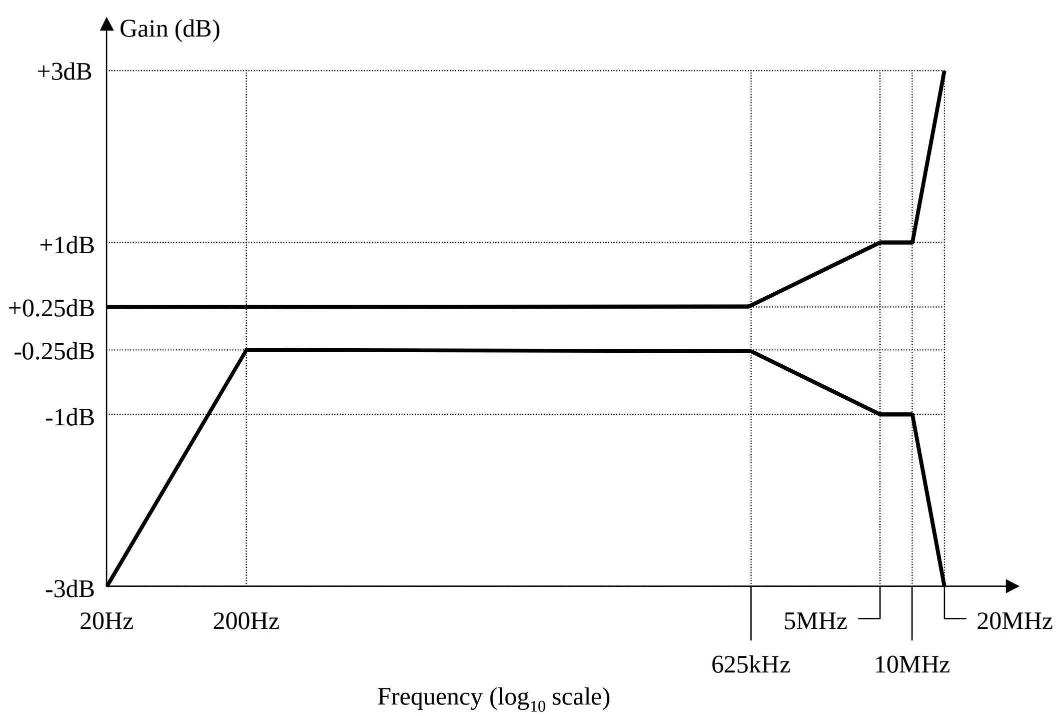
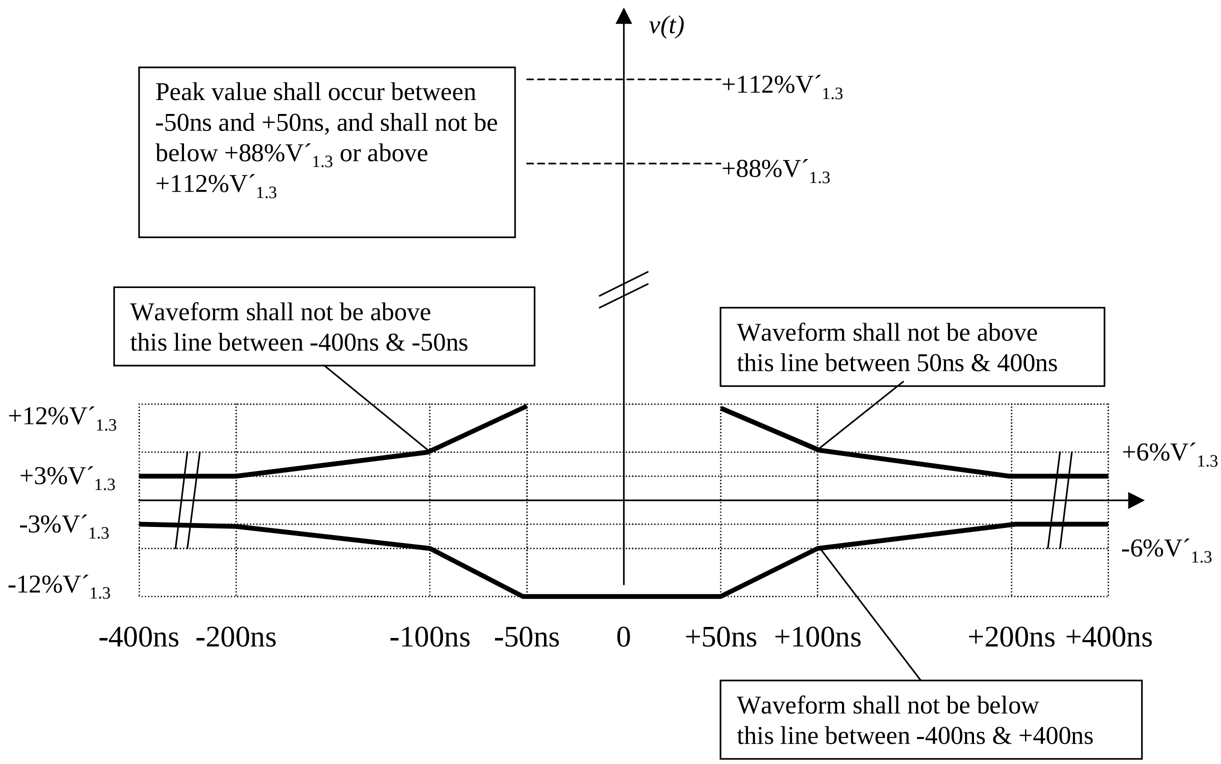


FIGURE 49. Proposed MIL-STD-1760 figure 9 relaxed gain misequalization envelope.



Note: The time origin (0ns) for the envelope is arbitary with respect to both the stimulus and response waveforms.

FIGURE 50. Proposed MIL-STD-1760 figure 6b – Relaxed allowed response envelope for cosine-squared 2T signal.

9. Low bandwidth (LB).

The LB interface is provided to transfer low frequency, low power level signals, which for various reasons are inappropriate for transfer over the digital data bus interface. Tones and voice grade audio currently represent the only allowed signals on the LB interface. This interface must not be used for transmitting discrete signals since such use would be an obstacle to aircraft/store interoperability. The LB interface must support the transfer of LB signals sourced either by mission stores (measurable at the MSI) or by internal aircraft systems (measurable at the RNASP).

In addition to the information in this section of the Handbook, the rationale and guidance in 15.4.3.3, 15.5.1.3, 15.5.2.3, and 15.5.3.3 (and subparagraphs) should also be consulted.

The requirements of the standard include the effect of the applicable mating contacts.

9.1 LB characteristics.

Use of the LB interface is limited by the Standard to the transfer of specific types of signal. It is possible that as the Standard matures the paragraph may be updated to include the transfer of further signal types. The intent is to control the growth of application signals that utilize the LB interfaces to achieve the maximum level of interoperability between aircraft and stores in the future. To cater for signal growth, aircraft and carriage store routing networks should be capable of transferring any signal that meets the general requirements of the standard and not be limited to the present-day signal assignment only.

The characteristics of the interface were originally defined to accommodate its potential use for transferring low speed digital data using balanced line differential receivers and drivers such as those defined by EIA Standard RS-485. This application, as a low cost alternative to the MIL-STD-1553 data bus, is no longer being considered and was dropped from the standard in revision C because of the wide availability of 1553 hardware.

9.1.1 Bandwidth.

LB signals are required to be compatible with a transmission passband of 300Hz to 3.4kHz. The LB signal may have frequency components outside this passband if subsequent truncation of the power/energy spectrum to the minimum passband does not affect the usefulness of the signal. Note that the voltage requirements are not band-limited and therefore can include a DC component.

9.1.2 Voltage.

The LB signal is defined in the standard as having a maximum instantaneous signal voltage (between the non-inverting connection and the inverting connection) of ±12V with the peak to peak signal voltage being 12V maximum. The maximum instantaneous common mode voltage (the sum of the voltages between the non-inverting connection and reference ground and the inverting connection and reference ground) is ±1V.

The LB signal between the non-inverting terminal and the inverting terminal consists of the signal plus a DC component. Therefore the requirements are defined in terms of volts peak-peak and an allowable DC offset. The common mode voltage is controlled to ensure that the signal is balanced. The figure of ±1V is a subjective one.

The maximum signal voltage requirement of 12 Vpp reflects the use of AC-coupling as some dynamic overhead may be required under transient conditions or for non-sinusoidal steady-state signals (hence the ±12V instantaneous voltage requirement also).

Note that the voltage level (12Vpp) is low compared with the amplitude typical of some current non-1760 audio sourcing missiles such as AIM 9. The lower amplitude is specifically selected to allow the aircraft to use solid state technologies for the internal distribution network. If an aircraft designer uses a common distribution network for MIL-STD-1760C LB signals and non-MIL-STD-1760C audio signals, then the network can either attenuate the non-MIL-STD-1760C audio signal amplitude, or be designed to handle higher voltages. It is not considered necessary or appropriate for the standard to mandate a higher voltage distribution network, since increasing the peak-peak voltage would also drive up the instantaneous voltage range which is not acceptable from a practical point of view.

The voltage requirements apply at the signal source output (MSI or RNASP) when the output is terminated with 600 ohms. These requirements assume an analog electrical network is employed. If other technologies (e.g. digital, fibre optic) are used, different requirements may be used at the RNASP provided they result in equivalent performance at the ASI.

9.1.3 Cabling.

The standard defines the LB interface as a three terminal connection; a non-inverting line, an inverting line and a grounded shield. While the standard does not mandate use of a shielded twisted pair cable for implementing this interface, that is the underlying intent. The standard does not define the specific type of cable to be used on any of the interfaces. Cable selection is considered an aircraft and store design issue (see section 14).

9.1.4 Impedance.

The final interface electrical characteristics required by the AEIS standard are the source and sink impedances. The nominal source and sink impedances are 0 ohms and 600 ohms respectively. These input and output impedances (line-to-line) of each signal path apply over the frequency band 150Hz to 8kHz. An impedance tolerance of ±10% is a typical requirement in audio transmission systems. It is assumed, but not stated, that the nominal impedance is resistive with the error component being either real or complex.

9.2 Aircraft design requirements.

The aircraft is required to provide a low bandwidth (LB) interface at all ASIs. This LB interface feeds into an aircraft LB distribution network or at least what appears at the ASI to be a distribution network. The specific aircraft equipment that is the ultimate recipient or source of the LB signals is application dependent and is not defined by the standard. All that the AEIS standard requires is that the distribution network be capable of transferring signals with specific characteristics.

9.2.1 Network implementations.

The use of a centralized distribution network (figure 51a) is recommended to provide the low bandwidth network in the same area as the high bandwidth network. However, this is dependent on the particular aircraft implementation. A centralized system results in greater aircraft wiring weight. In a distributed system where the network is "daisy chained" (figure 51b), the removal of a unit such as a pylon mounted Store Station Equipment (SSE) would result in the loss of the low bandwidth network to units further down the chain.

There are three main areas to consider before deciding whether a centralized or distributed approach is most appropriate.

9.2.1.1 Amount of aircraft wiring.

This is primarily dependent on the number of network paths to be provided for low bandwidth signals. From figure 51 it can be seen that a centralized approach requires more aircraft wiring than a distributed network for a single path. As more paths are added then a centralized network becomes more attractive in terms of amount of aircraft wiring.

9.2.1.2 Broken networks.

If the network is implemented in a "daisy chain", then removal of an SSE unit will break the chain and disconnect other ASIs from the low bandwidth network. Adding junction boxes in the aircraft wiring to "T" off the low bandwidth signal to removable SSE is possible, but this greatly complicates the aircraft wiring. A centralized network does not have this problem.

9.2.1.3 Similarity with high bandwidth network.

A neater design may result if all the analog signals are switched in the same location. Provisions would already have been made for the high bandwidth network to ensure interference to or from the high bandwidth signals is minimized. The same type of provisions may be needed for the low bandwidth signals, so grouping the low bandwidth signals with the high bandwidth signals would minimize the additional provisions necessary to reduce interference associated with the low bandwidth signals.

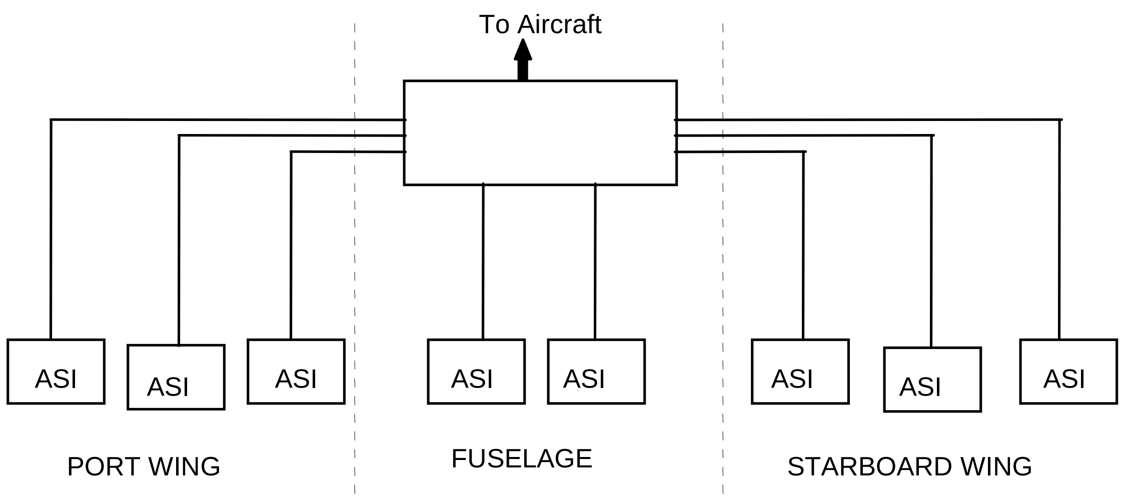


Figure 51a. Centralized LB network.

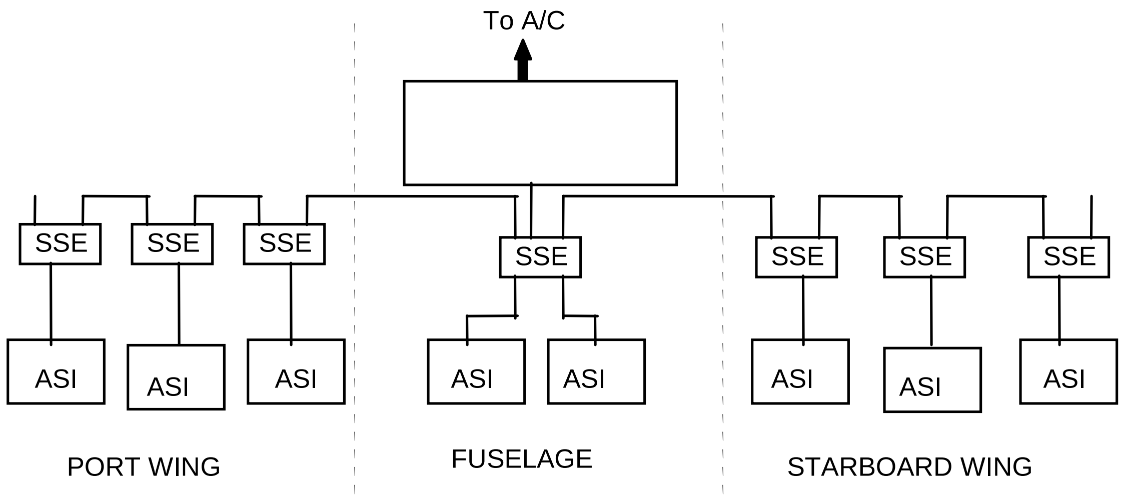


Figure 51b. Distributed LB network.

FIGURE 51. Centralized and distributed low bandwidth networks.

9.2.2 Technology.

The LB signal distribution network in the aircraft can be implemented using different technologies which include electromechanical and solid state switches, frequency division multiplexing (FDM) techniques, and active analog buses.

If electromechanical relays are to be used, it is recommended that signal relays similar to MIL-R-39016 be used for switching the low bandwidth signals.

Semiconductor switches of comparable size to MIL-R-39016 relays would introduce significant series impedance into the low bandwidth signal lines which could cause severe degradation or attenuation of the signals dependent on the driving or receiving circuits. MIL-R-39016 equivalent relays would have little effect on the signal quality over the frequency range of the low bandwidth network.

The use of FDM technology might be attractive if this is also to be used for implementing the high bandwidth Type A signal network. This would allow numerous signals to be transmitted on a single wire, but involves extra multiplex and demultiplex hardware and can result in a system that can be completely disabled by a single point failure.

In addition, due to the low frequency range, the LB signal can also be digitized and then transmitted over some form of digital data bus or point-to-point digital data link. As a general case, it is not practical to send digitized LB signals over MIL-STD-1553 unless a large percentage of the data bus's capacity can be devoted to LB service, or unless additional circuitry is included for achieving data compression.

Current requirements, for say AIM 9, will require aircraft to be fitted with a shielded wire capable of carrying a crude signal in the audio range. In order to connect the weapons to the intercom, some form of simple switching is provided. Consideration should not therefore be given to extending this facility, but rather that a totally new installation is planned. If all low bandwidth switching takes place in a special-to-type LRU, then growth can be easily provisioned for the switching and possibly to extend the use of the low bandwidth interface.

9.3 Mission store low bandwidth interface.

The low bandwidth interface requirements only apply to those mission stores which use the interface. If the store does not use the LB interface, then only a limited set of requirements apply. These are:

a. The MSI receptacle must be compatible with mating umbilical plugs which contain the LB interface twin-axial contact.

b. Impedance measurements made with this mating plug at the MSI must indicate a line-to-line, noninverting-to-inverting connection impedance of 540 ohms or greater, i.e. can be an open circuit.

c. Measurement of the LB shield connection at the MSI must indicate either an open circuit or continuity to store structure ground.

In contrast, if the store uses the LB signal interface, then the requirements of MIL-STD-1760C paragraph 5.2.3 apply and the comments below should be considered.

9.3.1 Design requirements.

The LB signal, sourced by the store or delivered to the store by the aircraft, is limited to -12 volts to +12 volts peak over the frequency range 300Hz to 3.4 kilohertz. The 300Hz to 3.4 kilohertz is intended to define the passband of the aircraft distribution network. As a result, a store's signal might contain frequency components outside this band, harmonics or a DC component for example, but the store must not rely on having these out-of-band signal components delivered to load equipment. Likewise, store LB receivers must not assume that signals sourced to the store will not contain frequency components outside the passband. The store is permitted, however, to filter out or otherwise discard these out-of-band components.

When the LB interface in the MSI is acting as a source, it is required to have a total source impedance not exceeding 60 ohms. When the LB interface in the MSI is acting as a sink, the input impedance is required to be 600 ±60 ohms. These requirements apply over the frequency band 150Hz to 8kHz.

9.3.2 Circuit implementations.

The store LB circuit design needs to be compatible with the aircraft network characteristics discussed in 9.2 and the design requirements described in 9.1.

Since MIL-STD-1760C restricts the use of the LB interface to audio frequencies, the use of transformer coupling as shown in figure 52 is a viable design choice. Transformer coupling provides the opportunity to de-couple the store signal ground from the aircraft sub-system signal ground. This de-coupling significantly reduces the injection of structure ground noise into the audio system.

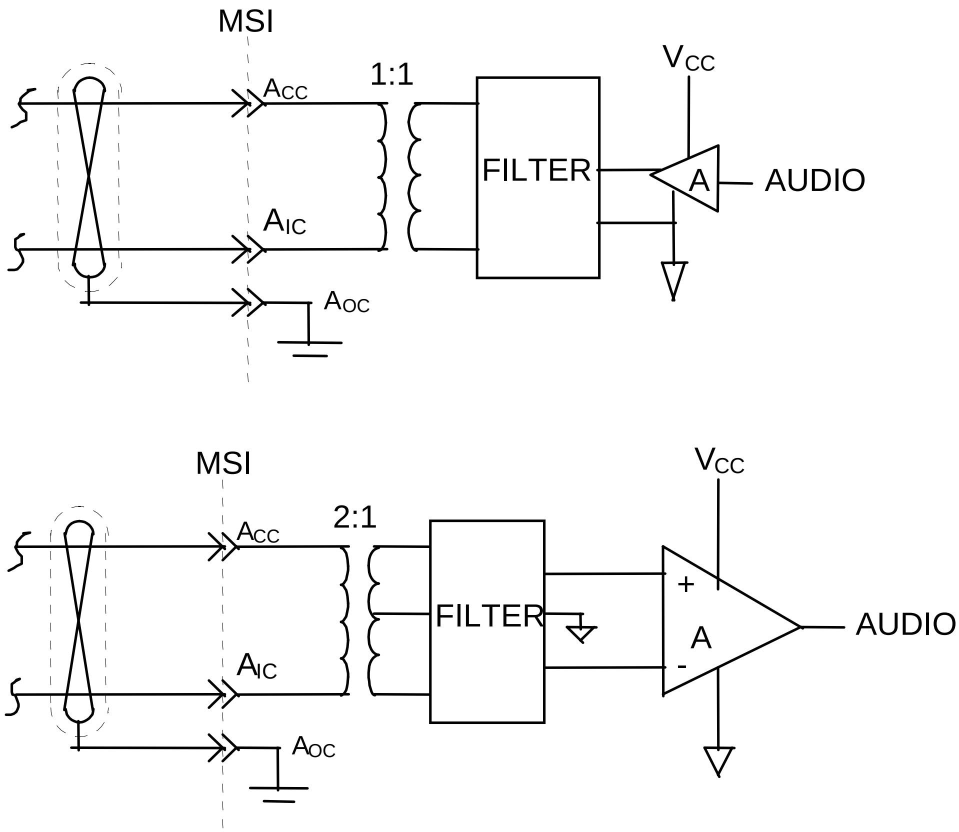


FIGURE 52. Transformer coupled audio.

9.4 Grounding requirements.

MIL-STD-1760C requires the store to ground the low bandwidth (LB) interface shield on the store side of the MSI. This ground connection, when combined with the aircraft requirements to ground the LB shield, results in a multi-point shield ground for the LB interface. Test results indicate that even though the LB interface operates at relatively low frequencies, which generally suggests a single ended shield ground, a multi-point shield ground provides low induced noise levels from external fields. These results are somewhat expected given that the LB line uses a shielded twisted wire pair. The twisted wire pair provides the electromagnetic de-coupling which allows the shield to be used as an electrostatic shield. Electrostatic shielding is more effective if multi-point grounding is provided.

The standard only requires that the shield be grounded somewhere on the aircraft side of the ASI and on the store side of the MSI. The specific physical location of the shield connection and the method of termination is not specified by the Standard.

9.5 Differential signal transmission.

To provide a degree of immunity from differences in ground potential between the aircraft and store, differential systems are recommended.

MIL-STD-1760C restricts the use of the LB interface to tones and voice grade audio signals, i.e. no DC component. Consequently, isolation transformers can be used (see figure 53) to minimize EMC problems, i.e. the electronics power supply grounds in the aircraft and store can be isolated from each other. Figure 54 shows a typical implementation example using a bi-directional transceiver. Proper operation of the transceiver circuit requires the presence of a signal return path to the store's transceiver. This circuit reference is established by a connection to the aircraft structure through a 100 ohm resistor. Ground continuity to the mission store circuit is provided through the shield and the structure ground line. Due to high common mode rejection of these differential receivers, acceptable operation is still available even with poor quality and high noise content of this return path.

The low bandwidth interface defined in MIL-STD-1760C must be capable of transmitting bi-directional signals in the 300Hz to 3.4 kilohertz range. MIL-STD-1760C also defines a three terminal connection for signal transmission which is conducive to differential driven techniques. For audio systems, a single point system grounded at the source or load is preferred. From a practical viewpoint, however, a single point ground system cannot be achieved when dealing with the interconnection of two vehicle systems (an aircraft and a store), which are mechanically attached to each other. The next best alternative is to isolate the signal systems of the two vehicles such that structure ground noise cannot loop through the two systems even if their structures are linked together.

Figure 55 shows how isolation can be achieved with dual transformer coupling, single transformer coupling, differential amplifier coupling and optical coupling. The LB interface definition in MIL-STD-1760C allows any of these implementations. Figure 55a and figure 55b show two variations on transformer coupling. The primary advantages of figure 55a over figure 55b are:

a. The additional design flexibility offered the store designer in selected load voltage/current combinations on the right side of transformer T2,

b. desensitizing the store load circuitry from line imbalances throughout the aircraft distribution network.

Transformer coupling will not pass any DC components of a specific signal and this is one reason the transformer in the two figures is shown on the aircraft equipment side of the LB distribution network.

An alternative is the electronic coupling of differential receivers as shown in figure 55c. This method relies on the high input impedance at the line receiver and the differential operating mode, to cancel any voltages which are common to both lines. However, since the circuit contains electronic coupling, a current return path is required from the store's signal ground to the aircraft signal ground. This path is provided from store signal ground through R_S to shield, through R_A to aircraft signal ground. The resistor values for R_A and R_S should be as high as practical to achieve the desired level of signal ground-to-structure ground isolation. However, the higher these resistor values, the lower the differential signal becomes. A value of 100 ohms is typically used for digital level signals.

The final coupling, optical, is illustrated in figure 55d. While the previous methods are suitable for both digital and analog signals the optical method is best used for digital only. The main advantage of this method is elimination of the need for the aircraft and store signal grounds to be interconnected, even through a "high impedance". The inverting and non-inverting lines of the LB interface take turns as the signal return as the signal polarity reverses.

The signal path equivalent circuits ensure that a differential, balanced transmission scheme is implemented with the correct signal zero-volt reference and shield grounding points defined.

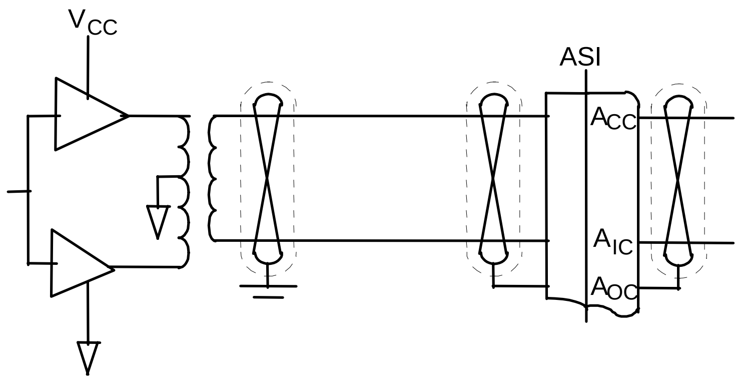


FIGURE 53. Transformer coupling implementations.

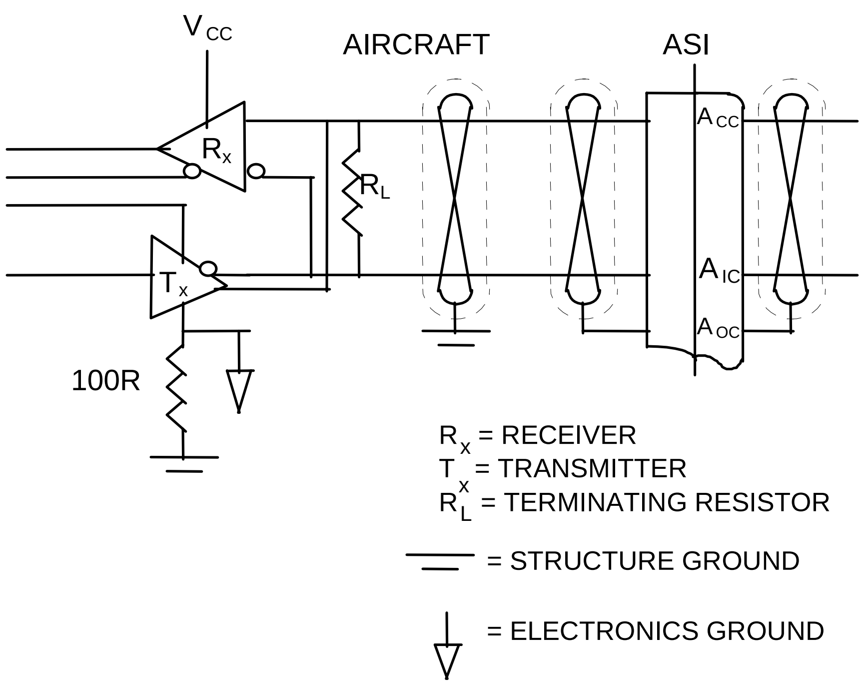


FIGURE 54. Balanced transmitter / receiver implementation

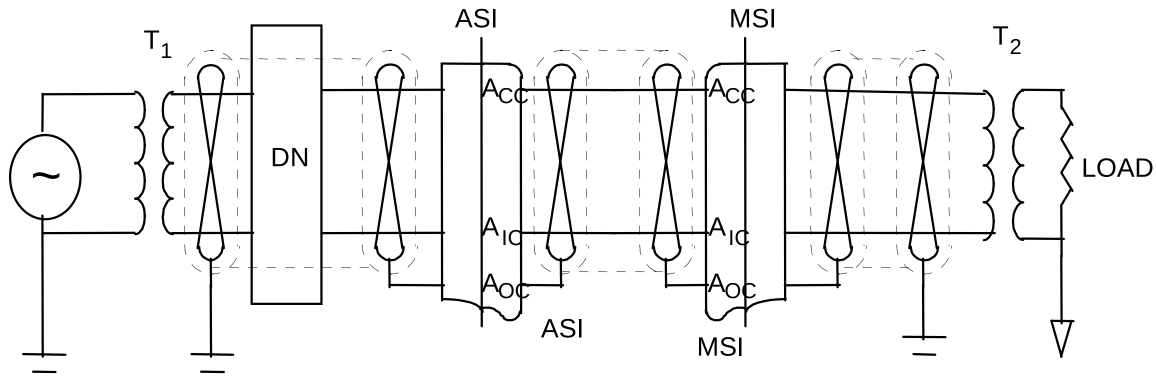


Figure 55a. Dual transformer

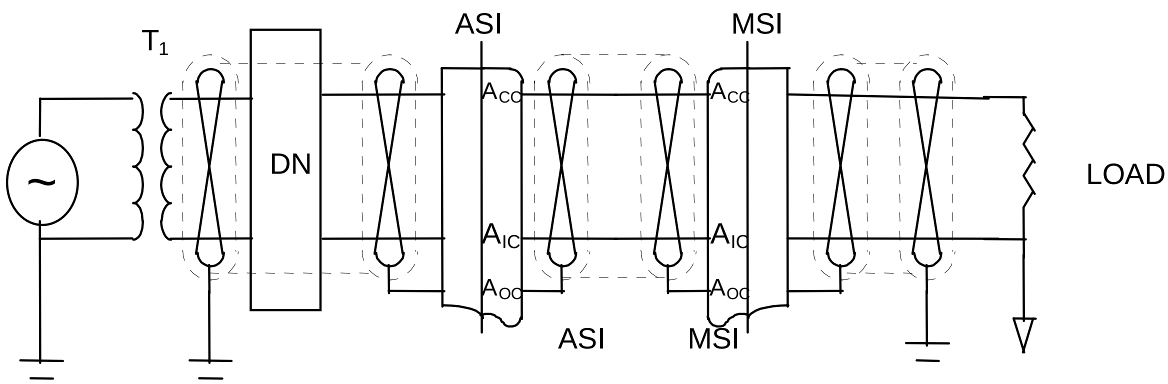


Figure 55b. Single transformer

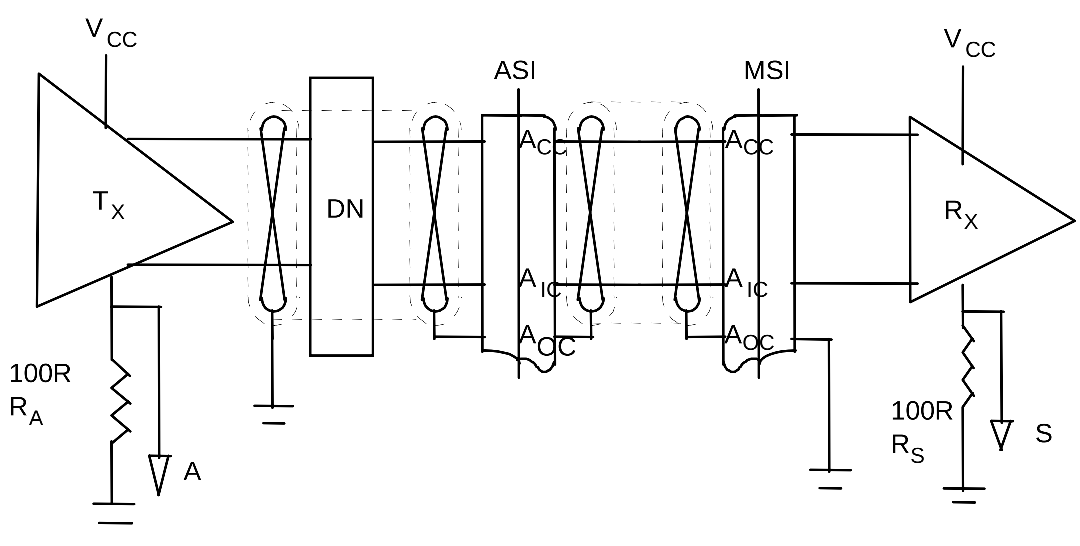


Figure 55c. Differential amplifier

FIGURE 55. Low bandwidth grounding options.

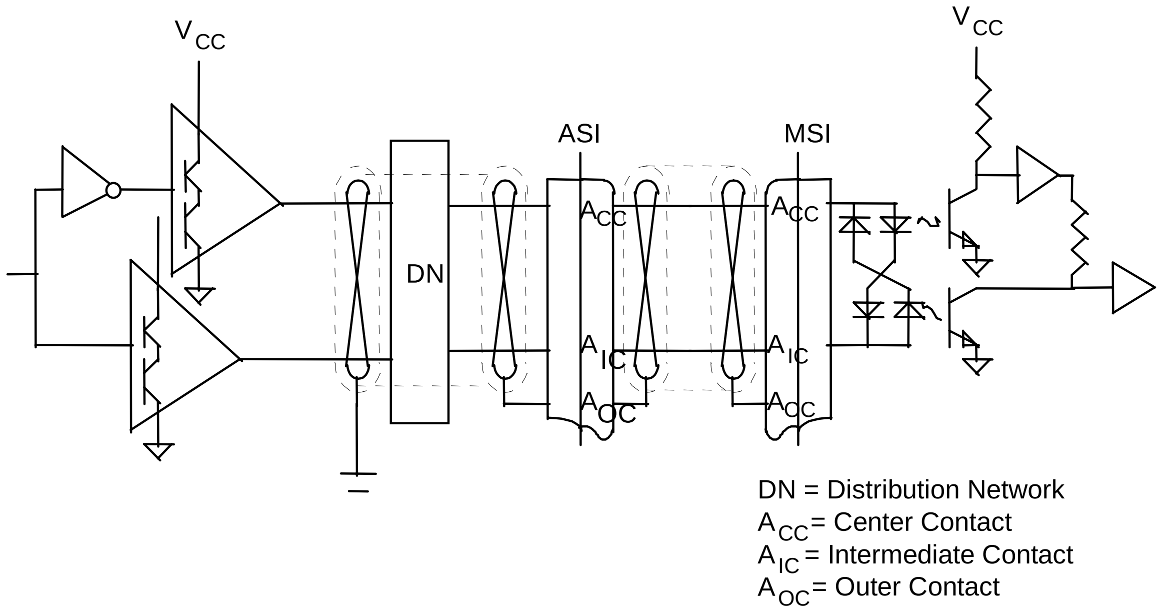


Figure 55d. Optical coupler

Figure 55. Low bandwidth grounding options. (cont)

9.6 Electromagnetic considerations.

Voltage limiting devices should be used on the signal lines as they enter equipments to suppress any spikes or surges generated by electromagnetic pick up in the wiring.

Common mode voltage is not part of the signal but must be controlled for EMI reasons. It is better to control the non-inverting and inverting common mode voltages together rather than separately.

9.7 Analog network BIT.

The circuit shown in figure 56 could be used for BIT of LB analog network circuitry. BIT for these circuits is limited to monitoring the analog element drive signal.

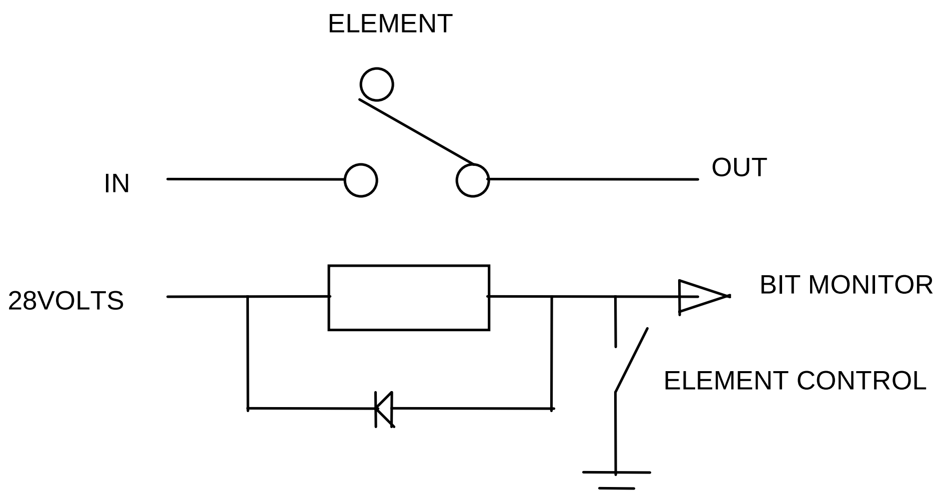


FIGURE 56. Analog network BIT.

9.8 Insertion gain.

Insertion gain is the amplitude of the signal at the output compared to the amplitude of the signal at the input. The total system budget for insertion gain (with one carriage store) is 0dB +2dB, -6dB. This overall figure is an addition of the aircraft budget (+1dB, -4dB) and the Carriage Store budget (+1dB, -2dB).

9.9 Equalization requirements.

The gain misequalization of any aircraft or carriage store signal path is defined by the standard. Gain mis-equalization is the permitted variance of the steady-state gain across the frequency passband. The lower limit (-2dB for the aircraft and -1dB for a Carriage Store) is set to cover the LB signal passband. The upper limit (+1dB for both the aircraft and Carriage Store) covers the extended frequency of 150Hz to 8kHZ defined for noise power.

9.10 Noise.

The standard requires the aricraft and carriage store signal path noise to be compliant over the frequency band 150Hz to 8kHz.

9.10.1 Periodic and random noise.

Cross-talk from other LB (and also HB) signal sources is treated as a form of periodic noise. Generally, when specific requirements for cross-talk rejection are established in other standards or specifications they apply to interference between identical signal types only (such as between two telephone signals). Requirements may then be based on knowledge of the interference waveform. In the case of MIL-STD-1760C however, a number of different signal types may be transferred across the interface with significantly different waveforms and therefore the noise contribution of cross-talk is more appropriately included within a more general noise requirement. Random noise is distributed over a large bandwidth.

The total system noise performance (including one carriage store) is 19mV RMS (addition law based on periodic noise). This equates to a signal-to-noise ratio of 47dB when the LB signal is a maximum-amplitude sinusoid. This compares favorably with the requirements of MIL-I-85850(AS).

MIL-I-85850(AS) also defined the minimum cross-talk interference between signal paths to be - 60dB.

For multiple simultaneous signal paths, the total cross-talk contribution could equal the periodic/random noise requirement (i.e.. -50dBrnC in MIL-I-85850(AS)).

9.10.2 Impulse noise.

The peak amplitude of an impulse (very narrow voltage spike) is proportional to the measurement bandwidth and therefore truncation of the energy spectrum to 8kHz (low pass) is very important. The practical design of a measurement filter (whether implemented physically or digitally) will also affect the result.

Cascading signal path segments together will either increase the impulse rate (if each segment is generating asynchronous impulses) or the impulse amplitude (if both segments are affected by the same external influence). Budgeting has been carried out on the premise that sources of impulse noise will be local to one signal path segment only, hence budgeting is based on impulse rate.

The system noise performance requirement (with one carriage store) is therefore two occurrences of impulse noise exceeding 20mV peak over a 3 minute period. Note that the (peak) signal to (peak) impulse noise ratio is approximately 50dB. This compares with the requirements of MIL-I-85850(AS). i.e. a maximum impulse noise is -50bBrnC (peak) when terminated, with a maximum of three occurrences in any 3 minute period.

-50dBrnC (peak) equates to 19mV (peak).

9.10.3 Stimulated noise.

Stimulated noise occurs as a result of harmonic distortion, intermodulation distortion, quantization noise and aliasing. MIL-STD-1760C budgets the overall stimulated noise between the aircraft (80mV) and Carriage Store (50mV).

9.10.4 Common mode noise.

Note that common mode noise is not actually signal noise. The purpose of controlling common mode noise is to minimize interference with other equipment of the AEIS interfaces and to prevent the finite CMRR of the receiving equipment from translating common mode noise into excessive signal noise. CMRR is not controlled by the standard.

Common mode noise needs to be controlled for the following reasons:

a. To limit the voltage ranges of the non-inverting connection with respect to ground and the inverting connection with respect to ground so that they can be accommodated by the receiving equipment.

b. To ensure that the signal is balanced and thus has controlled EMI.

c. To enable compatibility with the receiving equipment CMRR.

The required CMRR is implied but not stated. A ±1V common mode signal at the input should not increase the output periodic noise by more than the stated periodic and random noise requirement of 12.5mV RMS.

10. POWER AND STRUCTURE GROUND INTERFACES.

This section describes the electrical power interfaces, including characteristics of power to the ASI, carriage store power control and power available at the MSI. The use of 270V DC as a power source is also alluded to, although it is recognized that MIL-STD-1760C presently delegates this power system to a "growth" status only and it is not to be used until performance requirements for 270V DC are added to MIL-STD-1760. The standard (and this Handbook) does not require use of a specific kind or a specific size of power cable, since the intent is to standardize the characteristics of the interface without overconstraining the design of the aircraft or store.

10.1 Power source rating.

The aircraft electric power system must be capable of supplying 28V DC and 115/200V AC currents as defined by the "Maximum Load Current" curves in figures 17 and 18 of MIL-STD-1760C. The minimum requirement for a continuous operating condition is shown in table XXI. The 28V DC PWR 1, 28V DC PWR 2 and Auxiliary 28V DC power can be supplied from a common power source or from isolated power sources. Similarly, the 115/200V AC power can be supplied from a common or isolated power source. The design power capacity required at Class I and Class II ASIs is 4010 VA (3450 VA + 280 VA + 280 VA). The power required at a Class IA and Class IIA interface is established by the auxiliary signal set requirement which is 11190 VA (10350 VA + 840 VA). The total current required at a Class IA or IIA ASI through the combination of both primary and auxiliary connectors is 30 amperes of 28V DC and 30 amperes/phase of 115/200V AC. The actual maximum power available may be less than these numbers, since the source voltage is allowed to drop below the “nominal” 28V DC and 115/200V AC values, as discussed later. The number of ASIs that can be powered simultaneously at these levels is dependent on the power rating of the aircraft electric power system and is therefore not specified by MIL-STD-1760C.

TABLE XXI. Minimum continuous current rating at each ASI.

Voltage	Primary	Auxiliary
28V DC PWR 1	10 A	-
28V DC PWR 2	10 A	-
28V DC AUX	-	30 A
115/200V AC	10 A/PHASE	-
115/200V AC AUX	-	30 A/PHASE
270V DC	-	-
270V DC AUX	-	-

The primary signal set interface is always present at the ASI. Whenever an auxiliary signal set interface is present, some of the auxiliary power can be used to power the primary interface.

CAUTION
Supplying power from the auxiliary interface through the primary interface is not recommended without the addition of another series protective device. The aircraft's protective devices used to protect the auxiliary circuits will not directly protect the primary circuits. (See 10.10.1.)

It is recognized that the aircraft's primary interface wiring can be designed to be compatible with the auxiliary interface circuit protection system. The primary interface circuit downstream from the ASI probably will not, however, be compatible since the aircraft designer will have no control over this design. Furthermore, the "Maximum Overcurrent" of figure 17 of MIL-STD-1760C will not be met at the ASI under these conditions without additional protection.

10.2 Power return circuits interference issues.

Power ground returns are a frequent cause of interference problems due to the relatively high currents involved. It is imperative that the ground return path, e.g. aircraft structure or conductor, provide a low resistance to current flow. Figure 57 illustrates three options for grounding the return line, AC or DC. Figure 57a shows the best approach from an EMC perspective since the power delivered to the store is free of structure induced noise. However, this approach requires additional wire for the power return all the way back to the power source or distribution bus. This adds weight to the aircraft and consequently, is seldom used. A more likely design is shown in figure 57b, where the power return line is connected to the aircraft structure at a location near the ASI. However, this couples some structure ground noise into the power circuit. The approach shown in figure 57c is the least desirable, although acceptable and necessary for some applications.

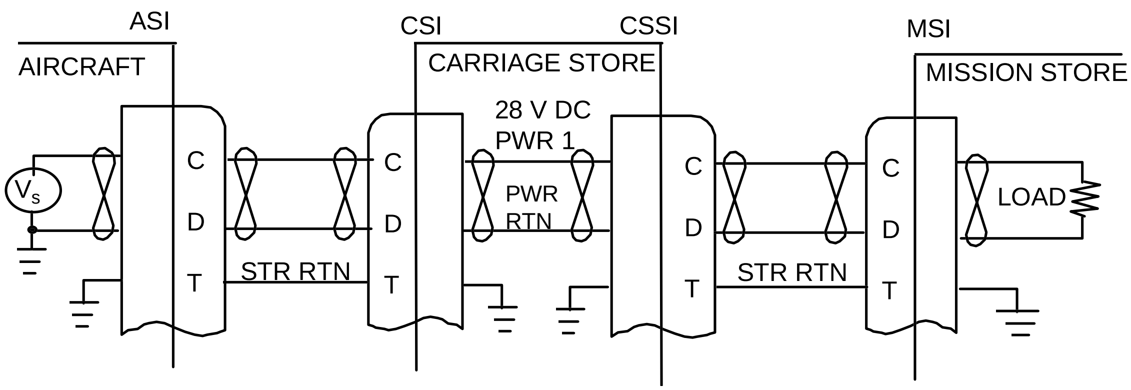


Figure 57a Single-point ground.

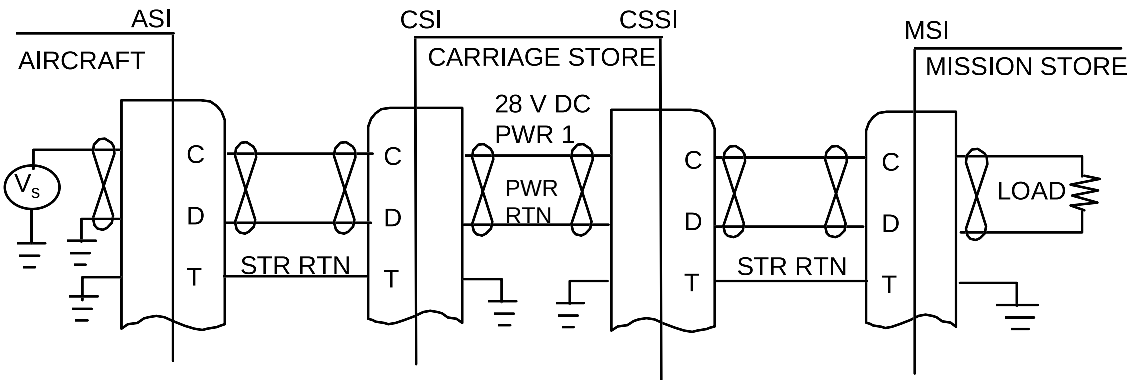


Figure 57b Isolated return to aircraft structure.

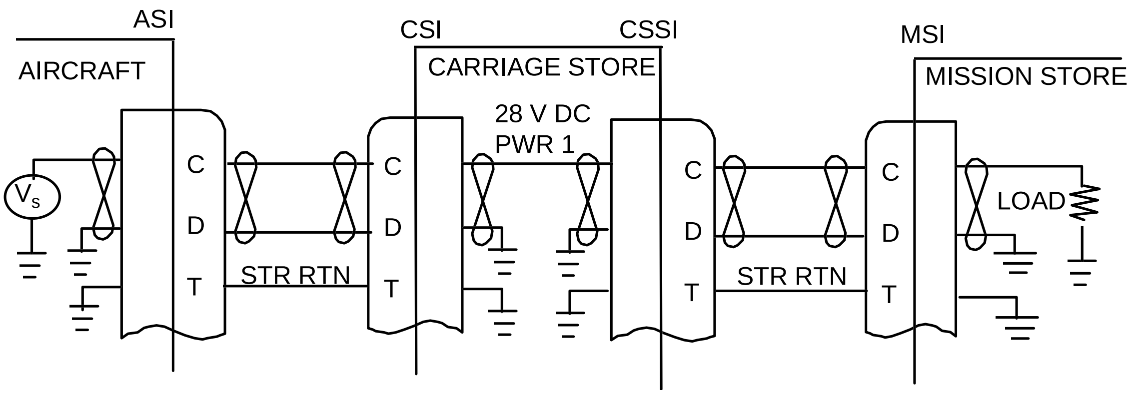


Figure 57c Non-isolated return.

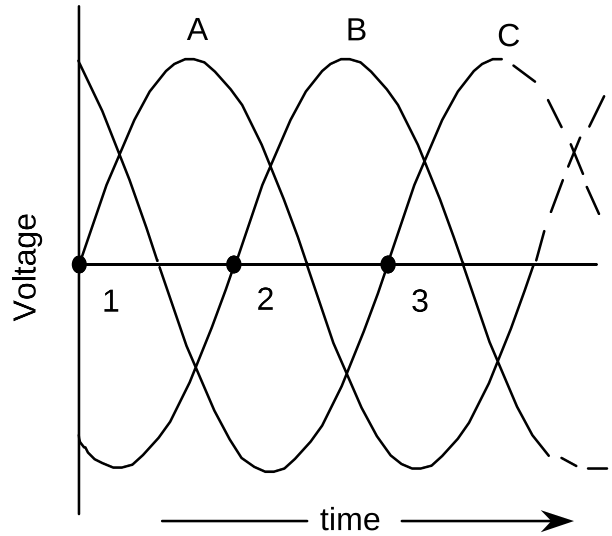
FIGURE 57. Power ground options.

It is recommended that noise sensitive stores isolate the return from store structure to minimize the coupling of the additional noise into the power circuit. As an alternative, the store can use a transformer coupled power converter, with sufficient regulation and filtering to attenuate a large portion of the structure noise. In either case, the power line and return line should be twisted to reduce magnetic coupling fields. The twisting applies to 28V DC, 270V DC and 115/200V AC circuits. The noise levels induced by a 200 volt/meter field in tests of a representative network were approximately 10 dB below those shown in figure 98 of ASD-TR-5028.

It is an accepted practice on many newer aircraft to specifically require subsystems to keep power returns isolated from structure. This allows the aircraft designer to minimize EMC problems, voltage drop, etc., by connecting the power returns to structure only at strategically chosen points. The standard does not require that power returns be isolated from structure in stores, although it is considered good design practice. (See 10.8 herein)

10.3 Phase sequence.

Phase sequence in a three phase power system means that the phase voltages cross zero volts at different times. This is illustrated in figure 58. Assuming a clockwise rotation of an AC generator, the instantaneous voltage of Phase B lags that of A by 120 degrees and the instantaneous voltage of Phase C lags that of Phase B by 120 degrees. The order in which the voltages come to the corresponding maximum values is ABC, which is referred to as phase sequence ABC. In general, the phase sequence of the voltages applied to the ASI is fixed by the order in which the three phase lines are connected. Interchanging any pair of lines reverses the phase sequence. Since some loads, such as induction motors, are affected by phase sequence, it is important that the phase sequence be known. Other loads, notably the AC-to-DC converters used at the input to many avionics units, are not affected by phase sequence. MIL-STD-1760C requires the phase sequence to be ABC, and connecting the three-phase lines as specified in Tables III and V of MIL-STD-1760C will ensure the correct phase sequence.



PHASE SEQUENCE	MIL-STD-1760 CONNECTOR PIN ASSIGNMENT	
	PRIMARY	AUXILIARY
A	P	A
B	M	C
C	J	E

FIGURE 58. Phase sequence.

While the sequence order is defined, the particular three-phase voltage line that is designated as "Phase A" is relative. Looking again at figure 58, "Phase A" was picked as the phase with its positive dv/dt crossing at point 1. The two remaining phases, B and C, have the second and third positive zero crossing. However, the voltage phase crossing at point 2 could equally have been named "Phase A" with phases B and C following at points 3 and 1. By "rotating" these phases at different ASIs while still maintaining the 0, 120, 240 degree sequence, the aircraft designer can sometimes help balance the power load on each of the generator phases. This can help to offset phase load imbalances caused by the stores. Usually, one would rotate phases at symmetrical stations based on an assumption that identical stores are normally loaded on symmetrical stations.

The standard, however, requires that the phase connections, A, B and C, at the primary connectors at each specific ASI be in phase, i.e. same zero crossing time, with the same phase connections in the auxiliary connector at the same ASI. Figure 59 illustrates this phase synchronization requirement as well as the use of phase rotation.

NOTE: 1. Switches and circuit breakers are not shown for simplicity.

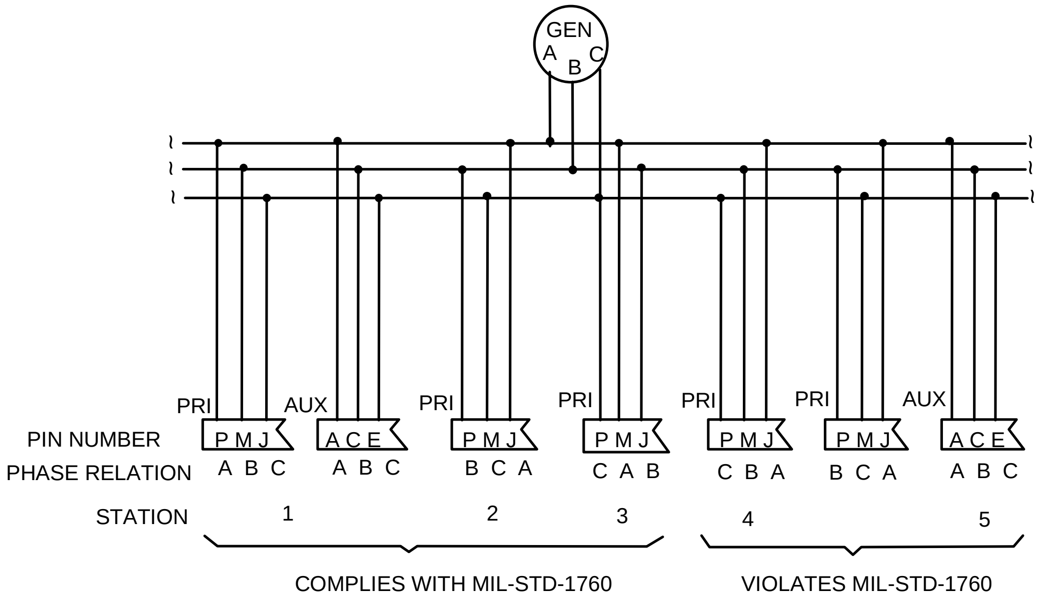


FIGURE 59. Examples of legal and illegal phase connections.

10.4 Shielding.

MIL-STD-1760C does not impose shielding design requirements (except for the requirement for an overbraid shield on umbilicals). Design requirements need to specify isolation, frequency range, coupling (magnetic, electrostatic) and environment. Isolation is defined as the difference between undesired field levels and tolerable field levels and is stated in dB. The frequency range and types of coupling is dependent upon circuit requirements. Environment is location dependent.

The individual power circuits need not be shielded. Twisting of each power line with the associated return line is recommended, as discussed in section 14 herein.

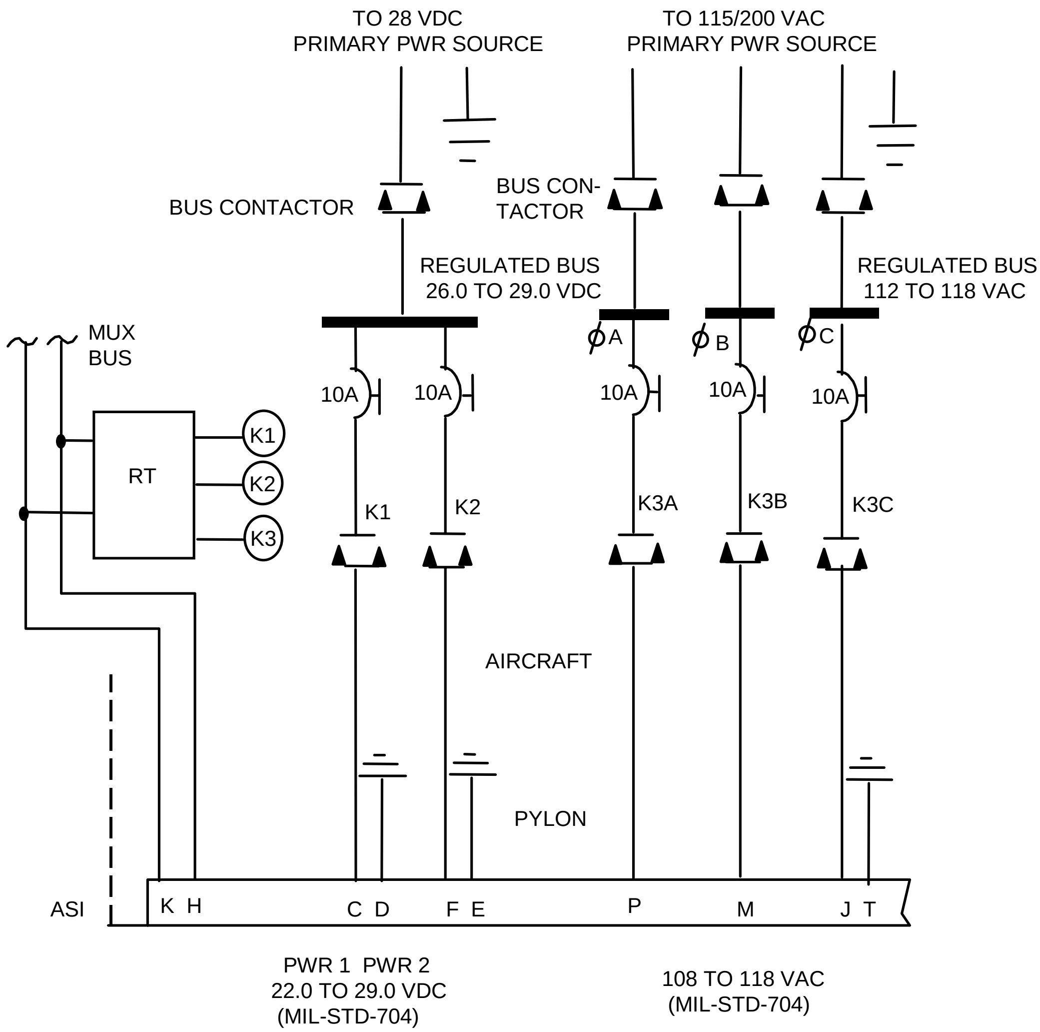
10.5 Aircraft power control and power characteristics at the ASI.

A basic approach for providing power at the ASI in compliance with MIL-STD-1760C is shown in figure 60 for the primary signal set. Control of the auxiliary signal set is similar. However, the size of the switching and isolation elements required for auxiliary power may make it impractical to distribute the circuitry especially within small pylons. Basically, MIL-STD-1760C requires:

a. Each power source at the ASI to be under the control of the aircraft, i.e. the aircraft's store management system,

b. Each power source to be controlled independently of each other.

Consequently, a contactor, relay, or Solid State Power Controller (SSPC) must be used in each power line between the aircraft's regulated bus and the ASI.



Note: The standard does not prohibit use of higher circuit breaker ratings, providing the maximum overcurrent limit, MIL-STD-1760C figure 17, is not exceeded and wiring to the ASI remains adequately protected under fault conditions

FIGURE 60. Typical primary signal set aircraft power control.

10.5.1 Power interface activation.

MIL-STD-1760C states that "The aircraft may energize 28V DC Power 1 at any time under the assumption that all store functions so powered are either not safety critical or that multiple safety interlocks exist within the store such that store safety is not significantly degraded by activation of 28V DC Power 1." This signal should therefore be treated as a non-critical power interface that can be applied to the store at any time.

WARNING

The aircraft must not energize primary 28V DC power 2 or auxiliary 28V DC until it has determined that the connected store can be safely powered from these sources.

This warning is a reflection of the power application requirements, paragraphs 5.1.8.8 and 5.1.9.11 of MIL-STD-1760C. These requirements, in conjunction with the independent control, paragraphs 5.1.8.1 and 5.1.9.1 of MIL-STD-1760C, result in the need for independent power interface control. Note that the interpretation of "independent control" is that all three phases of a 115/200V AC power interface can be switched together, i.e. independent control of each phase is not an actual requirement.

MIL-STD-1760C states that "The aircraft operation shall consider that some stores may utilize 28V DC Power 2 for powering safety critical functions such that store safety may be degraded with activation of this power interface." This signal should therefore be treated as a safety critical power supply and as such, as many of the recommendations as are practical for switching of safety critical signals should be applied to this line. This includes directly interlocking this line with an aircraft selectable safety critical switch such as Master Arm, as shown in figure 61, such that it cannot be activated until there has been a positive action by the aircrew. The designer should also be aware that the return for 28V DC Power 2 is also used as the return for release consent. This could affect the way these functions are partitioned within a SSE.

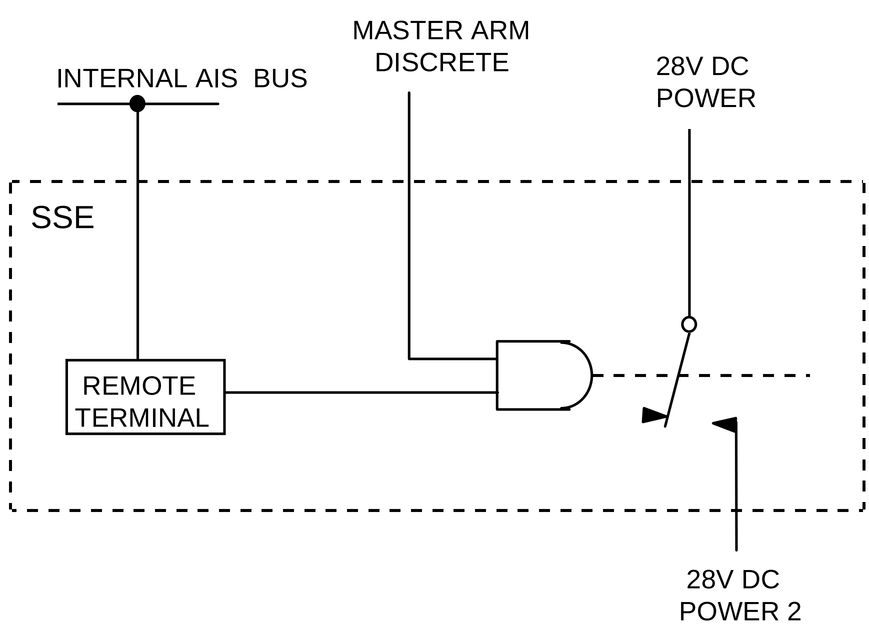


FIGURE 61. 28V DC Power 2 control.

To reduce the effects that may occur due to differences in ground potential across the aircraft the circuits for generating release consent and 28V DC Power 2 should be physically close together and derive their power from the same source.

MIL-STD-1760C states that "The aircraft may energize the 115V AC power interface at any time under the assumption that all store functions so powered are either not safety critical or that multiple safety interlocks exist within the store such that store safety is not significantly degraded by activation of 115V/200V AC power." Figure 62 shows three options for implementing the switching of 115V AC power. Figure 62a uses a single three-pole relay to switch all phases simultaneously. This approach uses a single relay, but if this interface is used to power existing stores that only require a single phase, such as AIM 9, then the remaining two phases may be active but left unconnected. Figure 62b shows separate relays being used to switch each phase independently. This could cause problems to stores which require all three phases to be applied simultaneously. As the switching times of the three relays will vary there could be a delay of up to 10 milliseconds between one phase becoming active and another phase becoming active. Figure 62c overcomes both of the above problems but at the expense of adding extra relays. This will increase the size and the cost of the circuitry required to implement the switching of 115V AC power.

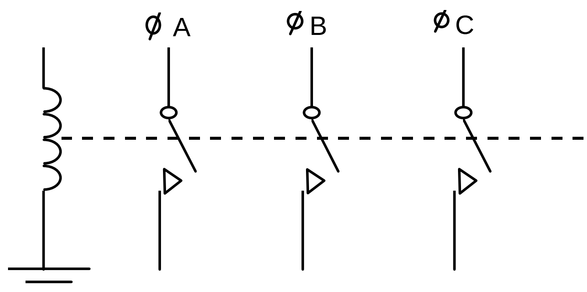


Figure 62a. Common relay.

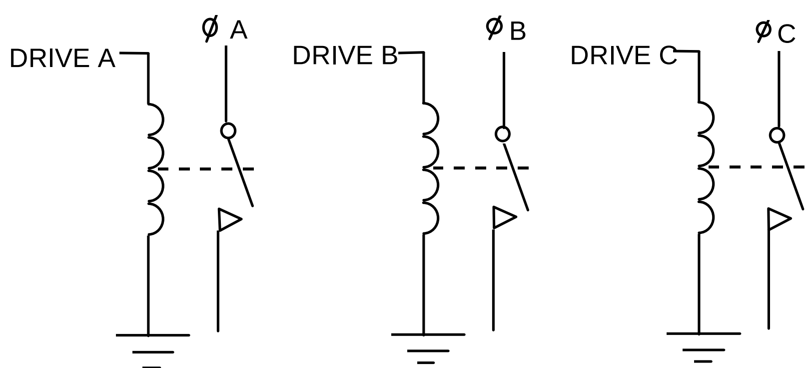


Figure 62b. Separate relays.

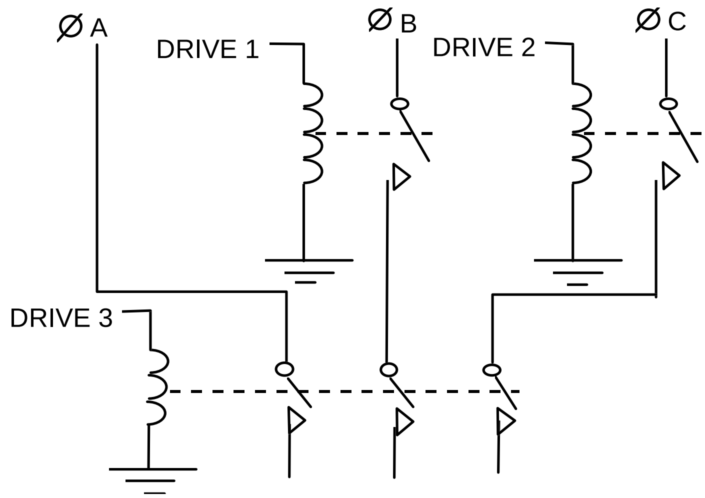


Figure 62c. Use of additional switching elements.

FIGURE 62. 115V AC switching.

This interface should therefore be treated as a non-critical power supply that can be applied to the store at any time. It is recommended that all three phases be switched together to reduce the circuitry required for power switching and to reduce the time slew between the switching of individual phases

10.5.2 Relationship to MIL-STD-704 voltages.

The standard sets specific voltage characteristics at the ASI, which comply with the utilization equipment requirements of MIL-STD-704 (versions B through E) for steady state and transient. If the voltage levels at the aircraft's regulated power bus are typical levels, then requiring MIL-STD-704 levels at the ASI allows a net voltage drop between the regulated bus and the ASI for 28V DC and for 115/200V AC.

During development of MIL-STD-1760C, serious consideration was given to reducing the power voltages required at the MSI. This would have accommodated the use of smaller wire for the long wire runs to aircraft store stations (the smaller wire resulting in greater voltage drop). It would impose a greater burden on stores, to operate at a lower voltage. This change was not made, primarily because of US Army concerns that it would complicate efforts to use off-the-shelf equipment within pods and because it would make new aircraft incompatible with the specified power requirements of existing MIL-STD-1760B stores like JDAM and JSOW.

Note that any program is free to “exceed” the 1760 requirements, e.g., provide MIL-STD-704 compliant power all the way to the MSI, if they have a specific store that requires the higher voltage. Requiring the larger wire only where it is needed should cost much less (in dollars and weight) than requiring it on every store station in every aircraft.

Note also that the power will not typically drop to the minimum voltage except at full load. Therefore, a store using less than 10 amps will receive MIL-STD-704 compliant power in most cases. An ICD could require the aircraft to provide higher power voltages (e.g., MIL-STD-704 compliant voltage at the MSI) at some lesser current with no significant impact on some aircraft (such ICDs are in effect on some current stores).

Aircraft power systems are typically required to deliver MIL-STD-704 compliant power to “utilization equipment”. The definition of utilization equipment is not very clear in MIL-STD-704, but most people agree that it is the first place a subsystem not part of the regular power system switches, modifies, or re-distributes power. For example, in a radar system made up of several units, with one unit feeding power to another, MIL-STD-704 stops at the first unit because it is very difficult to make the electrical power system responsible for power distribution within another subsystem on the aircraft. In the case of MIL-STD-1760 interfaces, the stores management system is required to provide independent power on/off control and circuit protection to the store at each ASI. This protection and control equipment, along with the wiring and connections out to the store stations, will result in additional voltage drop, so the only way to provide compliant power at the ASI is to regulate at a voltage above MIL-STD-704 minimums at the end of the basic power distribution system.

10.5.3 Interface deadfacing.

As a good design practice, aircraft power control should prevent unmated connectors at the ASI from being powered. The aircraft power control sequence should be such that no power can be supplied to the ASI until a connector-mated condition is detected. MIL-STD-1760 specifically requires the 115/200V AC power interface to be “deadfaced”, i.e., turned off when not connected to a store. The 115/200V AC power must be deactivated prior to store separation.

A requirement to deadface the 28V DC power sources was considered as part of Revision C to MIL-STD-1760. This change was not made because of concern that some stores (particularly nuclear) relied on the presence of power up to the point of connector separation. The fact that the standard does not require deadfacing does not prohibit deadfacing when it is acceptable to the store. The 28V DC interfaces should be deactivated as soon as practical after "store release".

In the event that 270V DC power is supplied through the ASI, the power must be deactivated prior to store release. If not, the arc resulting from the interruption of the 270V DC power circuit at the separating connector interface can result in severe damage to the connector and adjacent circuits.

The normal convention for power circuits (including household electrical outlets) is that sockets may be “hot” when disconnected, but exposed pins should never be “hot”. Exposed pins are much more susceptible to causing electrical shock or being shorted by contact with other conductive objects. Since umbilical cables (and buffers, in the case of Type II connectors) have pins on the “store” end, power must be turned off when a store is released in order to follow this convention.

10.5.4 Power Switching – centralized or distributed.

MIL-STD-1760C states that the application of 28V DC Power 2 may cause the safety of the store to be degraded, so this signal should be treated as a safety critical supply. Therefore as many of the recommendations for safety critical signals should be applied to this line as are practically possible. This includes providing the final switching element as close to the ASI as possible. Thus, a distributed system is preferred for 28V DC Power 2 switching. To minimize aircraft wiring associated with 28V DC the switching of 28V DC Power 1 should also be distributed. This enables single 28V DC power cables to be routed to a Store Station Equipment (SSE) where this power could then be switched locally to provide the 28V DC Power 1 and 28V DC Power 2 lines to the ASI as well as being used for internal SSE power. Otherwise at least three separate sets of 28V DC power wiring are required to each store station. Similarly reductions in aircraft wiring may be achieved if 115V AC power switching were distributed especially to store stations where two or more ASI are provided. There may be problems in the SSE if there is limited space available, as the size of the switching elements required for these power lines is relatively large. If there is a problem with space in the area of the ASI then some or all of the switch elements associated with 115V AC power could be located centrally. If there are still space problems then some or all of the 28V DC Power 1 switch elements could be located centrally.

Whichever method of switching is selected (centralized or distributed), it is important to note that protection devices should be located as close as practical to the bus bars, to avoid having long cable runs that are not protected.

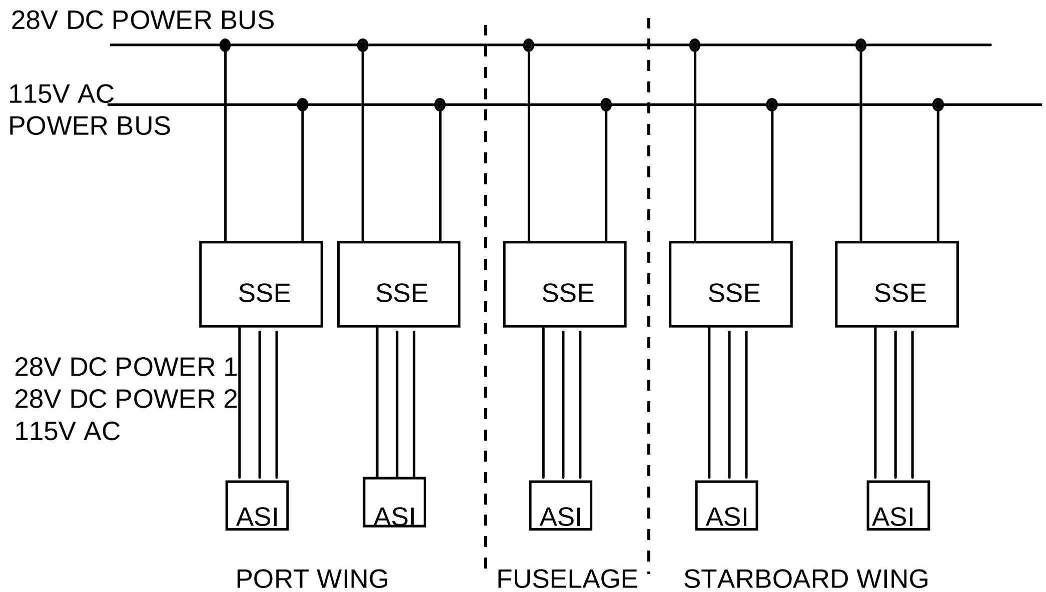


Figure 63a. Distributed power switching.

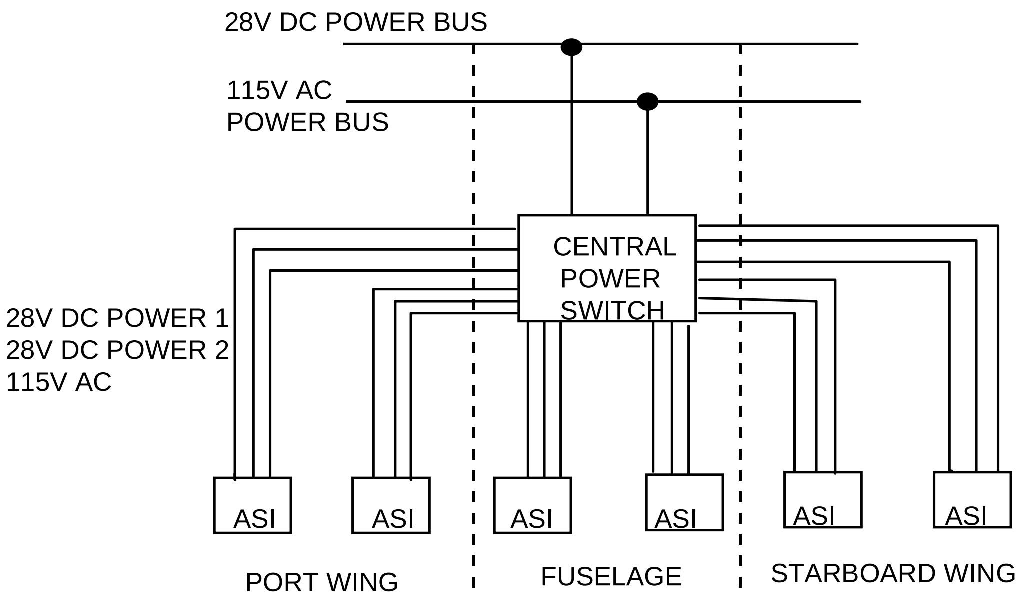


Figure 63b. Centralized power switching.

FIGURE 63. Centralized or distributed power switching.

As shown in figure 63b, a centralized system would require more aircraft wiring compared with a distributed system shown in figure 63a.

10.5.4.1 Power switch types.

MIL-STD-1760C requires the voltage level at the ASI to comply with the normal and abnormal operation characteristics for utilization equipment defined in MIL-STD-704 and states specific voltage minimums which correspond to the minimums allowed at utilization equipment in MIL-STD-704B through 704E. The power supply provided to the AEIS from the aircraft power systems must be well within the limits specified by MIL-STD-704 to allow for voltage drops within the AEIS. To allow a reasonable specification for the aircraft power system the voltage drops within the AEIS need to be minimized. The use of semiconductor switching elements for the power lines would introduce relatively large voltage drops whereas MIL-R-6106 or similar relays introduce very small voltage drops.

Mechanical power relays to MIL-R-6106 should therefore be used for the switching of power unless the voltage drops associated with solid state power switching devices can be accommodated within the requirements of MIL-STD-1760C.

It is important to ensure that the Current / Time characteristics of the switching elements used are capable of switching / carrying the maximum currents defined by figure 17 of MIL-STD-1760C without significantly affecting the life of the component.

10.5.5 Fault isolation.

It is recommended that, wherever possible, the fault isolation elements be located close to, but before, the switching elements as shown in figure 64. This will allow the fault isolation element to be monitored by the internal AEIS BIT (if required) without having to activate the switch elements and thus apply power to the store. This means the state of all the circuit breakers in the system can be obtained by the AEIS before the aircraft is airborne allowing any corrective action to be taken before the start of a mission.

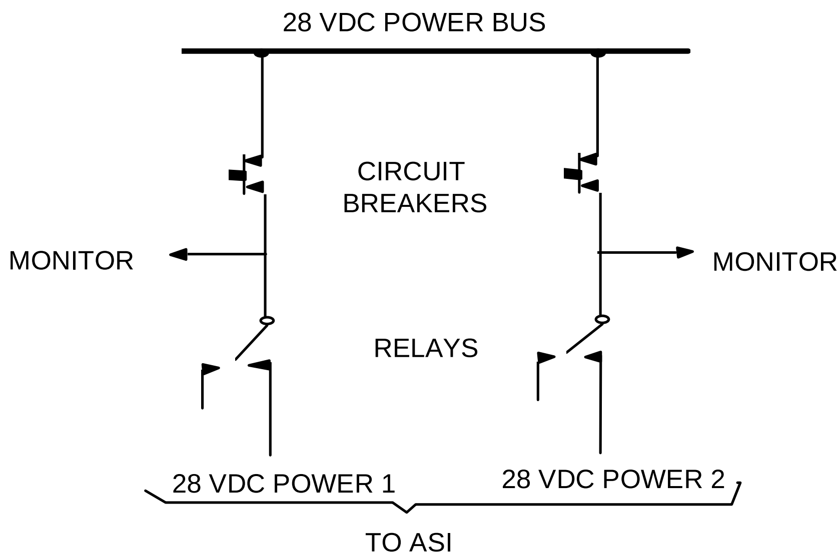


FIGURE 64. Location of power fault isolation elements.

10.5.5.1 Isolation elements.

MIL-STD-1760C gives curves defining the maximum overcurrent and maximum load current against duration relationships. These curves are derived from figures defined in MIL-STD-1498 for circuit protection devices. Circuit breakers are available which conform to this specification however the characteristics of fuses typically do not conform to these curves. Therefore great care must be taken, if fuses are to be used as the fault isolation elements in the power lines, to ensure that the characteristics of the fuse conform with those specified in MIL-STD-1760C. Replacement of fuses, if needed, also has implications on maintenance times which circuit breakers do not have.

10.5.5.2 Inrush current limitation.

Figures 17 and 18 of MIL-STD-1760C were modified to extend the load current lines over to zero time. This is intended to make the requirement more compatible with Solid State Power Controllers by not implying the need to pass very large currents for very short time periods. Note that the standard does not specify whether the aircraft will limit the current or trip the power off if the maximum load current is exceeded, therefore the store designer should limit inrush current to avoid the possibility of tripping the power controller.

10.5.6 Existing power installation.

10.5.6.1 Primary 28V DC power.

When retrofitting MIL-STD-1760 to an existing aircraft, what 28V DC wires will already be fitted and will be useable? Basically each primary ASI requires four x 28V DC facilities, which have medium and light capability, namely:

a. 2 x 28V DC at 10 amperes, maximum steady state, to be used for 28V DC Power 1 and 28V DC Power 2.

b. 2 x 28V DC at 100 milliamperes, maximum steady state, to be used for release consent and interlock.

Note: Release consent and interlock are 28V DC discretes and should not be confused or used as actual sources of 28V dc power.

This installation requires 2 x 16 AWG and 2 x 20 AWG wires respectively and MIL-STD-704 is acceptable in all four cases. It is very likely that at least the two medium capacity wires are already installed.

10.5.6.2 Primary 115V AC power.

What 115V AC wire will already be fitted and will be useable? It is believed that at least one phase will probably be available at most stations where current weapons having a semi-smart but analog capability have been fitted, such as AIM9 or the three phase AGM 65.

10.5.6.3 Auxiliary 28V/115V power.

What initial auxiliary power capability will there be? All of the information currently available indicates that the auxiliary power capability is unlikely to be required. Before any commitment is made to even start design, never mind installation, of the auxiliary power signal set, that is a Class IA or Class IIA ASI, the justification for the requirement must be fully examined. This is because such an installation will require a second ASI connector and associated wiring. The real estate required for such an installation will be a heavy burden to bear, as will the consequent aircraft weight increase, unless adequate justification is provided.

It is unlikely therefore that Auxiliary 28V DC or 115V AC 3 phase will currently be installed out at pylon stations. Because the installation requires the use of 10 AWG cable, then the auxiliary requirement should be very well justified before commencing or planning to fit auxiliary power capability.

10.6 Carriage store power control and distribution.

If a carriage store is installed, the carriage store must provide independent on/off control of each 28V DC power interface and each 115/200V AC power interface to each CSSI for both the primary and auxiliary power interfaces as applicable. Power on/off control commands are provided by the aircraft SMS via the data bus interface. The carriage store should rely on the aircraft, which is issuing power control commands, to manage the total connected load at the CSI to prevent overloads at the ASI. As noted in 10.5, the voltage levels at the ASI and MSI are specified by MIL-STD-1760C. Consequently, the voltage at the CSI and CSSI must allow for voltage drops in the two umbilicals (ASI-CSI and CSSI-MSI). A voltage drop should be allowed for 28V DC circuits and 115V AC circuits in each umbilical. A typical implementation concept is shown in figure 65. The preferred ground return design is to have a dedicated line for each return as shown in the figure. Using the carriage store structure as a return path is not an acceptable alternative.

CAUTION
The primary 28V DC No.1 and No.2 and the auxiliary 28V DC inputs at the CSI must not be connected to a common bus in the carriage store. Similarly, the primary 115/200V AC and the auxiliary 115/200V AC inputs at the CSI must not be connected to a common bus. Power from aircraft may be supplied from different sources which may be operating from different source buses and therefore have different voltages.

The carriage store is allowed to decrease the output AC current supplied to each CSSI to 9.0 amperes per phase for the primary interface and to a total of 29.0 amperes per phase for the primary plus auxiliary interface. This decrease in output current allows the carriage store control electronics to be powered from the AC power input terminals to the carriage store. It should be noted that some mission stores only require 28V DC power. In these applications, a transformer/rectifier (T/R) may be used within the carriage store to convert some or all 115V AC power to 28V DC as shown in figure 66. This arrangement allows more than one mission store to be powered simultaneously if such an operation is required or desired. The trade-off between this additional capability and the increase in carriage store complexity, the T/R will need to be switched "out" for stores needing the 115/200V AC, should be considered.

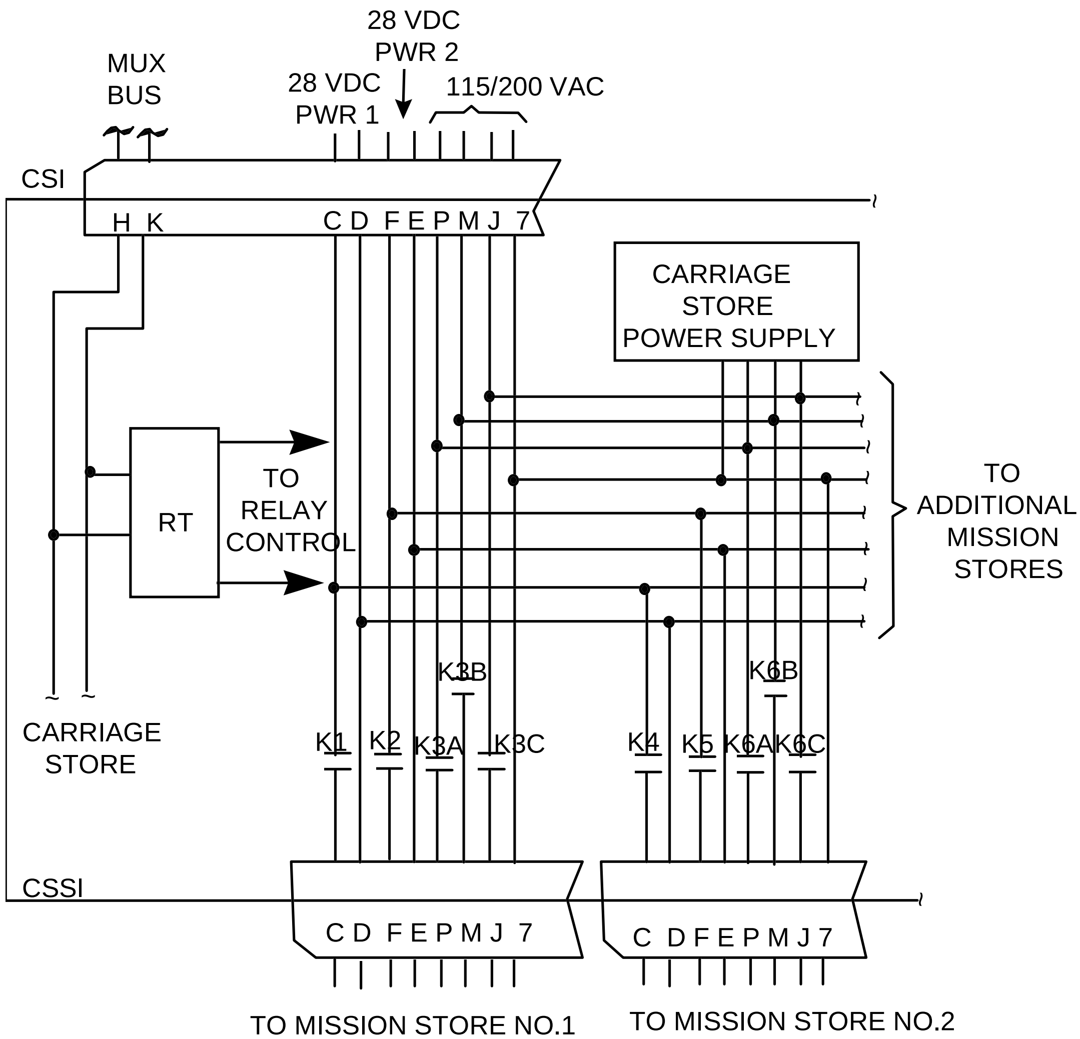


FIGURE 65. Typical carriage store power control.

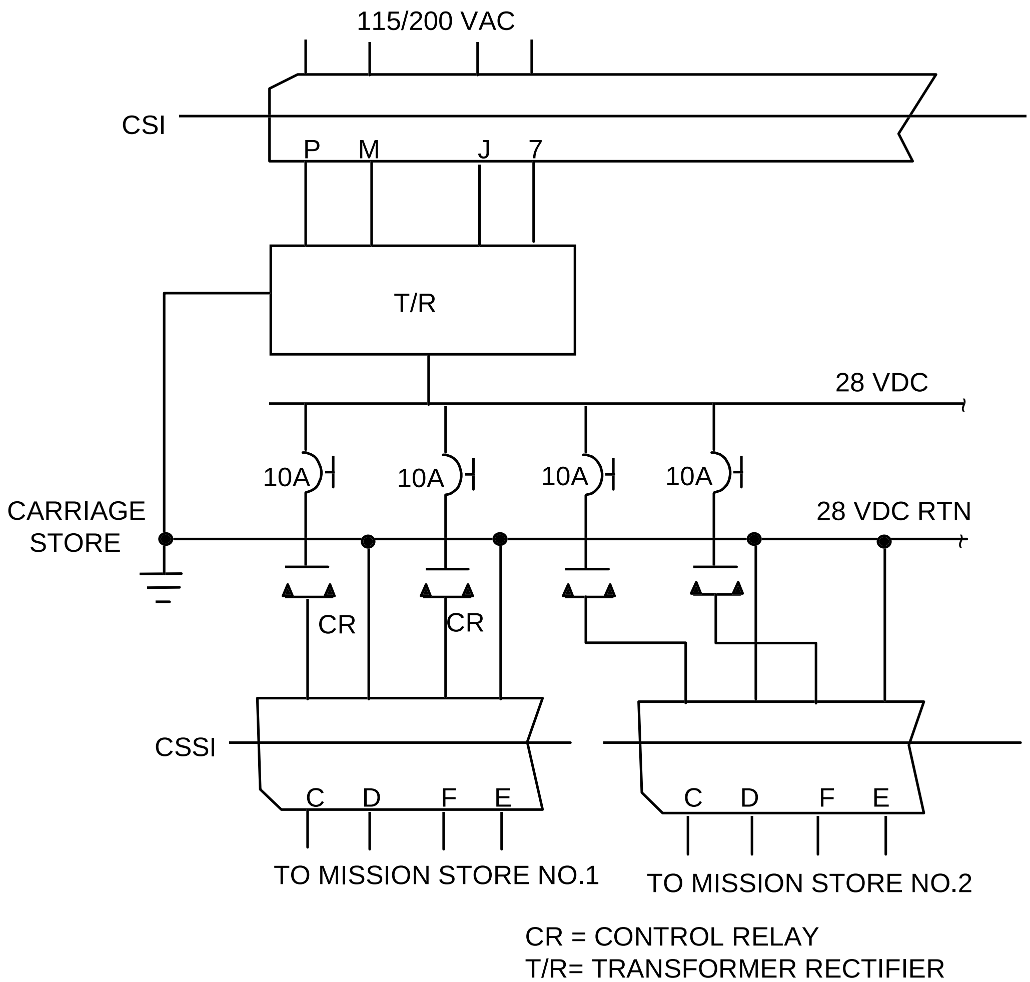


FIGURE 66. Power conversion in the carriage store.

10.7 Mission Store power control and power characteristics at the MSI.

This section discusses the voltage characteristics and power available at the MSI, power isolation, wire sizing and protection, power loss requirements, power factor, phase unbalance and connector deadfacing for the mission store.

10.7.1 Voltage characteristics at the MSI.

MIL-STD-1760C allows a 2.0 volt drop to the MSI for 28V DC power and a 3.0 volt drop for 115V AC power. The 270V DC power is not defined. The voltage drop allocations apply with and without the use of a carriage store. Subtracting these voltage drops from the voltage characteristics defined for the ASI results in the characteristics shown in figure 67 for 28V DC power and figure 68 for 115V AC power for the equivalent of MIL-STD-704 "normal" characteristics. The mission store is required to provide the full performance defined by its specification, when supplied with this normal voltage. The mission store is not required to meet its performance requirements when supplied with voltage characteristics that are abnormal. Abnormal voltages are voltages outside the limits shown in figure 67 and figure 68 and are caused by a malfunction, or failure, in the aircraft electrical power system. Unless designated in the system specifications, the mission store is also not required to perform during a momentary loss of power as occurs during a power bus transfer. During an abnormal voltage condition or momentary loss of power, however, the mission store:

a. Is permitted a degradation in performance unless specifically required otherwise by the mission store specification.

b. Must not produce a damaging or unsafe condition,

c. Must automatically recover to full specified performance when the voltage is restored to normal conditions.

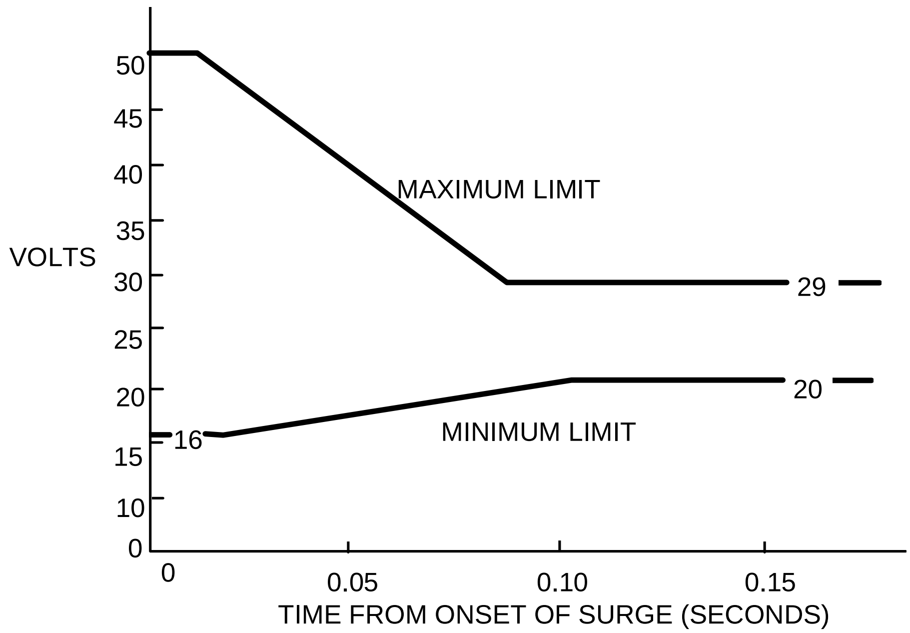


FIGURE 67. Envelope of normal DC voltage at MSI.

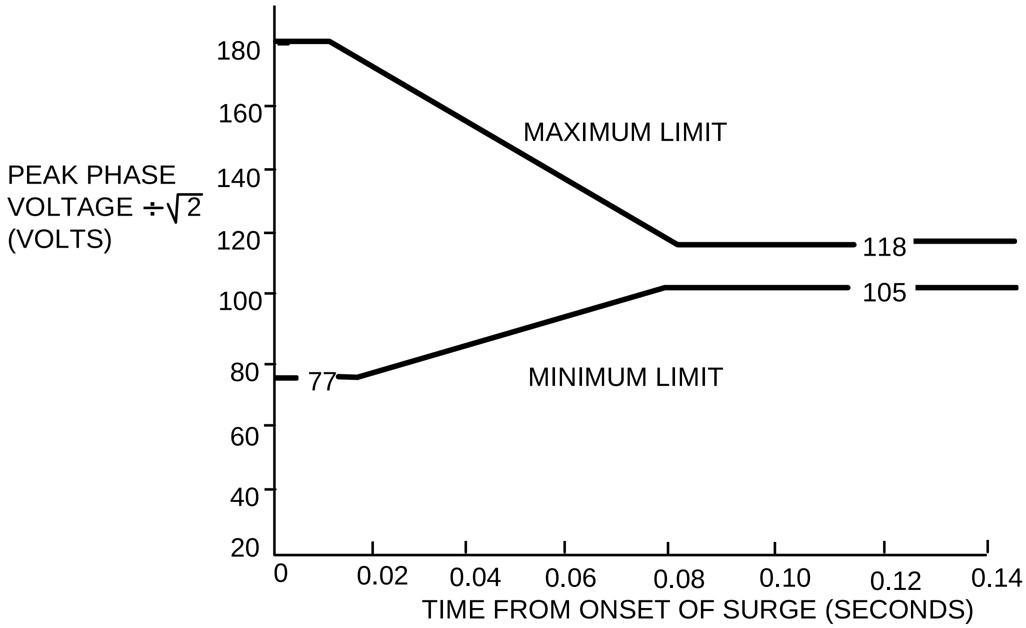


FIGURE 68. Envelope of normal AC voltage at MSI.

10.7.2 Power availability.

The continuous power available at the MSI is depicted in table XXII. However, see 5.2.1 for qualifications on the availability of these levels particularly when the aircraft is carrying a large store loadout.

TABLE XXII. Continuous power available at the MSI.

Voltage	Rated Current	
	Primary	Auxiliary
20.0 to 29.0V DC	-	30 A 2/
20.0 TO 29.0V DC PWR 1	10 A	-
20.0 TO 29.0V DC PWR 2	10 A	-
105 - 118V AC	10 A 1/	30 A 1/ 2/
270V DC	- 3/	- 3/

1/ The current available at the MSI is reduced to 90 percent of the per phase current for the primary interface and to a total of 29.0 amperes per phase for the Class IA and IIA interfaces if the current is supplied through a carriage store.

2/ This limit defines the maximum total current available at the MSI for both the primary and auxiliary interfaces.

3/ 270V DC power is a growth provision and presently is not available at the MSI.

10.7.3 Store power demand.

The mission store must limit its continuous and instantaneous current demand to values equal to or below the "Maximum Load Current" curve of figure 17 and figure 18 of MIL-STD-1760C when connected to the MSI.

NOTE

The mission store AC current demand must not exceed 90 percent of the per phase current for the primary interface and must not exceed a total of 29 amperes per phase for Class IA and IIA interfaces when the mission store is operated from a MIL-STD-1760C carriage store.

The mission store may be designed to use power from either the primary interface or the auxiliary interface. It should be noted, however, that the auxiliary interface will likely only be available at a very limited number of aircraft stations.

10.7.4 Power isolation.

Power to the MSI can be supplied from different aircraft power sources (buses). Consequently, it is important that isolation be provided within the mission store to prevent interaction between the power sources.

CAUTION

The store must not connect 28V DC power 1 and 28V DC power 2 nor primary interface 28V DC power and auxiliary 28V DC power to a common "bus" in the store. Similarly, primary 115/200V AC and auxiliary 115/200V AC must not be connected to a common "bus" in the store.

This caution is highlighted because the voltage level of one power source bus-bar, e.g. 28V DC power 1, can be different from the voltage level from a second source bus-bar, e.g. 28V DC power 2. These unequal voltages can result in current from the higher voltage source to flow into the store, then back out from the store towards the second power source. Another problem is that the unequal voltages will result in unequal load division between the two power sources and could result in tripping the aircraft power circuit protection device. Figure 69 shows acceptable, preferred and unacceptable designs for the store power load connections.

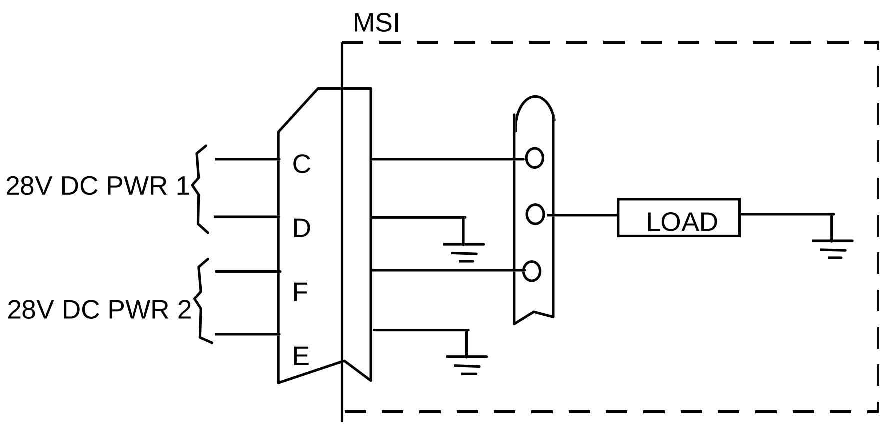


Figure 69a. Unacceptable.

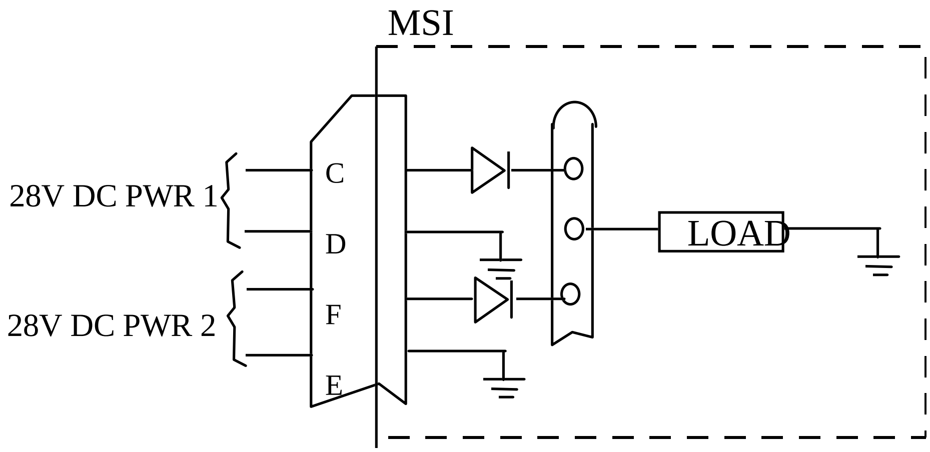


Figure 69b. Conditionally acceptable.

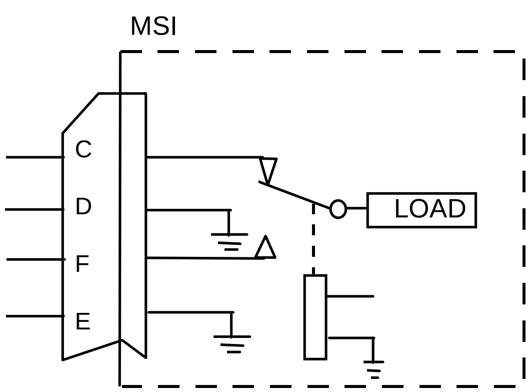


Figure 69c. Preferred.

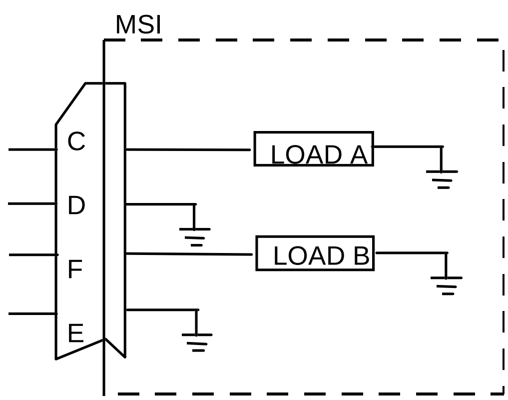


Figure 69d. Preferred.

FIGURE 69. Store power load connections.

10.7.5 Power phase loss.

In a three-phase power system, one phase may become inoperative or de-energized. This can result from a single-phase fault and the subsequent opening of a single phase circuit breaker, a wire breakage, or a failure of a power switching component. In general, a mission store is not required to perform in the event one or two phases become inoperative. The mission store detail specification will dictate if degraded or full performance operation is required during this condition. The mission store must not produce a damaging or unsafe condition, however, upon the loss of one or more phases of power. This requirement is representative of the requirements imposed on utilization equipment by MIL-STD-704.

10.7.6 Phase unbalance and power factor.

Mission stores utilizing AC power, must be designed to present as near a unity power factor, as practicable, for all modes of operation. The store is required to present a power factor on the worst phase not less than the limits specified in figure 20 of MIL-STD-1760C. These limits are the same as those specified in MIL-STD-704A for Category A and Category B equipment.

Subsequent revisions to MIL-STD-704 removed the phase power factor requirement and that is why it is included in MIL-STD-1760C.

Similarly, mission stores requiring three phase AC power must be designed to require equal phase volt-amperes as far as practical. The phase volt-ampere difference between the highest and lowest phase values must not exceed the limits specified in figure 70, assuming balanced voltages.

If a carriage store is used, balancing loads between phases can be improved by rotating phases within the carriage store, providing the phase sequence of ABC is maintained. See 10.3 for phase sequence discussion.

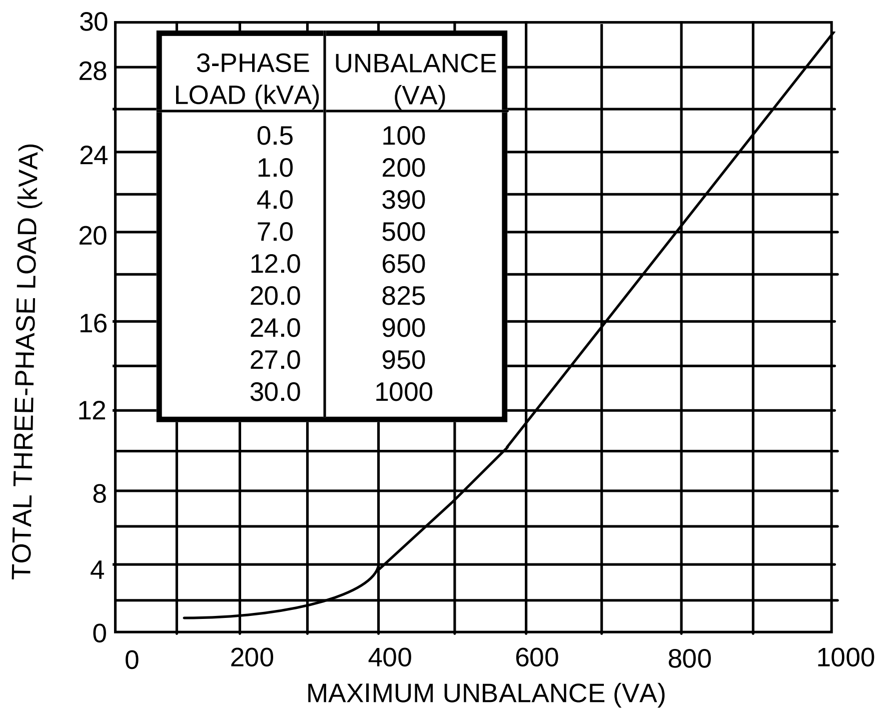


FIGURE 70. Unbalance limits for three phase mission store loads.

10.8 Store power return interfaces.

The AEIS standard requires a dedicated power return, or neutral, connection in the interface for each power type, i.e. 28V DC power 1, 28V DC power 2, auxiliary 28V DC, primary 115/200V AC, auxiliary 115/200V AC, primary 270V DC and auxiliary 270V DC. Also, the standard does not require any specific relationship between the power returns and structure ground in the store. The standard does, however, require the store to be compatible with aircraft, which connect the power returns to aircraft structure and with aircraft, which isolate power returns from aircraft structure. While this latter case complicates the aircraft's power system design, in order to meet personnel hazard requirements, it still might exist on some future aircraft systems.

Various power grounding schemes are covered in 10.2 and will not be repeated here. In general the single point grounding scheme is not practical, however, because at some point in the store's operation it will be disconnected from aircraft power and its ground and will then need its own connection to structure ground within the mission store. In addition, the internal store electronics will contain leakage paths to ground, such as stray capacitance and unintentional paths to ground. An example of an unintentional path is a fired EED shorted to ground because explosive residue temporarily provided a path between the firing signal and EED case. The store electronics needs a consistent connection to structure ground rather than an intermittent and variable impedance connection. With this connection to structure, however, comes the potential of inducing noise voltages into the store electronics due to the differences in voltage between the aircraft and store structures. Techniques to minimize this problem include use of transformer coupled power converters in the store for deriving store power from aircraft power and use of an internal store single point ground.

To minimize additional pick-up of induced noise and to minimize power line radiated emissions, the store should use twisted wire pairs for each set of 28VDC (270VDC for potential future systems) power interfaces and twisted wire quadruplets for each 115/200V AC interface. Generally, no advantages are gained in noise reduction by shielding the power lines, due to the relatively low frequency of the offending noise and the poor effectiveness of shields at these low frequencies.

Typical noise levels induced into the power interfaces for representative aircraft and store network configurations are defined in 10.2 for ASI measurement points. ASD-TR-5028 illustrates these levels for both radiated field coupled and for power switching transients. It also illustrates comparable field induced levels in figure 137 for 28V DC interfaces and in figure 138 for 115/200V AC interfaces. These values were measured at the primary interface using the standard EMI test cables, but are also comparable for the auxiliary interface.

10.9 Operational power interfaces.

Most mission stores will require a source of external power, from the aircraft, to operate the store until it is released. Also, MIL-STD-1760C applies to stores which require an electrical interface. The standard is not applicable to stores which only require a mechanical interface, and therefore the entire issue of signal subsets becomes “not applicable to non-electrically interfaced stores”.

Due to safety concerns and to provide a common initialization facility, the store must implement either:

a. 28V DC power 1,

b. primary 115/200V AC power,

c. auxiliary 115/200V AC power.

These choices preclude the store from using 28V DC power 2 or auxiliary 28V DC without one of the three power interfaces listed above. (See MIL-STD-1760C, paragraphs 5.2.8.8 and 5.2.9.10)

If the store implements one of the 115/200V AC power interfaces, then the store designer needs to consider the phase unbalance requirements of the standard and provide three phase loads if the current levels are sufficiently high to require a three phase connection. Basically, once the AC load exceeds 500 volt-amperes, the store is required to use a three phase connection instead of a single or two phase connection.

10.10 Circuit protection.

Overload protection applies to the aircraft power distribution system and to any power distribution circuit(s) downstream of the ASI. MIL-STD-1760C intends for the aircraft installed protective device to provide some level of protection for the complete circuit chain, i.e. aircraft + umbilicals + carriage store + mission store. This level of protection is directed at providing an upper bound on the fault current sourced by the aircraft so the stores and umbilicals can be designed to safely withstand faults.

10.10.1 Aircraft circuit protection.

MIL-STD-1760C defines the maximum overload and minimum capacity currents required at the ASI by the aircraft's power distribution system. These current limits are depicted in figure 17 for the primary interface and figure 18 for the auxiliary interface of MIL-STD-1760C. The "Maximum Overcurrent" curve defines the maximum fault current allowed at the ASI. These maximum current-time limits are allowed to occur whenever a fault occurs downstream, store side, from the ASI. The "Maximum Load Current" curve defines the minimum normal current capacity that the aircraft power distribution system must supply to the ASI. The area between the "Maximum Overload Current" curve and "Maximum Load Current" curve defines the current-time band within which the aircraft's circuit protective device, e.g. circuit breaker, must trip.

Numerous Military Standard circuit protective devices have trip characteristics that fall within this area. These include circuit breakers, current limiters, remote controlled circuit breakers and solid state power controllers. Proper selection must result in a device with the lowest current rating that will not open inadvertently when conducting rated current as depicted by the "Maximum Load Current" curve in figure 17 and 18 of MIL-STD-1760C as applicable.

The aircraft designer is responsible for protecting the aircraft's power distribution circuit upstream of the ASI and normally his design responsibility stops at the end of his system (the ASI). However, MIL-STD-1760C intends for the aircraft's protective system to provide some level of protection to the power distribution system downstream of the ASI as well. To meet this intent, as well as to minimize weight in the aircraft, the designer should select the smallest gauge wire that will support the current, at the specified voltage, depicted by the "Maximum Load Current" curve and then select a protective device that will protect the wire.

The current-time trip characteristics of the protective device selected must lie above the "Maximum Load Current" curve and below the current-time characteristics of the wire. In no case are the trip characteristics allowed to exceed the "Maximum Overcurrent" curve. It is recommended that wire gauges no larger than 16 for the primary interface and 10 for the auxiliary interface be used. These sizes are compatible with the power contacts contained on the interface connector and are adequate, i.e. low resistance, for all applications except extremely long cable lengths.

For aircraft stations with Class IA or IIA interfaces, the designer may consider sharing a common power feeder to the station for both primary and auxiliary interfaces. When this choice is selected additional protection at the station will be required. Figure 71a illustrates the baseline approach for powering primary and auxiliary interfaces at a station. While the use of a common feeder, i.e. remove the two 10 ampere feeders, is acceptable, the protection provided by figure 71b is unacceptable. In this figure, overload currents on the primary interface power lines will exceed the Maximum Overcurrent curve of figure 17 of MIL-STD-1760C. Figure 71c shows an approach where the feeder wire weight saving is still achieved while the overcurrent requirements at the primary ASI are still met. In order to achieve remote resetting of the SSE installed protective devices, remote controlled circuit breakers or solid state power controllers should be used. These devices can also provide the power on/off control function.

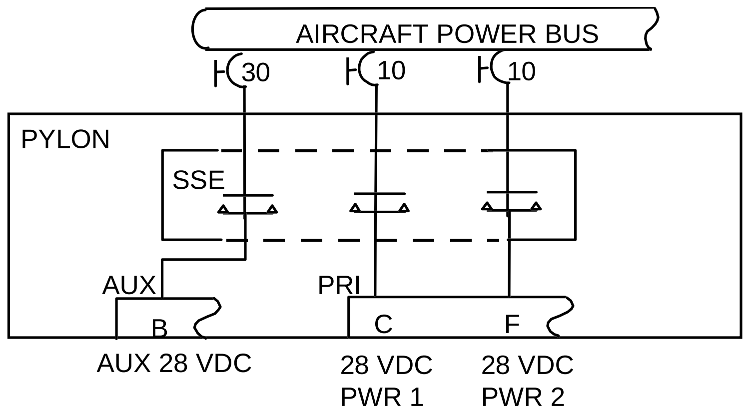


Figure 71a Baseline.

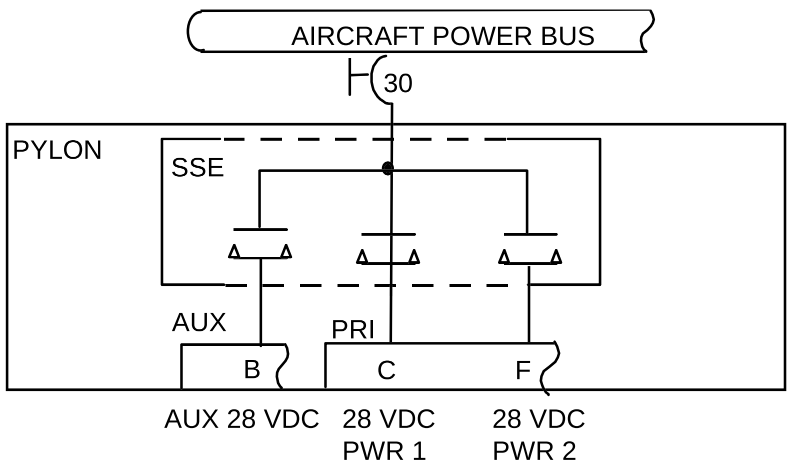


Figure 71b. Unacceptable.

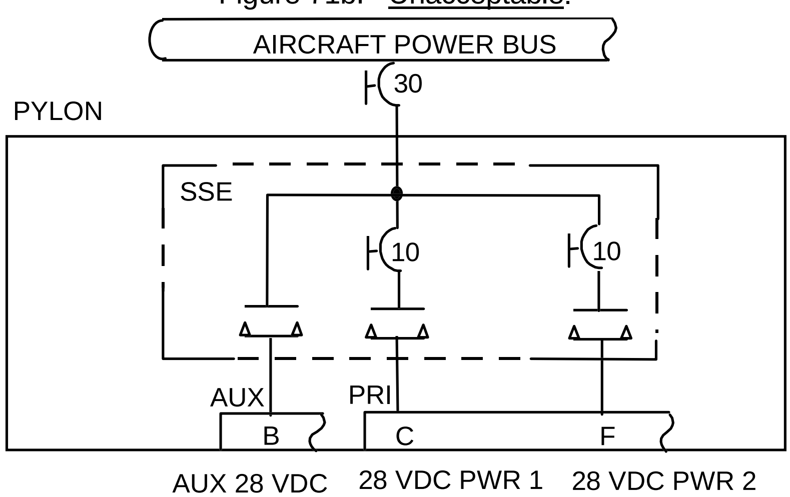


Figure 71c. Acceptable.

FIGURE 71. ASI overcurrent protection alternatives.

10.10.2 Carriage store circuit protection.

Similarly to the umbilical cable, the wire and power distribution components used in the carriage store are intended to be protected by the aircraft's circuit protection system. The current-time characteristics of wire and power distribution components must lie above the "Maximum Overcurrent" curve in figure 17 for the primary interface and figure 18 for the auxiliary interface of MIL-STD-1760C. This requirement may impose a weight penalty on some weapon systems since the wire size as well as the power distribution components may be larger than necessary to support some load currents. However, in the interest of interoperability, it must be assumed that some aircraft power distribution circuits will allow fault currents equal to those depicted by the "Maximum Overcurrent" curve. It must be remembered that the curve represents an "abnormal" operating condition that can only occur for a short time condition, typically one flight time, or may never occur over the life of the carriage store. It is necessary, however, that the wire and power distribution components within the carriage store withstand this "abnormal" condition without causing an unsafe condition. To ensure protection, the wire should be Size 16, or larger, for the primary circuits and Size 10, or larger, for the auxiliary circuits. The use of high temperature wire insulation should be considered.

As an option, the carriage store designer may choose to use smaller gauge wire than required to meet the maximum overcurrent limits and install protective devices within the carriage store to protect the smaller wire. In addition to reducing weight, adding protective devices within the carriage store can provide fault isolation between the mission store power circuits. This is accomplished by installing a protective device in each power line to the mission store as shown in figure 72. A fault on any one line will not disrupt power to the remaining good lines. Co-ordination of trip limits between the aircraft breaker and the carriage store breaker is not required by MIL-STD-1760C since opening of either breaker will provide protection. Co-ordination of trip limits is required, however, to achieve the above fault isolation. The carriage store trip limits must be below the aircraft breaker trip limits. Due to the broad range of trip levels allocated to the aircraft by figure 17 and figure 18 of MIL-STD-1760C, it will be difficult for the carriage store to achieve this co-ordination between a primary CSI and primary CSSI. If the carriage store is bussing an auxiliary CSI to primary CSSIs, then fault protection co-ordination is both possible and required.

Adding circuit protection in the carriage store increases design complexity and makes it more difficult to meet the ASI-to-MSI voltage drop limits for 28V DC circuits and 115V AC circuits established by MIL-STD-1760C. For this reason, MIL-STD-1760C does not require circuit protection to be added to the carriage store though it is allowed. If current protection is added, the "Maximum Load Current" limits defined by figure 17 and figure 18 of MIL-STD-1760C must still be provided at the CSSI.

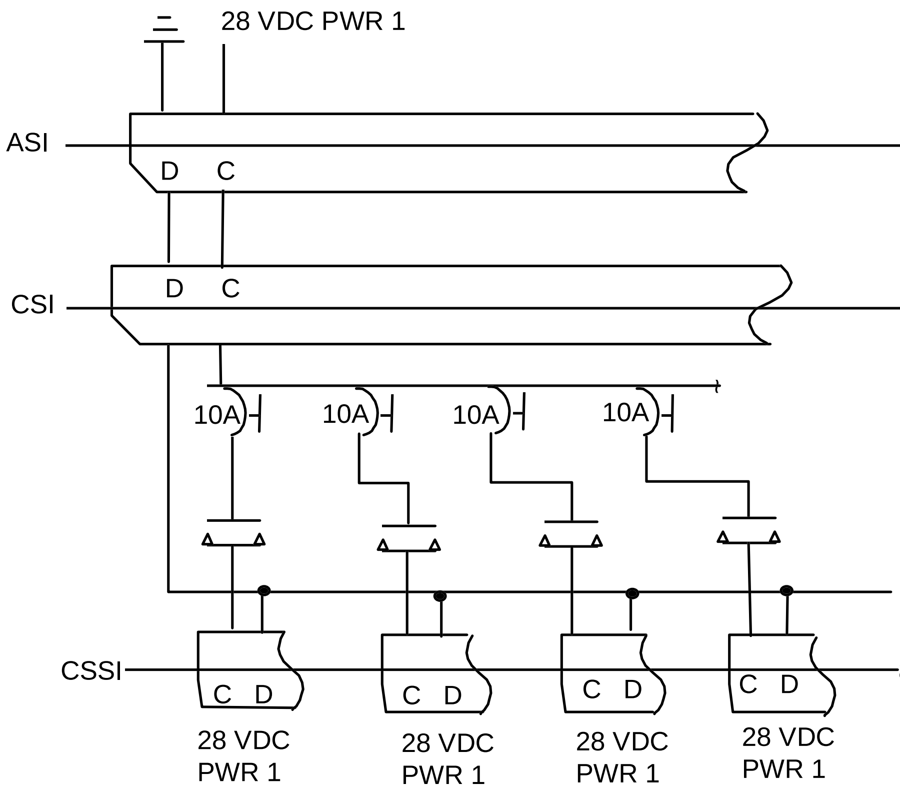


FIGURE 72. Circuit protection provided within the carriage store.

Applications that include a T/R within the carriage store, to convert 115/200V AC to 28V DC, must provide circuit protection at the T/R output as shown in figure 66. This arrangement provides fault isolation between power circuits. Current requirements at the CSSI are the same as those defined for the ASI, i.e. figure 17 for the primary interface and figure 18 for the auxiliary interface of MIL-STD-1760C.

Primary interface CSSI power may be derived from the Auxiliary CSI interface. However, the following caution must be observed:

CAUTION
Aircraft protective devices used to protect the auxiliary circuits will not provide protection to the primary circuits.

10.10.3 Mission store circuit protection.

10.10.3.1 Wire sizing.

MIL-STD-1760C requires the mission store to be compatible with, i.e. safely withstand, the overcurrents at the MSI. These overcurrents, as well as the time duration for the overcurrents, are given by the "Maximum Overcurrent" curve in figure 17 for the primary interface and figure 18 for the auxiliary interface of MIL-STD-1760C. This curve defines the maximum current that can be sourced to the MSI during a fault condition, when the fault occurs on the mission store side of the MSI. The mission store wiring and power distribution components must be able to support this current without becoming unsafe. It must be remembered that the "Maximum Overcurrent" curve represents an abnormal condition, which may never occur over the life of the mission store. Nevertheless, it must be assumed that this condition can occur and the continuous current of 24 amperes for the primary interface and 58 amperes for the auxiliary interface could last for an appreciably long period of time, i.e. one flight time. If the mission store circuit designer chooses to use the aircraft protective system for mission store protection, the wire and power distribution components within the store must be able to withstand this abnormal condition for at least one flight time. It is assumed the fault will be corrected after the flight by removing the faulty store.

If a store designer chooses to use the aircraft protection system to protect the store wire, it is recommended that wire used be no smaller than gauge 16 for the primary interface and no smaller than gauge 10 for the auxiliary interface.

10.10.3.2 Mission store circuit protection devices.

An optional design for meeting the compatibility requirement is to include protection within the mission store. This may be a viable option, especially if the mission store current demand is much less than 10 amperes for the primary interface and 30 amperes for the auxiliary interface. The mission store protective device can be a fuse, a circuit breaker or current limiter. A trade-off between reliability degradation and safety, resulting from including a protective device, should be made during store design.

The store's protective device fault clearing capability can be lower than is normally required, because the fault current is limited by the aircraft protection system. Coordination of the store protective device with the aircraft protective device is not required, since tripping of either device will protect the store power distribution system. The disadvantage of using protection within the store is the added design complexity and the voltage drop resulting from using these devices.

10.11 Structure ground.

The structure ground line in both primary and auxiliary AEIS connectors is included to provide a higher level of assurance that the aircraft and store structures are electrically interconnected, and therefore prevent an electrical shock hazard. It is to ensure that hazardous voltage is not present on a store, just as the third conductor in residential wiring and appliances connects all chassis to ground to prevent shocks in the event of an electrical short. Other structure ground paths should exist between the aircraft and store due to mechanical connections, gross shields on interconnecting umbilicals and possibly power return connections, i.e. 28V DC Power 1 return etc. These other connections may, however, not exist (especially during ground or lab operation) or may be poorly controlled.

10.11.1 Structure ground requirements change.

Revision C deleted the requirement to comply with MIL-B-5087, since 5087 has been canceled. It also changed 5.1.7 to require the ability to carry the “overcurrent levels defined in figures 17 and 18”, rather than the rated current. This better reflects the intent of a safety ground (to carry a large fault current long enough to trip a circuit breaker) and makes this paragraph consistent with 5.2.8.

The reference to MIL-B-5087 in prior revisions in turn imposed a maximum resistance requirement of 0.1 Ohm on bonding. Since that specification was cancelled, the requirement was changed in Revision C to state only the performance requirement, i.e., provide a safety ground. While the 0.1 Ohm bonding requirement is no longer a firm requirement, it is probably a reasonable criteria to use in testing to establish that a solid ground connection has been made.

Note that "bonding resistance" refers to a connection between one wire or component and another, such as between a ground wire and the adjacent aircraft structure. Therefore, the 0.1 Ohm requirement from the old mil-standard should not be interpreted as the resistance of the entire path from the store structure to the aircraft structure.

10.11.2 Structure ground resistance.

MIL-STD-1818 states that the goal of a safety ground is to prevent potentials of over 30 volts from appearing on equipment structure or chassis during electrical faults. For example, if one phase of the 115 V AC power in the auxiliary interface were shorted to ground in a store that was not otherwise electrically connected to aircraft structure (sitting on a store loader during maintenance, no shield braid on test cables, etc.), the safety ground would carry the 30 to 58 Ampere current (per figure 18 of the standard) required to trip the aircraft circuit breaker. If the path from store chassis through cables and connectors to aircraft structure had a resistance of 1/2 Ohm, this would result in the chassis reaching about 30 Volts relative to aircraft ground at the worst case current.

10.11.3 Structure ground not a power return.

The statement in the standard prohibiting use of this connection for a signal or power return could lead to some confusion. The intent of this sentence is that power and signal circuits through the AEIS interfaces must not rely on the existence of the structure ground line for proper operation. Because the standard does not define specific relationships between various grounds in the aircraft or in the store, it is possible that the aircraft will connect 28V DC and 115/200V AC returns to aircraft structure. It is also possible that the store will connect its 28V DC and 115/200V AC load returns to store structure. Under these two design conditions (which are allowed by the standard) some power supply currents will flow through the structure ground line. The standard does not disallow this condition. It is intended to disallow two other possibilities:

a. An aircraft or store using structure ground as the reference ground for an AEIS signal,

b. An aircraft or store relying on structure ground to carry return currents instead of installing dedicated 28V DC return or 115/200V AC neutral lines through the interfaces.

11. RESERVED FUNCTION – 270 VDC

MIL-STD-1760 includes connector contact locations that are reserved to allow compatibility with High Voltage DC electric power systems.

In addition to the information in this section of the Handbook, the rationale and guidance in 15.5.1.10, 15.5.2.10, and 15.5.3.10 (and subparagraphs) should also be consulted.

11.1 Characteristics of high voltage DC electric systems.

The high voltage DC (270V DC) (HVDC) electric system under development offers several potential advantages over the standard 115/200 volt AC system currently used in most aircraft. These advantages include the following:

a. HVDC eliminates the need for a constant-speed drive, thereby reducing weight and maintenance associated with generator or alternator drives.

b. HVDC allows the use of a wild frequency generator which is light in weight because operation can be at very high and varying speeds.

c. DC/DC converters are lighter in weight than AC/DC converters because high frequency transformers can be used.

d. HVDC allows a reduction in wire weight, since the higher voltage means more power is transmitted at a given current level.

e. Bus power dropout during power source switching can be eliminated because parallel operation is easier to accomplish with DC systems than with AC systems.

The disadvantages of a high voltage DC system include:

1. When an arc occurs in a DC system (e.g., due to bad wiring insulation, or between the contacts of a switch which is opening), it does not self-extinguish like it does when the instantaneous voltage of an AC system passes through zero.

2. DC power voltage can not be changed by passing it through a simple transformer. An active DC-DC converter must be used. Fortunately, this technology is becoming much more available, and is typically lighter (for the same power capacity) than a transformer, although there may be efficiency implications.

3. Inititial installations revealed problems with ripple, generated by the switching-mode DC to DC converters used in avionics, being induced back into the power lines.

11.2 Status of 270V DC systems.

MIL-STD-704 includes 270V DC as a "legal" standard power system voltage, and it has been incorporated into some new aircraft. However, at the time of this writing (2000), the 270 V DC system has not been used at store stations. This is due to the time and cost required to change to a new voltage standard and the development required to ensure that HVDC equipment will perform and survive for the long term in the aircraft environment.

11.3 Strategy for incorporating 270V DC.

Power voltage of 270V DC is intended to replace 115/200V AC, but the change results in a short-term penalty since immediate conversion would make 115/200V AC equipment in inventory obsolete and gradual conversion would have a negative impact on system complexity and logistics. Consequently, MIL-STD-1760 retains the standard 115/200V AC and 28V DC power voltages, while reserving connector provisions for 270V DC in the event that 270V DC systems are introduced into aircraft store stations and stores. This reserved status is intended to restrict implementations to some degree. For example, a store cannot be designed to require 270V DC. If a store requires 270V DC, it would result in an immediate obstruction to interoperability since aircraft will not provide 270V DC at an ASI at this time.

The SAE AS-1B MIL-STD-1760 Users Group is currently (2000) studying the possibility of adding specific 270V DC requirements to the standard. Potential strategies being considered are summarized in figure 73.

Delay ←——————————————→ Push

Options:

Do nothing:	**Allow 270:**	**Encourage transition to 270:**	**Force change to 270:**
Leave prohibition against use of 270 V dc in the standard	Change 1760 to make 270 V dc optional for the aircraft and optional for the store	Change 1760 to require aircraft to provide either 270 V dc or 115 V ac; require stores to be able to use either one or to require neither.	Change 1760 to require aircraft to provide 270 V dc. and prohibit stores from requiring 115 V ac.
Result:			
- No transition to 270 (unless a major program ignores 1760 and does it on their own). - Cannot benefit from weight reduction or reliability improvements offered by 270 power.	- Slow use of 270. - Delayed benefit from weight reduction or reliability improve-ments because aircraft must keep 115 to assure compatibility with new stores.	+ Orderly transition to 270. + New aircraft can benefit from weight reduction or reliability improvement. - Stores must have extra circuit. (Makes sense only if this is low in cost.) + Rev D stores would be backward compatible.	- Forced transition to 270 - not acceptable to Europeans and existing US aircraft. + New aircraft would benefit from weight reduction or reliability improvement. - 270 V dc Rev. D stores not compatible with Rev. C.

Assumptions for "transition" option:
- Changing the power requirements would take the Std to Rev. D (Approx. year 2000)
- 270 would be part of the Class 1 and class 1A signal sets
- Store power circuitry can easily be made compatible with both 115 V ac and 270 V dc power.

FIGURE 73. Strategy for incorporating 270 V DC power requirements.

12. RESERVED FUNCTION – FIBER OPTICS.

MIL-STD-1760 includes reserved contact (more correctly called termini) locations for two fiber optic channels through the interface.

In addition to the information in this section of the Handbook, the rationale and guidance in section 15 paragraphs 15.4.3.9, 15.5.1.11 and 15.5.2.11 (and subparagraphs) should also be consulted.

12.1 Characteristics of fiber optics.

Fiber optic communication techniques can offer significant advantages to future aircraft-store interface performance if high data rates or higher electromagnetic environmental requirements are needed. Currently available transmitter, receiver, and connector hardware tends to be more expensive and more fragile than the corresponding “copper wire” systems. Thus, installation of fiber optics through the interface is dependent on either an improvement in the available hardware or a high bandwidth requirement that can not be met with the existing HB lines.

12.2 Strategy for implementation of fiber optics.

While near-term projections indicate that MIL-STD-1553 communication links provide an adequate service capability for the weapon, growth provisions are included in the interface for fiber optics. These provisions are limited to two 16 gauge contact cavities in the primary connector for two reasons. The intent of the Air Force and Navy developers of MIL-STD-1760 is that the AEIS will adopt the fiber optic standard once it is available and an application to stores is needed. Since design requirements such as operating wavelength(s), optical fiber core size and optical contact performance can be significantly affected by the requirements in the fiber optic communication standard, the prudent approach in that time frame was to specify only the contact cavities.

12.3 Proposed interface.

The following replacement fiber optics section was in the earlier draft versions of MIL-STD-1760C, but was removed in the final draft:

"5.1.11 Aircraft fiber optic interface. All class I interface connectors at all ASIs shall include two fiber optic paths (FO1 and FO2). The fiber optic interfaces shall not be used until the optical and logical (protocol) characteristics of the fiber optic interfaces are added to this standard.

"5.1.11.1 Termini and dummy seal plug characteristics. Fiber optic termini and dummy seal plugs shall be in accordance with table II. The termini shall accommodate 100 micron nominal diameter core / 140 micron nominal diameter clad fiber.

"5.1.11.2 Fiber characteristics. Optical fiber shall meet the following requirements:

a. 100 micron nominal diameter core / 140 micron nominal diameter cladding
b. fused silica-based glass/glass construction
c. minimum of 200 MHz*km bandwidth product at 1300 nm wavelength window
d. minimum proof stress level of 200 k psi
e. graded index of refraction construction

f. numerical aperture of 0.29 ± 0.02

"5.1.11.3 Cable characteristics. Fiber optic cable shall be compatible with MIL-T-29504/4 and /5 termini. The attenuation of the cable shall be as follows:

a. less than 8 dB/km attenuation at 850 nm wavelength

b. less than 6.5 dB/km attenuation at 1300 nm wavelength."

Reasons this requirement was not included in the standard are:

- Termini which meet these requirements are not believed to be able to withstand the environment on the end of an umbilical cable in flight, which includes exposure to the airstream, along with rain and dust.

- This type of fiber only offers a small increase in data rate compared to the existing HB coax cable interfaces.

13. ELECTROMAGNETIC COMPATIBILITY.

MIL-STD-1760 does not contain specific Electro Magnetic Compatibility (EMC) requirements. However, the requirements of the standard are designed to accommodate the EMC environment normally found at store stations on aircraft.

13.1 Reason for lack of EMC requirements.

The MIL-STD-1760 interface hardware should be designed and tested to the EMC requirements that apply to the aircraft and stores where it will be used. These requirements will normally be found in a System Specification (or similar document) that defines system requirements. Under “acquisition reform” policies of the US Department of Defense, references to military specifications and standards in contracts (and therefore, in standards such as MIL-STD-1760) are to be minimized to prevent overlapping or tiered requirements. The limited EMC requirements that were in Revision B were removed because they attempted to impose requirements upward on the aircraft, i.e., the interface standard was trying to indicate what requirements the aircraft should meet. Removing these requirements also simplifies the document, avoids overlapping or conflicting requirements, and prevents anyone from assuming that the standard contains a complete or sufficient set of EMC requirements for an aircraft and store system.

MIL-HDBK-235 was also referenced, but it is a compilation of emitter characteristics, useful for defining a required environment, but, being a handbook, it cannot be called out as a requirement.

13.2 EMC requirements that were in Revision B.

Revision B to MIL-STD-1760 included an EMC paragraph (5.1.3) requiring compliance with MIL-E-6051 and the applicable sections of MIL-HDBK-235. This paragraph was deleted in Revision C. MIL-E-6051 has been cancelled and replaced by MIL-STD-464. The requirements in MIL-STD-464 are appropriate to apply to equipment but do not belong in the interface standard (1760). There was also an Electo Magnetic Interference (EMI) paragraph that required testing in accordance with MIL-STD-462 to the requirements of MIL-STD-461 “when required by the system specification”. This also appears to be true and valid for the system, but does not need to be stated in the interface standard.

Appendix A to MIL-STD-1760B defined standard EMI test cables. This appendix was not included in Revision C, since it is for guidance and is not a required part of the standard interface. It is reproduced on the following pages for reference and possible use in EMI testing of stores.

"Appendix A from MIL-STD-1760**B**

"CABLES FOR ELECTROMAGNETIC INTERFERENCE (EMI)
TESTING OF MISSION STORES

"(This section is for guidance and is not a required part of the standard interface. It is reproduced on the following pages for reference and possible use in EMI testing of stores.)

"A.10 SCOPE

"A.10.1 Scope. This appendix covers the requirements for the test cables to be used for EM testing of mission stores.

"A.10.2 Purpose. This appendix should be implemented when mission stores are tested in accordance with MIL-STD-462.

"A.20 REFERENCE DOCUMENTS

"A.20.1 Government documents

"A.20.1.1 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-C-17/94	Cables, Radio Frequency, Flexible Coaxial, 75 OHMS
MIL-C-17/113	Cable, Radio Frequency, Flexible Coaxial, 50 OHMS
MIL-C-17/176	Cables, Radio Frequency, Flexible, Twinaxial
MIL-W-22759/16	Wire, Electric, Fluoropolymer Insulated, Extruded Estfe, Medium Weight, Tin Coated Copper Conductor, 600-Volt, +150 Degrees Celsius

STANDARDS

Military

MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of

(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.)

"A.20.2 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.

"A.30 DEFINITIONS

Not applicable.

"A.40 REQUIREMENTS

"A.40.1 Mission store testing . If tested in accordance with the requirements of MIL-STD-462, mission stores shall use cables which comply with the requirements of Table A-1. These test cables shall be used to interconnect the MSI to the simulated (or actual) aircraft loads and sources. For MIL-STD-462 RS03 tests, the mission store shall be tested at 200 volts/meter with shielded test cables 1 and 1A (see Table A-I) and at 20 volts/meter with unshielded test cables 2 and 2A (see Table A-I). Test cables 2 and 2A shall be used for all other MIL-STD-462 EMI tests.

"Appendix A from MIL-STD-1760**B**

TABLE A-I. EMI test cable requirements.

SIGNAL NAME	CABLE REQUIREMENTS		
	WIRE SPECIFICATION SHEET AND SIZE	WIRE TWISTS/METER	TEST CABLE 1/
Primary signal set			1 of 2
HB 1 & 2	MIL-C-17/113 (RG316)	-	
HB 3 & 4	MIL-C-17/94 (RG179)	-	
Mux A, Mux B, LB	MIL-C-17/176	-	
Fiber optic channel 1 & 2	(No line required)	-	
Release consent	MIL-W-22759/16-20	-	
Interlock and interlock return	MIL-W-22759/16-20	Pair: 15 ±3	
Address bit A4 Address bit A3 Address bit A2 Address bit Al Address bit A0 Address parity Address return	MIL-W-22759/16-20	Set: 15 ±3	
Structure ground	MIL-W-22759/16-16	-	
28V DC power 1 and 28V DC power 1 return	MIL-W-22759/16-16	Pair: 15 ±3	
28V DC power 2 and 28V DC power 2 return	MIL-W-22759/16-16	Pair: 15 ±3	
115V AC phase A, B, C and neutral	MIL-W-22759/16-16	Quad: 15 ±3	
270V DC power and 270V DC power return	(No line required)		

"Appendix A from MIL-STD-1760**B**

TABLE A-I. EMI test cable requirements (continued).

SIGNAL NAME	CABLE REQUIREMENTS		
	WIRE SPECIFICATION SHEET AND SIZE	WIRE TWISTS/METER	TEST CABLE 1/
Auxiliary power signal set.			1A and 2A
28V DC power and 28V DC power return	MIL-W-22759/16-10	Pair: 15 ±3	
115V AC phase A, B, C and neutral	MIL-W-22759/16-10	Quad: 15 ±3	
270V DC power and 270V DC power return	(No line required)		
Structure ground	MIL-W-22759/16-10		

1/The test cables shall comply with the following requirements:

1 and 1A: The cable assembly shall be enclosed by a braided wire shield with 80 to 95 percent optical coverage. The shield shall have a 360 degree connection to the connector assembly at each end of the cable. The cable length, measured between the front faces of the two connectors, shall be two meters, plus or minus two percent. The “aircraft end" cable connector shall be a D38999/26WJ20PN plug for test cable 1 and a D38999/26WJ11PA plug for test cable 1A.

2 and 2A: The cable assembly shall provide no gross shielding other than that provided by the connector assembly. The cable length measured between the front faces of the two connectors shall be two meters, plus or minus two percent. The “aircraft end" cable connector shall be a D38999/26WJ20PN plug for test cable 2 and a D38999/26WJ11PA plug for test cable 2A."

14. CONNECTORS, WIRING AND UMBILICALS

This section discusses the connector, contact, and wiring harness design criteria and hardware required to conform to MIL-STD-1760C. One of the first steps in defining the connector requirements is to define the type of connection that will be made. For store manufactures this is relatively simple since the choices are limited to MSI, CSI or CSSI. For an aircraft, definition of the location of the ASI in the overall stores management system is an important step in the system requirements' definition. Figures 74a, b, and c illustrate possible locations for the different connection types that meet the requirements of MIL-STD-1760C.

In addition to the information in this section of the Handbook, the rationale and guidance in paragraphs 15.4.5, 15.5.1.1, 15.5.2.1, and 15.5.3.1 (and subparagraphs) should also be consulted.

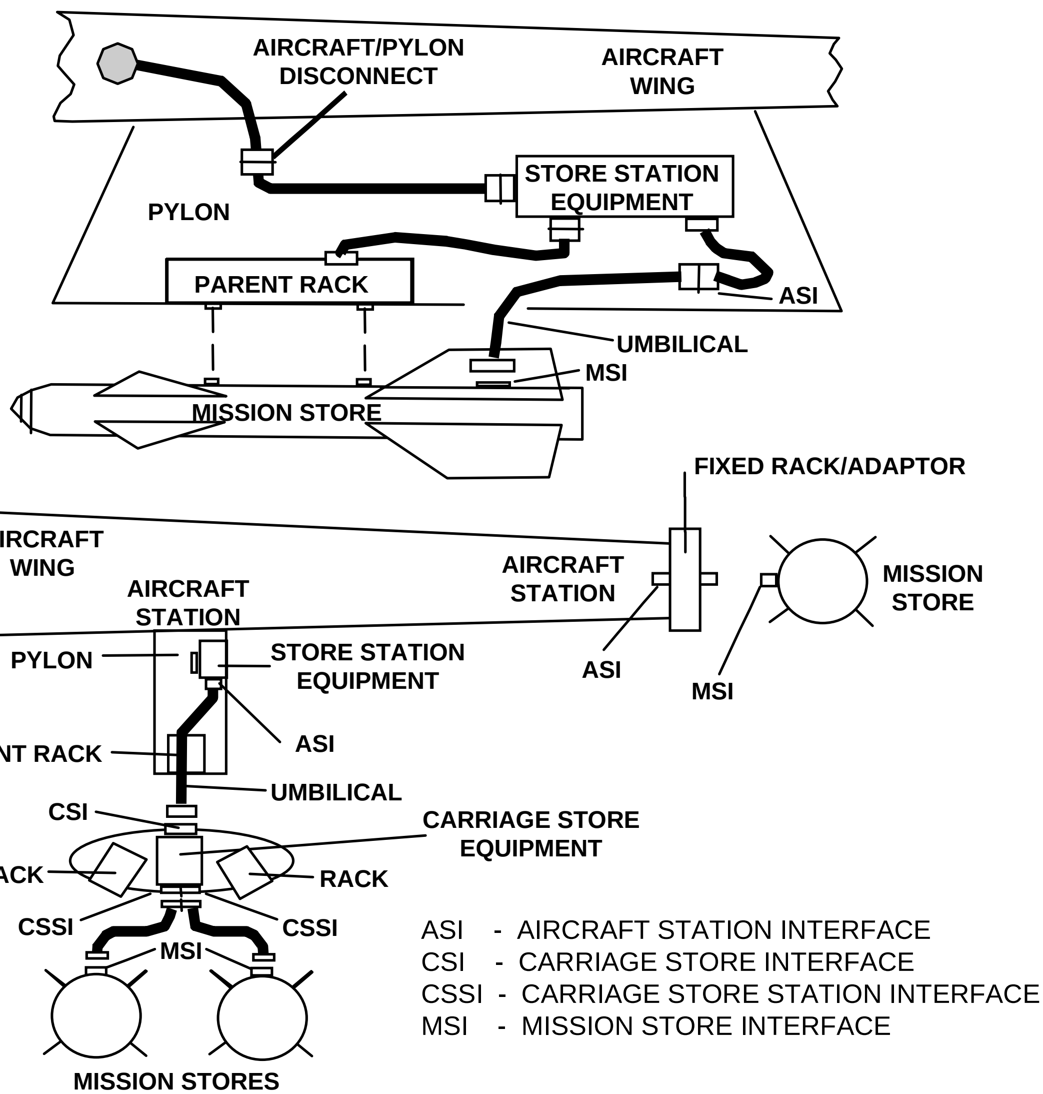


FIGURE 74. (a) Typical locations of ASI connectors within a stores management system.

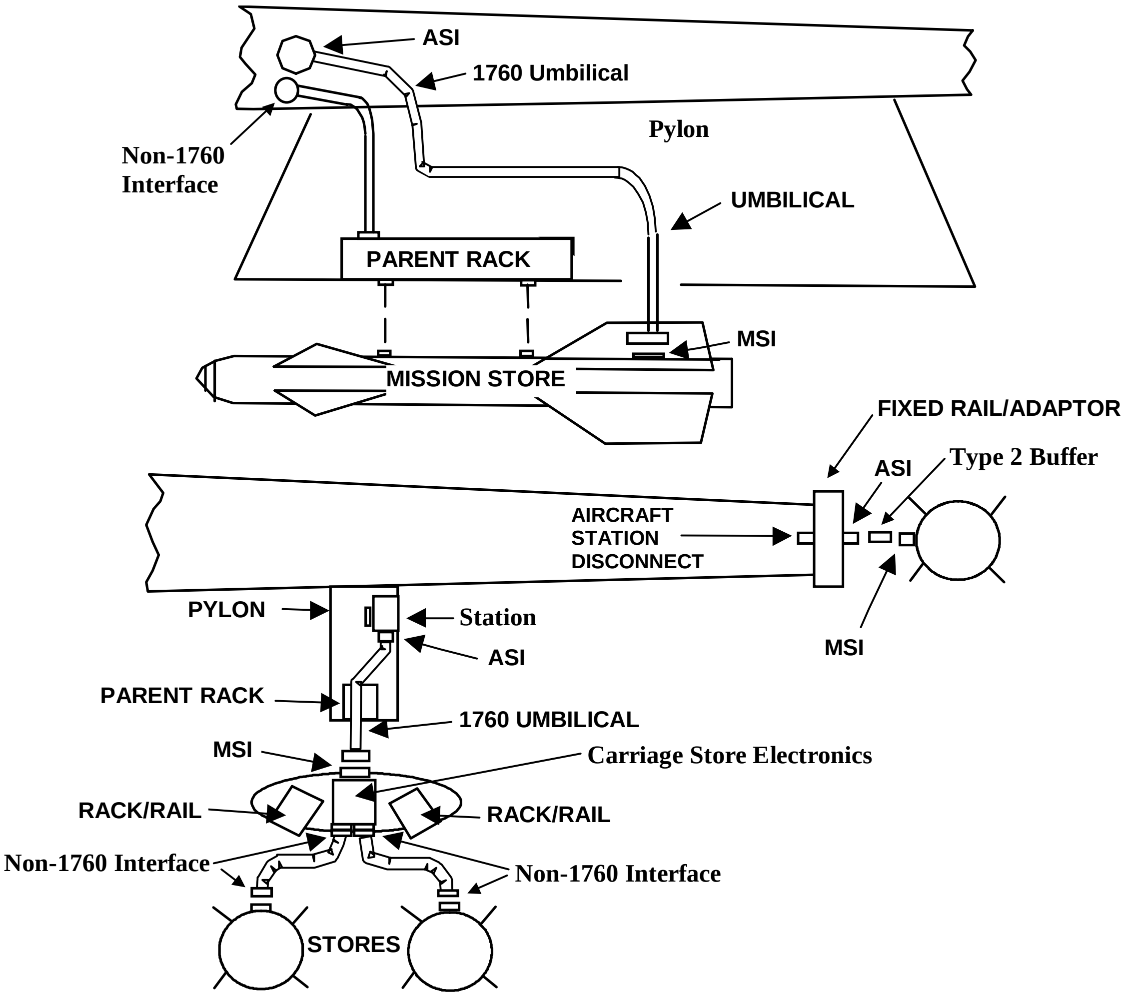


FIGURE 74. (b) Typical locations of ASI connectors within a stores management system. (cont)

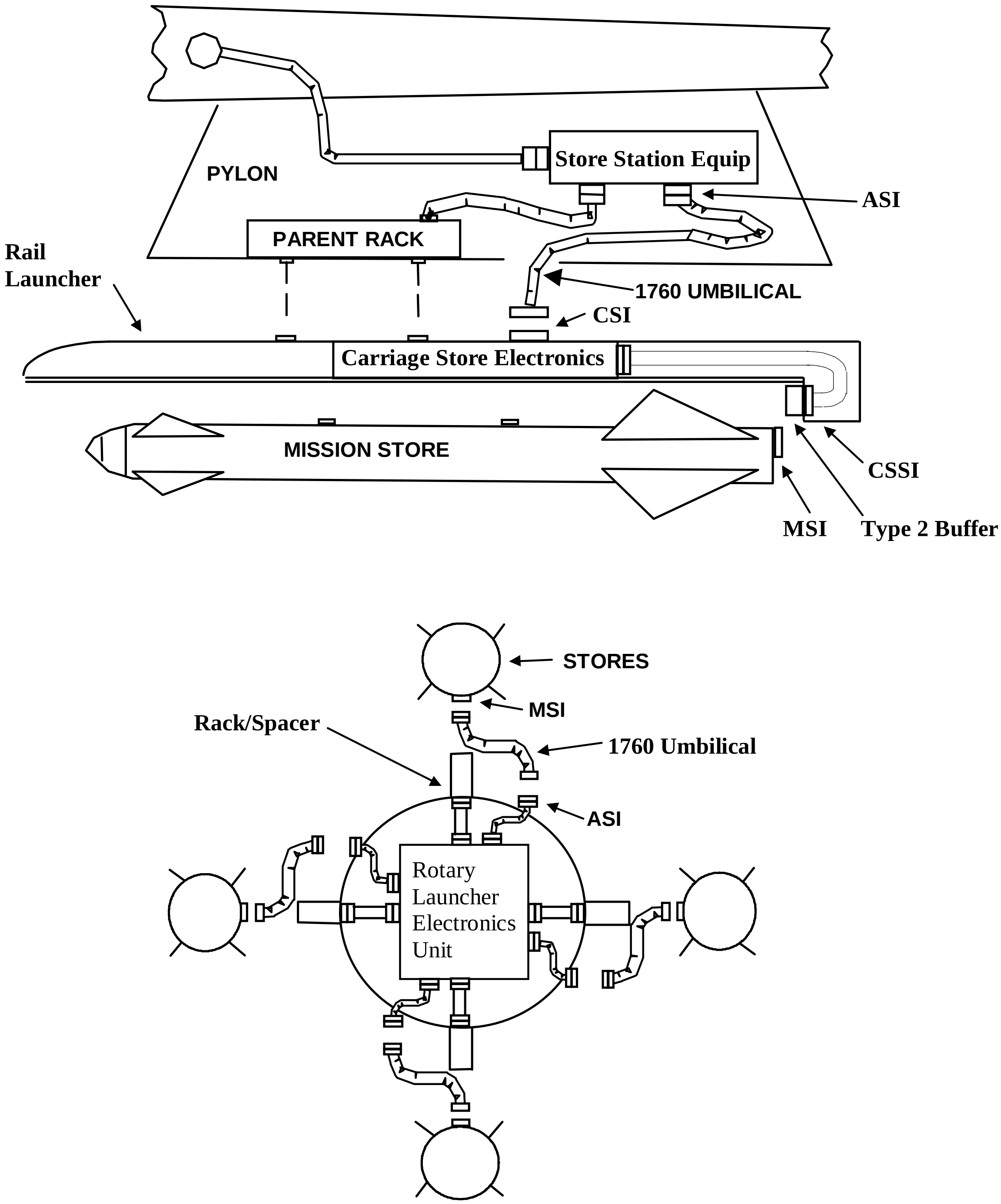


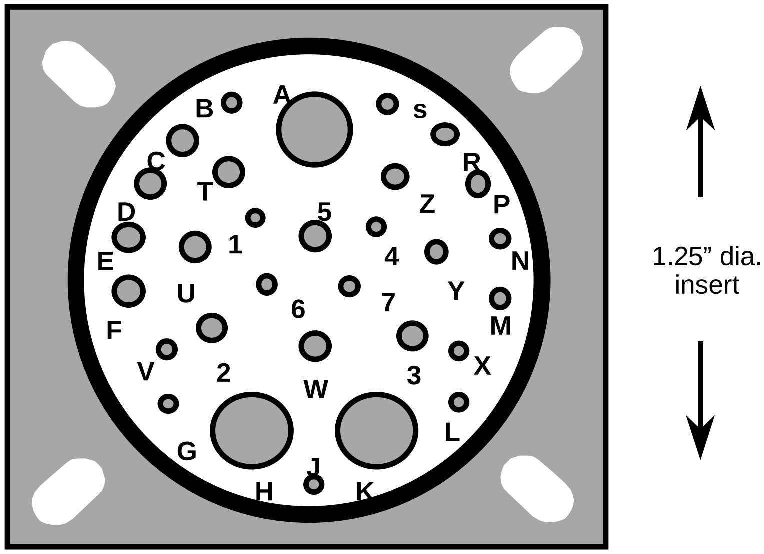
FIGURE 74. (c) Typical locations of ASI connectors within a stores management system. (cont)

14.1 Aircraft station interface connectors.

The aircraft station interface (ASI) consists of the primary connector, auxiliary connector (in some applications), and the aircraft wiring necessary to service the interface.

14.1.1 Primary connector.

There are two types of primary connectors. The Type one connector is used for applications in which an umbilical with a snatch type connector ("lanyard release") will be used to connect to the MSI or CSI. The Type two connector is used in rail launch or blind-mate eject launch applications where the buffer adapter is used to connect to the store. Both connector types use the MIL-STD-1560 insert, arrangement number 25-20 as shown in figure 75, with the exception of the pin call out for location W. Specific requirements for the Type one and Type two connectors are described in the following sections.



K, H	Mux A & B (twinaxial) (MIL-STD-1553)
5	High Bandwidth 1 (20 Hz - 1.6 GHz)
W, 3, 2	HB 2*****, 3 & 4***** (20 Hz - 20 MHz)
(HB 1, 2 = 50 Ohm co-ax, HB 3, 4 = 75 Ohm co-ax)	
A	Low Bandwidth (twinaxial) (Audio)
Y, U	Fiber Optic 1***** & 2***** (reserved)
1	Release Consent
B, S	Interlock & interlock return
L, X, 7, 4, V	Address bits 0 thru 4
G, 6	Address parity & return
T	Structure ground (safety, 10 Amp)
C, D	28 VDC power 1 & return (10 Amp)
F, E	28 VDC power 2 & return (10 Amp)
P, M, J, Z	115 VAC, 3 phase & return (10 Amp)
R, N	270 VDC power***** & return***** (10 Amp)

***** = Not required for Class II interface

FIGURE 75. Primary signal set insert arrangement.

Table XXIII is a partial list of components that can be used in aircraft harness design. Note that, in MIL-STD-1760C, the aircraft is not required to use connectors and contacts that fully comply with MIL-C-38999, MIL-C-83538, and the listed MIL-C-39029 specification sheets but it is highly encouraged since the ASI may be mated/unmated several thousands of times over the life of an aircraft .

TABLE XXIII. MIL-STD-1760 hardware, primary signal set.

ITEM	Part Number	Nomenclature
1	D38999/20WJ2OSN	Receptacle - Wall Mount
2	D38999/24WJ2OSN	Receptacle - Jam Nut
3	MIL-C-83538	Launcher Receptacle
4	M39029/56-XXX	Contact, Socket
5	M39029/75-XXX	Contact, Shielded, Socket
6	M39029/91-XXX	Contact, Concentric Twinaxial, Socket
7	M39029/103-XXX	Contact, Coaxial, Socket
8	M17/094-RG179	Cable, Coaxial, 75 ohm
9	M17/133-RG316	Cable, Coaxial, 50 ohm
10	M17/152-00001	Cable, Coaxial, 50 ohm (Double Shield)
11	M17/131-RG403	Cable, Triaxial, 50 ohm
12	M17/176-0002	Cable, Twinaxial, 77 ohm
13	M85049/20-25W	Backshell

14.1.1.1 Type 1 connector.

A Type 1 ASI connector is either a Wall Mount Receptacle (D38999/20WJ20SN) or a Jam Nut Receptacle (D38999/24WJ20SN) threaded MIL-C-38999, Series III, shell size 25 with a Polarization Key Identification N. The ASI connector is intermateable with a standard plug (D38999/26WJ2OPN) used by the aircraft umbilical that connects between the ASI and the MSI or CSI. Figure 76 illustrates the ASI connector types.

The designer should consider the safety implications of a failure of the lanyard release process during store mechanical separation (ejection) from the aircraft. This would result in S&RE no longer retaining the store, but the umbilical cable would still be connected. The most probable causes of the umbilical failing to disconnect are:

a. Failure of ground crew to connect lanyard to retention device, such as pylon bail bar.

b. Defective lanyard due to corrosion or other mechanical damage.

c. Defective umbilical plug release mechanism.

While the probability that one of these conditions will occur is low, the safety and aircraft damage implications of either a store "dangling" from the aircraft by its umbilical or the store ripping out aircraft wiring due to a lanyard problem warrants some consideration during ASI design. Prior experience has shown that the aircraft ASI can be severely damaged when a lanyard fails and the separation forces of the store rip the umbilical off the ASI connector.

For Type 1 ASI applications, use of a frangible wall mount receptacle or jam mount receptacle should be considered to reduce damage to the aircraft in case of a lanyard failure. Use of a frangible connector will limit damage to the connector shell rather than damaging aircraft store station wiring. One version of a frangible Type 1 receptacle that has been tested contains a shear mechanism in the receptacle shell. This shear point allows part of the receptacle shell to break loose at a pre-set force (range). Once the shell separates, the umbilical plug with part of the shell will disconnect from the remainder of the store receptacle. The fracture force can be adjustable over a fairly broad range to optimize the frangible shell feature for specific store applications. Frangible connectors that meet the requirements of MIL-C-38999/34 and /35 are recommended.

A dust cover should be provided to cover the ASI to reduce dirt/fluid build up in the ASI when not in use. Remember that an ASI may be unused for months or even years before it is used. An option that should be considered is use of a dust cover that has alignment contacts to help keep the ASI pins aligned when not in use. Once a pin in the ASI is miss-aligned, several umbilicals may be damaged before the ground crew determines the cause of the damage.

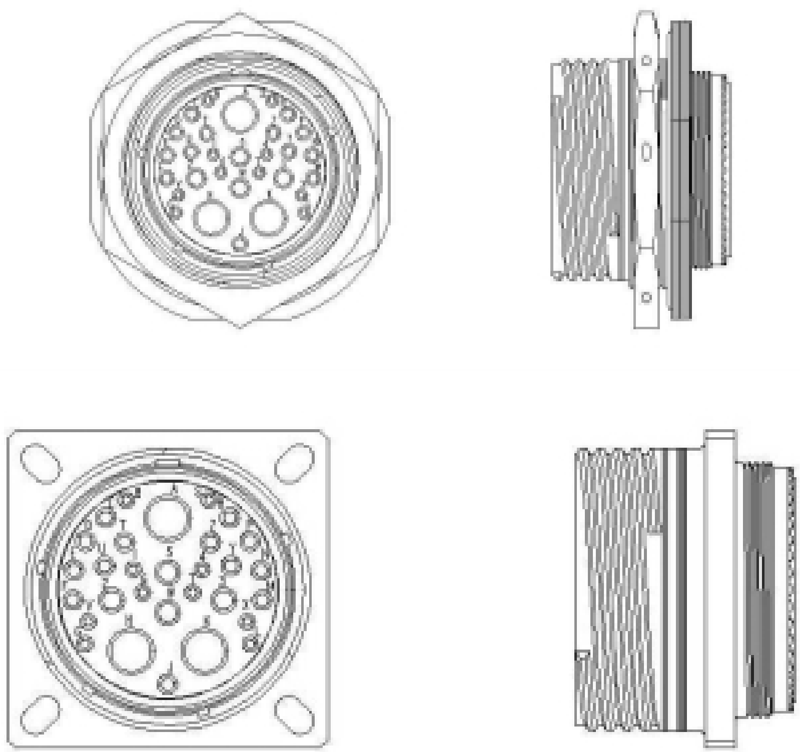


FIGURE 76. Type 1 ASI/MSI Connectors.

14.1.1.2 Type 2 connector.

The Type 2 ASI connector is defined by the form, fit, and function requirements of the MIL-C-83538 Launcher Receptacle and is intermateable with the MIL-C-83538 Buffer Plug. This connector is also known as a “Blind Mate” connector. The Buffer Plug acts as a fixed umbilical between the Launcher Receptacle and the MSI. The buffer is expendable, and is typically replaced after each launch in applications where it is exposed to damaging rocket exhaust during the launch. Figure 77 illustrates the parts of the Type 2 connector.

FIGURE 77. Type 2 ASI, MSI and buffer connectors and dust covers.

14.1.1.3 Contacts.

The aircraft ASI connector is a receptacle with socket contacts as listed in table XXIV. All unused contact locations must be filled with seal plugs or dummy sockets to keep water or other contaminants from entering a mated connector from the backside.

TABLE XXIV. Primary signal set connector requirements (ASI).

Size	MIL-C-39029 Slash Sheet	Contact Location	Abbreviated Title	Seal Plugs/Dummy Contacts
20	/56	B,G,L,S,V,X,1, 4,6,7,	Contact, socket	MS27488-20 RED
16	/56	C,D,E,F,J,M,N ,P,R,T,Z	Contact, socket	MS27488-16 BLUE
12	/75	2,3,W (See note 1)	Contact, shielded, socket	M85049/80-12 YELLOW
12	/103	5	Contact, coaxial, socket	M85049/80-12 YELLOW
8	/91	A,H,K	Contact, concentric twinax, socket	M85049/80-8 GREEN
16	NA	U,Y	Terminus, socket	TBD

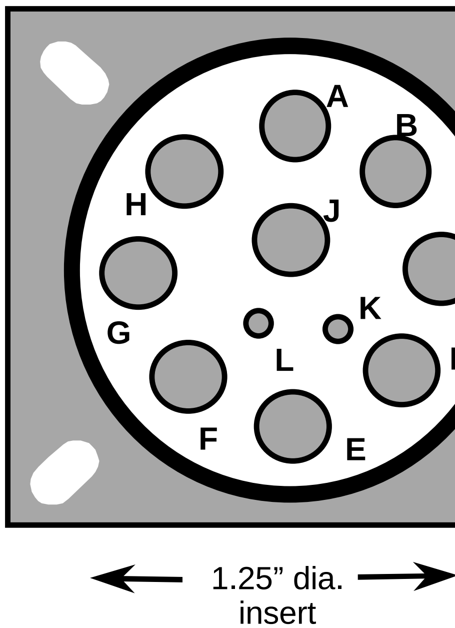
Note 1: The HB2 contact can be either a /75 or /103 contact. Every effort should be made to have the umbilical pin be the correct mate for the selected socket (/75 with /28, /103 with /102) to reduce VSWR and return losses.

14.1.2 Auxiliary connector.

There is only one type of auxiliary connector. The auxiliary connector is always used with an umbilical cable, i.e., there is no “type II” auxiliary connector. The connector is a MIL-C-38999, Series III, Shell Size 25, polarization key identification A with a MIL-STD-1560 insert arrangement 25-11. The insert arrangement is shown in figure 78. Figure 79 shows examples of the auxiliary connector. The MIL-C-39029 slash sheets listed in table XXV define the requirements on contacts in the Auxiliary connector. The connector on the aircraft ASI is a receptacle with socket contacts.

TABLE XXV. Auxiliary signal set connector requirements.

Size	Slash Sheet Number	Abbreviated Title
20	/56	Contact, Socket
20	/58	Contact, Pin
10	/56	Contact, Socket
10	/58	Contact, Pin



A, C, E, G 115 V AC, 3 phases & Return (30 Amp)

B, D 28 V DC Power & Return (30 Amp)

F, H 270 V DC Power* & Return* (30 Amp)

J Structure Ground (Safety, 30 Amp)

K, L Interlock & Interlock Return

* = Not required for Class II interface

Note: Contacts A through J are size 10, K and L are size 20

FIGURE 78. Auxiliary signal set insert arrangement.

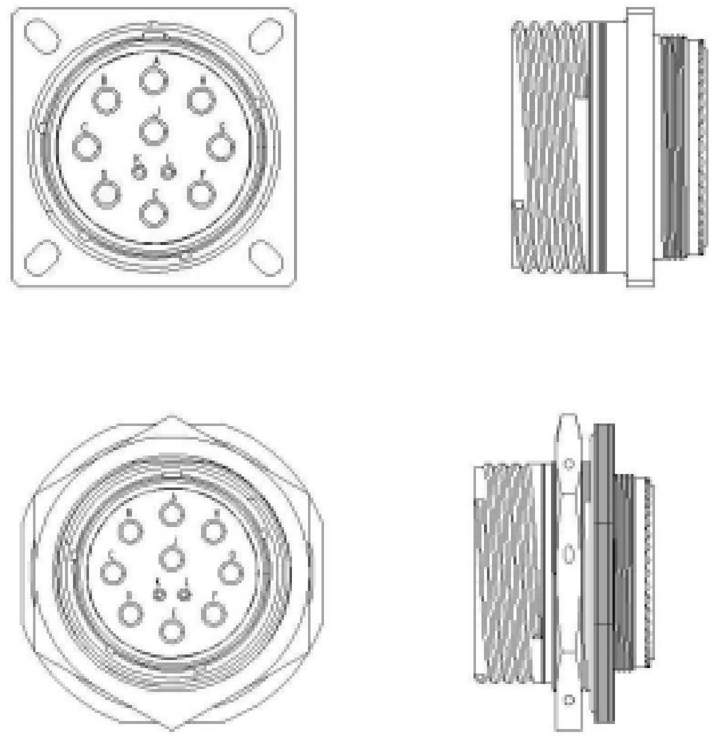


FIGURE 79. Auxiliary connector ASI/MSI examples.

Table XXVI is a partial list of components that can be used in harness design. The aircraft can use other parts providing the ASI requirements are met. The auxiliary connector shell is the same as the primary connector shell.

TABLE XXVI. MIL-STD-1760 hardware, auxiliary signal set.

Part Number	Nomenclature
D38999/20WJ11SA	Receptacle - Wall Mount
D38999/24WJ11SA	Receptacle - Jam Nut
D38999/56-XXX	Contact, Socket
M85045/20-25W	Backshell

14.1.3 Assembly.

This section of the Handbook addresses some of the assembly issues with the ASI connector and harness.

14.1.3.1 Primary ASI connector assembly.

Contact insertion and removal is accomplished with MS27495, or equivalent, insertion and removal tools. Precautions need to be taken when assembling the No.8 twinaxial pin into a plug assembly. The length of the pin contact, the relative stiffness of the twinaxial cable, the location of the contact cavities near the periphery of the insert and the relatively large pin diameter can cause a severe contact skewing problem. This skewing can be especially severe in the D38999-26WJ20PN plug if the wire bundle is clamped down near the rear of the plug's rubber sealing grommet. The skewed pin can cause unequal loading on the contact retention device and result in permanent damage if the load is excessive. Furthermore, the skewed pin can be misaligned sufficiently with the mating socket insert in the receptacle to cause it to strike the closed entry chamber around the socket contact opening. The pin, rigidly confined at the rear by the cable clamp, cannot float within its cavity as intended. Therefore, the pin either chips the plastic or begins to wear it away. Once chipped or worn away, it no longer serves its function as a pre-alignment for the entry into the socket contact. Also, push-out of the pin can occur if the pin does not enter the socket and the force exerted by rotating the coupling nut is sufficient to overcome the strength of the retention collet.

The wire harness design must keep the twinaxial pin in proper axial alignment. One design concept uses a spider, which supports the twinaxial contacts and has openings to permit the wires to pass through as shown in figure 80. The spider is made from non-conductive material such as Teflon and fits inside the connector backshell. Another approach is to pot the back of the connector during harness manufacturing to rigidly hold all pins in alignment. One draw back to the use of potting in the back shell is the loss of reparability of the harness.

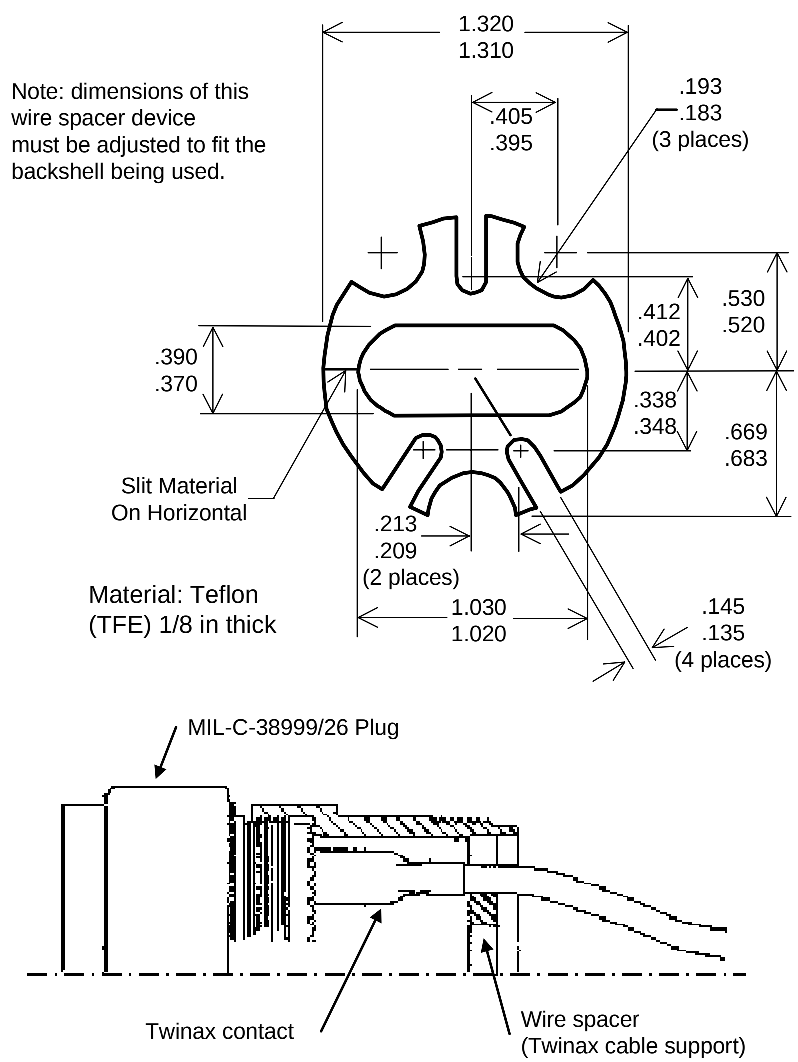


FIGURE 80. Design concept to maintain twinaxial pin in proper axial alignment.

14.1.3.2 HB contact selection/assembly.

An important factor in HB contact performance is proper termination of the coaxial cable to the connector contact and proper alignment of the contact set. Contact set misalignment, perpendicular to the contact axis, can have a serious effect on VSWR characteristics. This alignment effect plus axial misalignment is part of the cause for higher VSWR in MIL-STD-1760B compliant connectors over dedicated RF connectors. Some misalignment is necessary to insure alignment of all other contacts in one mating operation of the multi-contact connector.

Other factors that add to VSWR degradation in the MIL-STD-1760 connector is wear due to repeated mating/unmating and contamination due to contact exposure at the ASI. The extent of VSWR degradation due to wear and contamination is higher with store interface connectors than with dedicated RF connectors because mating and unmating is more frequent. The MIL-STD-1760 connector is mated/unmated when any store is installed. See figure 64 of ASD-TR-87-5028 for examples of return loss versus frequency for a mated set of the M39029/28 and 75 contacts. See figure 65 of the same TR for similar data for the M39029/102 and /103 contacts that are used for the High Bandwidth #1 application.

The /28 and /75 contacts are uncontrolled impedance "shielded" contacts and are available from several suppliers. They provide adequate performance for use in HB2, HB3 and HB4 applications but are inadequate for HB1. The M39029/102 and /103 contacts provide good performance of both HB1 and HB2 applications due to their matched impedance design. Special care should be taken for applications that can cause a mixture of /102 and /103 contacts with /75 and /28 contacts in HB-2 applications. Testing has shown that /103 contacts will mate with /28 contacts with acceptable degradation of the signal due to the impedance mismatch. But, although /102 contacts will mate with /75 contacts, the signal degradation due to the impedance mismatch is significantly worse. See section 8, High Bandwidth, for cabling considerations for HB applications.

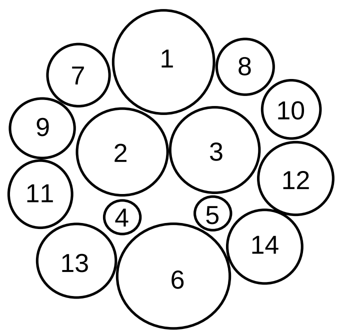
MIL-STD-1760C only calls for the /102, /103 devices in location 5. MIL-C-38999, which the connector is qualified to, calls for the contact to be as specified by MIL-STD-1560, not MIL-STD-1760. When a MIL-C-38999 qualified connector is ordered with contacts, it includes two /102 contacts for locations 5 and W and two /28 contacts for locations 2 and 3 as specified in MIL-STD-1560. (It may instead include four /28 and no /102, depending on the vendor, but that's another topic). To avoid writing a special source control document to get the contact configuration called for by MIL-STD-1760, one can request qualified connectors, which come with two /102 and two /28 for the four high bandwidth locations which is acceptable for most applications. The pin callout in MIL-STD-1760C was changed without changing MIL-STD-1560, which creates a procurement hassle. Letting these two specs get out of sync forces the community to purchase the connector without contacts and purchase the proper mix of contacts separately. The alternative is to buy the connector with contacts and order additional /28 contacts and throw the extra /102 contacts away. Both of these options are fiscally imprudent. The connector vendors cannot provide what is called out in MIL-STD-1760 with regard to contacts and claim MIL-C-38999 compliance since MIL-C-38999 compliance relies on MIL-STD-1560 for the contact callouts. This issue will face the procurement community until MIL-STD-1760 is changed back so it matches MIL-STD-1560 (which supports backwards compatibility) or MIL-STD-1560 is changed.

14.1.3.3 Triax contact assembly.

The triax contacts should be given special attention due to the height of the contact. The length of the pin contact can cause a severe contact skewing problem. This skewing can be especially severe in the D38999-26WJ20PN plug if the wire bundle is clamped down near the rear of the plug's rubber sealing grommet. The skewed pin can cause unequal loading on the contact retention device and result in permanent damage if the load is excessive. Furthermore, the skewed pin can be misaligned sufficiently with the mating socket insert in the receptacle to cause it to strike the closed entry chamber around the socket contact opening. The pin, rigidly confined at the rear by the cable clamp, cannot float within its cavity as intended; therefore, the pin can be damaged during the mating process.

14.1.3.4 Primary ASI harness flexibility.

To increase harness flexibility, the lay of wires in the harness should form a twist. The lay length should be 8 to 16 times the pitch diameter, i.e., a 1 cm diameter cable layer would have one turn every 8 to 16 cm in length. The cable should be twisted with a unidirectional lay where all cable layers are twisted in the same direction but with different lay lengths. This produces a cable with maximum flexibility and ruggedness. Figure 81 shows a suggested twisting arrangement for the primary harness. Other arrangements are also acceptable.



LOCATION	CONDUCTOR	FUNCTION
1	7-20 AWG TWISTED	ADDRESS DISCREET
2	2-16 AWG TWISTED	28 V DC POWER 1
3	2-16 AWG TWISTED	28V DC POWER 2
4	1-18 AWG	STRUCTURE GROUND
5	1-20 AWG	RELEASE CONSENT
6	4-16 AWG TWISTED	115/200V AC
7	COAX/TRIAX CABLE	HB4
8	COAX/TRIAX CABLE	HB2
9	COAX/TRIAX CABLE	HB1
10	COAX/TRIAX CABLE	HB3
11	2-20 AWG TWISTED	INTERLOCK
12	TWINAXIAL	MUX B
13	TWINAXIAL	LB
14	TWINAXIAL	MUX A

FIGURE 81. Suggested primary harness conductor arrangement.

14.1.3.5 Auxiliary ASI connector assembly.

Contact insertion and removal is accomplished with MS27495, or equivalent, insertion and removal tools. Care must be taken when inserting the No.10 contact. Due to the large contact size, inserting the contact can be relatively difficult. The force necessary to insert the contact through the grommet can result in an over-travel once the initial seal resistance is overcome. This over-travel can result in damage to the interfacial seal and hard dielectric behind the seal. Also, due to the stiffness of Size 10 wire, damage can result to the interfacial seal even after successful contact insertion if the wire is not handled with care. The wire cable must be properly secured to the connector with backshell hardware, otherwise damage to the interfacial seal can result while handling the harness.

14.1.3.6 Auxiliary ASI harness flexibility.

The stiffness of Size 10 wire results in a stiff harness if the wires are laid in straight lines parallel to each other and secured to provide a tight bundle. Laying the wires to form a twist will increase harness flexibility. The lay length should be 8 to 16 times the pitch diameter, i.e., a 1 cm diameter cable layer would have one full turn for every 8 to 16 cm in length. The umbilical cable should use a unidirectional lay for maximum flexibility and ruggedness.

14.1.4 Mechanical.

This section of the Handbook deals with intermateability requirements associated with the interface mating connectors and the umbilical cables. Physical design areas such as the mechanical interface between store and aircraft for suspension and release and structural design issues are not addressed by MIL-STD-1760 and, therefore, are not addressed by this Handbook.

14.1.4.1 Keyway orientation.

MIL-STD-1760 defines the orientation (clocking) of the major keyway for the ASI (Type 1 and Type 2), CSI, CSSI and MSI connectors on the aircraft, carriage store and mission store, respectively. This orientation is compliant with MIL-A-8591 and with the System 2 specification for nuclear weapon interfaces. The keyway orientation needs to be controlled because the axial rotational flexibility of shield over-braided umbilical cables is very limited. Total twist typically available on a shielded, 0.6m long, umbilical is less than ± 25 degrees. With some cable constructions, the twist available can be significantly less or significantly more.

14.1.4.2 ASI location.

Placement of the ASI should be chosen to provide sufficient room for a range of MSI/CSI locations and heights. Due to design constraints on store development, MSI/CSI locations may not always be in accordance with MIL-A 8591. Additionally, the MSI/CSI height relative to the hook plane may vary from recessed connectors several inches below the hook plane to applications placed on top an existing moldline which could protrude to just an inch below the hook plane.

14.1.5 Environmental considerations.

Environmental considerations primarily concern the interface connectors, which are exposed to the outside airflow around the aircraft and store. In many instances, the ASI connector is exposed to the environment (temperature extremes, vibration, shock, contamination, etc) while unmated. The unmated condition occurs when there is not a store loaded at a station. For conditions where the umbilical or buffer is not installed, the ASI connector should be covered with a protective cap.

The location of the ASI in the aircraft and the resulting location of the disconnected end of the umbilical cable after store separation influence the environmental performance of the connector. While the connector location is very much constrained, the installation designers should attempt to locate the ASI connector to maximize protection against moisture, ice build-up and exhaust from rocket motors.

The specific environments that the ASI will be exposed to will vary considerably with each application and will, therefore, be defined in the applicable system specifications. Representative environmental considerations are presented in the aircraft environment sections of MIL-HDBK-244. Noteworthy environments are:

a. High temperature exposure of the ASI.

b. Low temperature exposure during captive carry and following store release from the aircraft.

c. High pyrotechnic induced shocks during store ejection.

d. Gas plume impingement on the ASI and umbilical cable/buffer.

14.1.6 EMI/EMC considerations.

For a connector to provide high EMI shielding effectiveness, the ASI connector should include the following features:

a. EMI grounding fingers that provide a good shell-to-shell connection prior to mating of individual contacts in the connector,

b. Conductive finishes on the connector shell,

c. Provisions for 360 degree braid termination, if used on the aircraft harness,

d. Minimal shield degradation following environmental exposure.

The ASI receptacles must be bonded to aircraft structure to minimize potential differences. Also, since the umbilical gross overbraid can be one of the paths for lightning currents, the ASI receptacle should be bonded sufficiently to handle the expected current. The ASI should as a minimum meet the Class R bonding requirements of MIL-B-5087 between the ASI connector and the aircraft structure ground.

14.2 Mission store interface.

The mission store interface (MSI) consists of the primary connector, auxiliary connector (in some applications), and the mission store wiring necessary to service the interface. This section will discuss the design criteria for the MSI to conform to MIL-STD-1760.

14.2.1 MSI primary connector.

There are two types of primary connectors. The Type 1 connector is used for applications in which an umbilical will be used to connect to the MSI. The Type 2 connector is used in rail launch or conformal eject launch applications where the buffer adapter is used to connect to the store. Both connector types use the MIL-STD-1760 insert arrangement, number 25-20 as shown in figure 75. Specific requirements for the Type 1 and Type 2 connectors for the MSI are described in the following sections.

Table XXVII is a partial list of components that can be used in mission store interface design. The mission store is required to use connectors that comply with the form, fit, and function requirements of MIL-C-38999 or MIL-C-83538. The contacts used by the mission store are not required to be fully compliant with the listed MIL-C-39029 specification sheets but must be intermateable with MIL-C-39029 compliant contacts.

TABLE XXVII. MIL-STD-1760 hardware, primary signal set.

ITEM	Part Number	Nomenclature
1	D38999/20WJ2OSN	Receptacle - Wall Mount
2	D38999/24WJ2OSN	Receptacle - Jam Nut
3	MIL-C-83538	Store Receptacle
4	M39029/56-XXX	Contact, Socket
5	M39029/75-XXX	Contact, Shielded, Socket
6	M39029/91-XXX	Contact, Concentric Twinaxial, Socket
7	M39029/103-XXX	Contact, Coaxial, Socket
8	M17/094-RG179	Cable, Coaxial, 75 ohm
9	M17/133-RG316	Cable, Coaxial, 50 ohm
10	M17/152-00001	Cable, Coaxial, 50 ohm (Double Shield)
11	M17/131-RG403	Cable, Triaxial, 50 ohm
12	M17/176-0002	Cable, Twinaxial, 77 ohm

14.2.1.1 Type 1 connector.

A Type 1 MSI connector is either a Wall Mount Receptacle (D38999/20WJ20SN) or a Jam Nut Receptacle (D38999/24WJ20SN) threaded MIL-C-38999, Series III, shell size 25 with a Polarization Key Identification N. The MSI connector is intermateable with a standard plug (D38999/26WJ2OPN) or Lanyard Release plug (D38999/31WJ20PN) used by the aircraft umbilical that connects between the ASI and the MSI. Figure 76 illustrates the MSI connector types.

The designer should consider the safety implications of a lanyard release mechanism failure during store separation (ejection) from the aircraft i.e., S&RE no longer retaining the store, but umbilical cable still connected. The most probable causes of the umbilical failing to disconnect are:

a. Failure of ground crew to connect lanyard to retention device, such as pylon bail bar.

b. Defective lanyard due to corrosion or other mechanical damage.

c. Defective umbilical plug release mechanism, likely due to severe corrosion.

While the probability that one of these conditions will occur is low, the safety and hardware damage implications of either a store "dangling" from the aircraft by its umbilical, or the store ripping out aircraft wiring due to a lanyard problem, warrants some consideration during store design. Prior experience has shown that the store MSI can be severely damaged when a lanyard fails and the separation forces of the store rip the MSI connector off the store.

For Type 1 MSI applications, use of a frangible wall mount receptacle or jam mount receptacle should be considered to reduce damage to the aircraft/store in case of a lanyard failure. Use of a frangible connector will limit damage to the connector shell rather than damaging store wiring. One version of a frangible Type 1 receptacle that has been tested contains a shear mechanism in the receptacle shell. This shear point allows part of the receptacle shell to break loose at a pre-set force (range). Once the shell separates, the umbilical plug with part of the shell will disconnect from the remainder of the store receptacle. The fracture force can be adjustable over a fairly broad range to optimise the frangible shell feature for specific store applications.

14.2.1.2 Type 2 connector.

A Type 2 MSI connector is a MIL-C-83538 Store Receptacle and is intermateable with the MIL-C-83538 Buffer Plug. This connector is also known as a “Blind Mate” connector. The Buffer Plug acts as a fixed umbilical between the Launcher Receptacle and the MSI. Figure 82 illustrates the Store Receptacle.

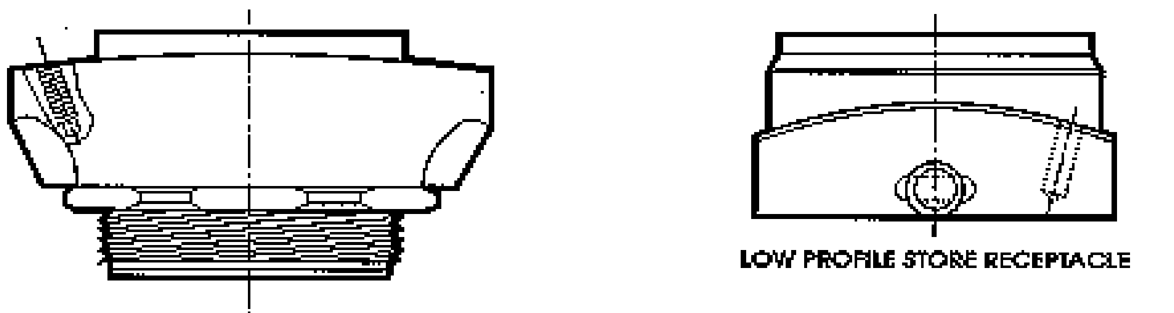


FIGURE 82. Type 2 Store Receptacle.

14.2.1.3 Contacts.

The MSI connector is a receptacle with socket contacts as listed in table XXVIII. All unused contact locations will be filled with a plugged cavity or dummy sockets.

TABLE XXVIII. Primary signal set connector requirements (MSI).

Size	MIL-C-39029 Slash Sheet	Contact Location	Abbreviated Title	Seal Plugs/Dummy Contacts
20	/56	B,G,L,S,V,X, 1,4,6,7,	Contact, socket	MS27488-20 RED
16	/56	C,D,E,F,J,M,N ,P,R,T,Z	Contact, socket	MS27488-16 BLUE
12	/75	2,3,W (See note 1)	Contact, shielded, socket	M85049/80-12 YELLOW
12	/103	5	Contact, coaxial, socket	M85049/80-12 YELLOW
8	/91	A,H,K	Contact, concentric twinax, socket	M85049/80-8 GREEN
16	NA	U,Y	Terminus, socket	TBD

Note 1: The HB2 contact can be either a /75 or /103 contact. Every effort should be made to have the umbilical pin be the correct mate for the selected socket (/75 with /28, /103 with /102) to reduce VSWR and return losses.

14.2.2 MSI auxiliary connector.

There is only one type of auxiliary connector. The auxiliary connector is only used in applications utilizing an umbilical cable. The connector is a MIL-C-38999, Series III, Shell Size 25, polarization key identification A with a MIL-STD-1560 insert arrangement 25-11. The auxiliary power signal set connector insert arrangement is shown in figure 78. The MIL-C-39029 slash sheets listed in table XXIX define the contacts in the auxiliary connector. The connector on the Store MSI is a receptacle with socket contacts.

TABLE XXIX. Auxiliary signal set connector requirements (MSI).

Size	Slash Sheet Number	Abbreviated Title
20	/56	Contact, Socket
10	/56	Contact, Socket

Table XXX is a partial list of components that can be used in an auxiliary MSI. Figure 79 is a picture of the Auxiliary connector.

TABLE XXX. MIL-STD-1760 hardware, MSI auxiliary signal set.

Part Number	Nomenclature
D38999/20WJ11SA	Receptacle - Wall Mount
D38999/24WJ11SA	Receptacle - Jam Nut
D38999/56-XXX	Contact, Socket
M85045/20-25W	Backshell

14.2.3 Assembly.

This section of the Handbook addresses some of the assembly issues with the MSI connector and harness.

14.2.3.1 Primary MSI connector assembly.

Contact insertion and removal is accomplished with MS27495, or equivalent, insertion and removal tools. Precaution needs to be taken when assembling the No.8 twinaxial pin into a plug assembly. The length of the pin contact, the relative stiffness of the twinaxial cable, the location of the contact cavities near the periphery of the insert, and the relatively large pin diameter can cause a severe contact skewing problem. This skewing can be especially severe in the D38999-26WJ20PN plug if the wire bundle is clamped down near the rear of the plug's rubber sealing grommet. The skewed pin can cause unequal loading on the contact retention device and result in permanent damage if the load is excessive. Furthermore, the skewed pin can be mis-aligned sufficiently with the mating socket insert in the receptacle to cause it to strike the closed entry chamber around the socket contact opening. The pin, rigidly confined at the rear by the cable clamp, cannot float within its cavity as intended. Therefore, the pin either chips the plastic or begins to wear it away. Once chipped or worn away, it no longer serves its function as a pre-alignment for the entry into the socket contact. Also, push-out of the pin can occur if the pin does not enter the socket and the force exerted by rotating the coupling nut is sufficient to overcome the strength of the retention collet.

The wire harness design must keep the twinaxial pin in proper axial alignment. One design concept uses a spider, which supports the twinaxial contacts and has openings to permit the wires to pass through as shown in figure 80. The spider is made from non-conductive material such as Teflon and fits inside the connector backshell. Another approach is to pot the back of the connector during harness manufacturing to rigidly hold all pins in alignment. One draw back to the use of potting in the back shell is the loss of reparability of the harness.

14.2.3.2 HB contact selection/assembly.

An important factor in HB contact performance is proper termination of the coaxial cable to the connector contact and proper alignment of the contact set. Figure 63 of ASD-TR-87-5028 shows the effect of contact set misalignment, perpendicular to the contact axis, on VSWR characteristics. This alignment effect plus axial misalignment is part of the cause for higher VSWR in multi-contact store interface connectors compared to dedicated RF connectors. Some misalignment is necessary to insure alignment of all other contacts in one mating operation of the multi-contact connector.

Other factors that add to VSWR degradation in the store interface connector is wear due to repeated mating/unmating and contamination due to contact exposure at the MSI. The extent of VSWR degradation from wear and contamination is higher with store interface connectors than with dedicated RF connectors because mating/unmating is more frequent. The MIL-STD-1760 connector is mated/unmated when the store is installed. See figure 64 of ASD-TR-5087 for examples of return loss versus frequency for a mated set of the M39029/28 and 75 contacts. See 65 of the same TR for plots of similar data for the M39029/102 and /103 contacts that are used for the High Bandwidth #1 application.

The /28 and /75 contacts are uncontrolled impedance "shielded" contacts and are available from several suppliers. They provide adequate performance for use in HB2, HB3 andHB4 applications but are inadequate for HB1. The M39029/102 and /103 contacts provide good performance of both HB1 and HB2 applications due to its matched impedance design. Special care should be taken for applications that can cause a mixture of /102 and /103 contacts with /75 and /28 contacts in HB-2 applications. Testing has shown that /103 contacts will mate with /28 contacts with acceptable degradation of the signal due to the impedance mismatch. But, although /102 contacts will mate with /75 contacts, the signal degradation due to the impedance mismatch is significantly worse. See section 8 (High Bandwidth) for cabling consideration for HB applications.

14.2.3.3 Triax contact assembly.

The triax contacts should be given special attention due to the height of the contact. The length of the pin contact can cause a severe contact skewing problem. This skewing can be especially severe in the D38999-26WJ20PN plug if the wire bundle is clamped down near the rear of the plug's rubber sealing grommet. The skewed pin can cause unequal loading on the contact retention device and result in permanent damage if the load is excessive. Furthermore, the skewed pin can be misaligned sufficiently with the mating socket insert in the receptacle to cause it to strike the closed entry chamber around the socket contact opening. The pin, rigidly confined at the rear by the cable clamp, cannot float within its cavity as intended. Therefore, the pin can be damaged during the mating process.

14.2.3.4 Auxiliary ASI connector assembly.

Contact insertion and removal is accomplished with MS27495, or equivalent, insertion and removal tools. Care must be taken when inserting the No.10 contact. Due to the large contact size, inserting the contact can be relatively difficult. The force necessary to insert the contact through the grommet can result in an over-travel once the initial seal resistance is overcome. This over-travel can result in damage to the interfacial seal and hard dielectric behind the seal. Also, due to the stiffness of Size 10 wire, damage can result to the interfacial seal even after successful contact insertion if the wire is not handled with care. The wire cable must be properly secured to the connector with backshell hardware, otherwise damage to the interfacial seal can result while handling the harness.

14.2.4 Mechanical.

This section of the Handbook provides supplementary information on the intermateability requirements associated with the interface mating connectors and the umbilical cables. Physical design areas such as the mechanical interface between store and aircraft for suspension and release and structural design issues are not addressed by MIL-STD-1760 and, therefore, are not addressed by this Handbook.

14.2.4.1 Keyway orientation.

MIL-STD-1760 defines the orientation (clocking) of the major keyway for the MSI (Type 1 and Type 2 connectors (primary and auxiliary) on the mission store. This orientation is compliant with MIL-A-8591 and with the System 2 specification for nuclear weapon interfaces. The keyway orientation needs to be controlled because the axial rotational flexibility of shield over-braided umbilical cables is very limited. Total twist typically available on a shielded, 0.6m long, umbilical is less than ±25 degrees. With some cable constructions, the twist available can be significantly more or less.

14.2.4.2 MSI location.

Placement of the MSI should be chosen to provide sufficient room for a range of aircraft umbilical lengths and connector stack heights. Due to design constraints on store development, typically occurring after the aircraft are in service, the existing aircraft umbilical connection capabilities could drive the location of the MSI from the MIL-A-8591 required location.

14.2.5 Environmental considerations.

The interface connector is exposed to the environment (temperature extremes, vibration, shock, contaminants, icing etc) in both the mated and unmated condition. The unmated condition occurs prior to a store being uploaded on the aircraft and in flight after separation from the aircraft. For conditions where the store is not installed, the MSI connector should be covered with a protective cap. Icing around the mated connector pair (MSI and umbilical/buffer) can occur both on the ground and in flight and must be carefully examined. Severe icing around a lanyard release connector could prevent release of the connector during the separation event.

The specific environments that the MSI will be exposed to will vary considerably with each application and will, therefore, be defined in the applicable system specifications. Representative environmental considerations are presented in the store environment sections of MIL-HDBK-244. Noteworthy environments are:

a. High temperature exposure of the MSI.

b. Low temperature exposure during captive carry.

c. High pyrotechnic induced shocks during store ejection.

d. Ice build up around recessed MSI/CSI

14.2.6 EMI/EMC considerations.

For a connector to provide high EMI shielding effectiveness, the connector should include the following features:

a. EMI grounding fingers that provide a good shell-to-shell connection prior to mating of individual contacts in the connector,

b. Conductive finishes on the connector shell,

c. Provisions for 360 degree braid termination,

d. Minimal shield degradation following environmental exposure.

The MSI receptacles must be bonded to store structure to minimize potential differences. Also, since the umbilical gross overbraid can be one of the paths for lightning currents, the MSI receptacle should be bonded sufficiently to handle the expected current. The MSI should, as a minimum, meet the Class R bonding requirements of MIL-B-5087 between the MSI connector and the store structure ground.

14.3 Carriage store interface (CSI).

The CSI must meet the same requirements as the MSI. Refer to the MSI Primary Type 1 and Auxiliary sections for guidance on the CSI primary and CSI auxiliary connectors.

14.4 Carriage store station interface (CSSI).

The CSSI must meet the same requirements as the ASI. The CSSI can be a Primary Type 1 or Type 2 interface. The CSSI will never support an auxiliary interface. Reference the ASI Primary Type 1 and Type 2 sections for guidance on the CSSI Primary Type 1 and Type 2 connectors.

14.5 Umbilicals and buffers.

The umbilical and buffer consists of the mate to the ASI/CSSI Primary Connector or Auxiliary Connector (in some applications), and the mate to the MSI/CSI Primary connector or auxiliary connector. The requirements in MIL-STD-1760 are written to make umbilicals as common as possible so that the same umbilical can be used for multiple stores. However, unique umbilical designs may be needed to take into account the unique aircraft and store configurations that are to be mated. This section will discuss the design criteria for the umbilical and the buffer to meet the requirements of MIL-STD-1760.

The standard does not cover factors like the height of connector to be used, the backshell arrangement and the type of cable to be used. These design features are therefore left to the discretion of the umbilical designer to meet the unique requirements of the weapon system.

14.5.1 Primary umbilical connectors.

There are two kinds of type 1 connectors normally used in umbilicals. The standard hand mated plug (D38999/26WJ2OPN) connector is normally used to connect to the ASI Wall Mount Receptacle (D38999/20WJ20SN) or a Jam Nut Receptacle (D38999/24WJ20SN), but may also be used to connect to the CSI or MSI connector for non-ejectable carriage/mission stores. For ejectable carriage/mission store applications the MSI end of the umbilical uses a D38999/31WJ2OPN Lanyard Release connector to connect to the MSI. Both the hand-mate and the lanyard release connector use MIL-STD-1560 insert arrangement number 25-20 as shown in figure 75. Figure 83 illustrates these two connector types.

Table XXXI is a partial list of components that can be used in umbilical design. The umbilical is required to use connectors that meet the form, fit and function requirements of MIL-C-38999. The umbilical is required to use contacts that meet the form, fit and function requirements of the listed MIL-C-39029 specification sheets.

TABLE XXXI. MIL-STD-1760 hardware, primary umbilical.

ITEM	Part Number	Nomenclature
1	D38999/26WJ2OPN	Plug - Standard
2	D38999/31WJ2OPN	Plug - Lanyard Release
3	MIL-C-83538	Buffer Plug
4	M39029/58-XXX	Contact, Pin
5	M39029/28-XXX	Contact, Shielded, Pin
6	M39029/90-XXX	Contact, Concentric Twinaxial, Pin
7	M39029/102-XXX	Contact, Coaxial, Pin
8	M17/094-RG179	Cable, Coaxial, 75 ohm
9	M17/133-RG316	Cable, Coaxial, 50 ohm
10	M17/152-00001	Cable, Coaxial, 50 ohm (Double Shield)
11	M17/131-RG403	Cable, Triaxial, 50 ohm
12	M17/176-0002	Cable, Twinaxial, 77 ohm
13	M85049/20-25W	Backshell

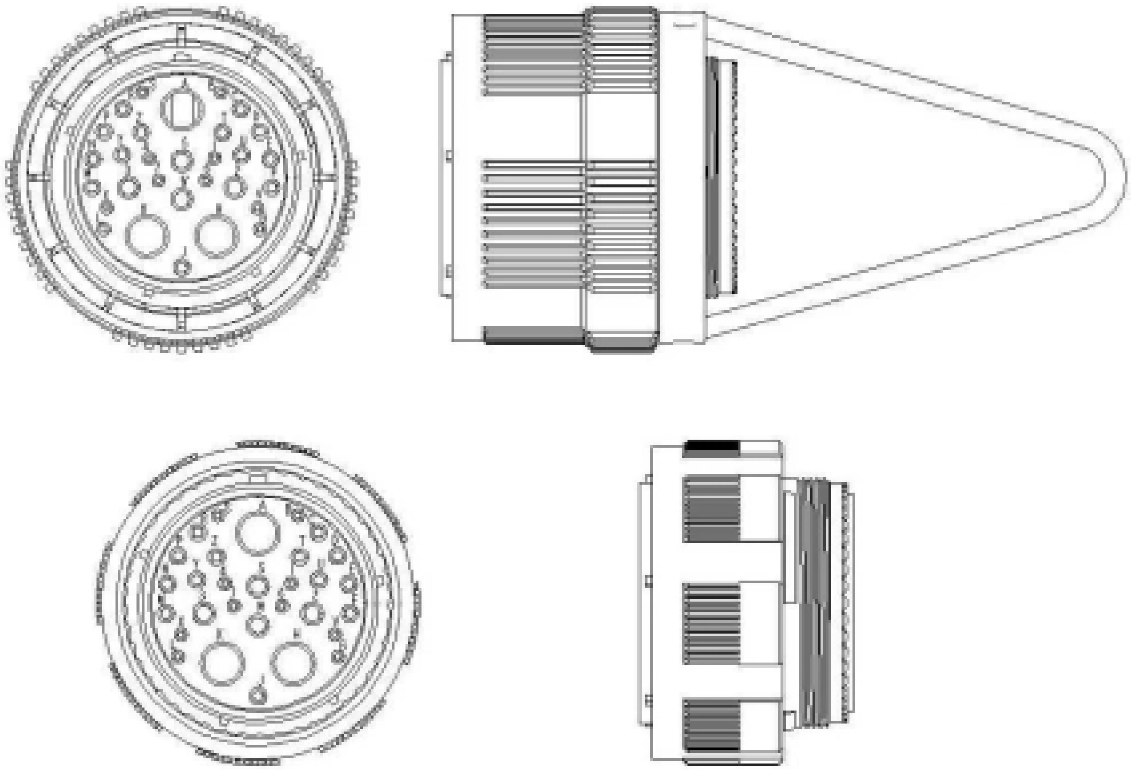


FIGURE 83. Umbilical primary connector types.

14.5.1.1 Contacts.

The Umbilical connectors are plugs with pin contacts as listed in table XXXII. All pin positions will be populated except use of plugged cavities in lieu of pin termini for the fiber optic interface is permitted.

TABLE XXXII. Primary signal set connector requirements (umbilical).

Size	MIL-C-39029 Slash Sheet	Contact Location	Abbreviated Title	Seal Plugs/Dummy Contacts
20	/58	B,G,L,S,V,X,1, 4,6,7,	Contact, socket	MS27488-20 RED
16	/58	C,D,E,F,J,M,N ,P,R,T,Z	Contact, socket	MS27488-16 BLUE
12	/28	2,3,W (See note 1)	Contact, shielded, Pin	M85049/80-12 YELLOW
12	/102	5	Contact, coaxial, pin	M85049/80-12 YELLOW
8	/90	A,H,K	Contact, concentric twinax, pin	M85049/80-8 GREEN
16	NA	U,Y	Terminus, socket	TBD

Note 1: The HB2 contact can be either a /28 or /102 contact. Every effort should be made to have the umbilical pin be the correct mate for the selected socket (/75 with /28, /103 with /102) to reduce VSWR and return losses.

14.5.2 Auxiliary umbilical.

There is only one type of auxiliary connector. The auxiliary connector is a lanyard-release type, i.e., is only used in applications utilizing an umbilical cable. The connector is a MIL-C-38999, Series III, Shell Size 25, polarization key identification A with a MIL-STD-1560 insert arrangement 25-11. The auxiliary power signal set umbilical connector insert arrangement is shown in figure 79. The contacts in the auxiliary umbilical connectors must meet the form, fit and function requirements of the MIL-C-39029 slash sheets listed in table XXXIII.

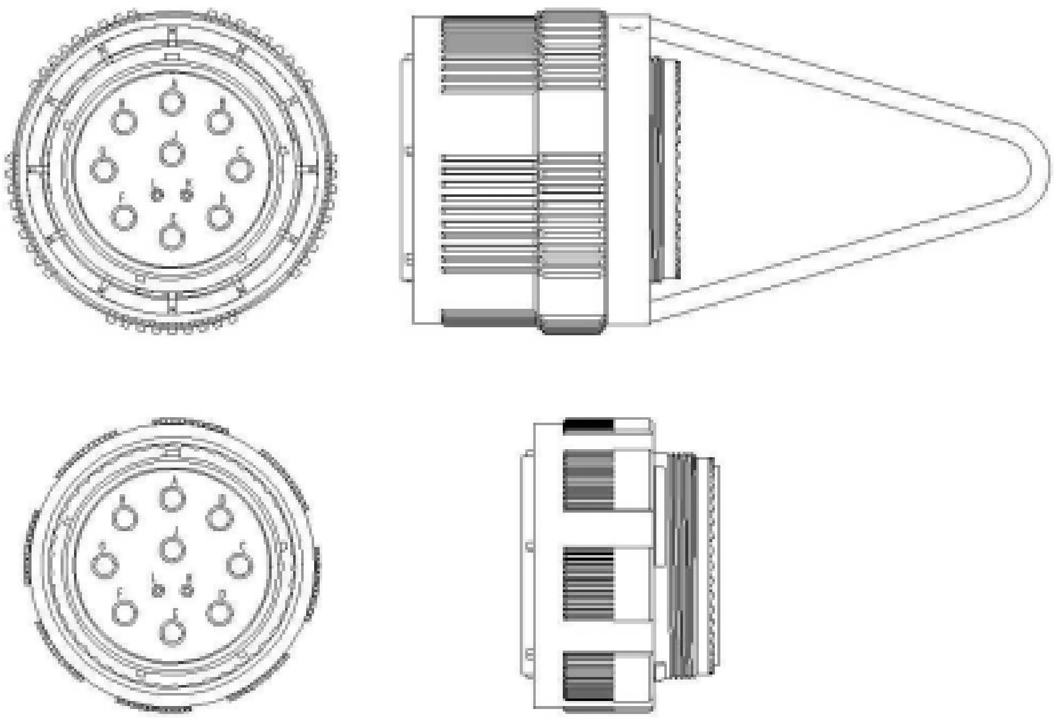


FIGURE 84. Umbilical auxiliary connector types.

TABLE XXXIII. Auxiliary signal set umbilical contact requirements.

Size	Slash Sheet Number	Abbreviated Title
20	/58	Contact, pin
10	/58	Contact, pin

Table XXXIV is a partial list of components that can be used in an auxiliary umbilical.

TABLE XXXIV. MIL-STD-1760 hardware, MSI auxiliary signal set (auxiliary umbilical).

Part Number	Nomenclature
D38999/26WJ11PA	Plug - Standard
D38999/31WJ11PA	Plug - Lanyard Release
D38999/58-XXX	Contact, Pin
M85045/20-25W	Backshell

14.5.3 Type 2 buffer plug.

A type 2 MIL-C-83538/3 Buffer Plug is intermateable with a MIL-C-83538/1 Store Receptacle and MIL-C-83538/4 Launcher receptacle. The Buffer Plug acts as a fixed umbilical between the Launcher Receptacle and the MSI. Figure 85 illustrates the Buffer Plug. The buffer plug is intended to be a disposable item depending on environmental exposure. Special care must be paid to good environmental seals between the buffer plug and the MSI. Water intrusion into the pin cavities could lead to the formation of ice that may prevent or delay separation of the buffer from the store during a release.

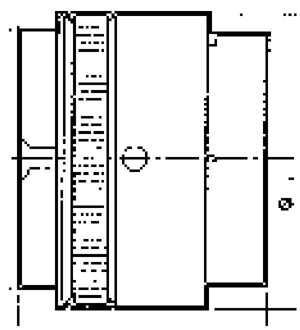


FIGURE 85. Type 2 buffer.

14.5.4 Umbilical assembly.

This section of the Handbook addresses some of the assembly issues with the umbilical harness.

14.5.4.1 Primary umbilical assembly.

As with the ASI and MSI assembly, special care needs to be taken with the assembly and stress relief of the /102, /28 and /90 contacts due to the length of the contact and the stiffness of the cables connected to the contact. If the pins are misaligned, damage may occur to the umbilical contacts during the insertion or the center conductors of the ASI/MSI will be damaged when the connector is cinched down. Typical damage to the center conductor socket is the center conductor pushing into the insulation between the umbilical pin center and outer conductor resulting in pushback of the insulation or the center conductor pushing into the insulation material and not making contact. Also, on occasion the center conductor of the socket in the ASI/MSI will be bent or crushed requiring rework of the contact. Also, assembly of the center conductor of the /102 and /28 warrant special consideration due to the pulling forces incurred on the center conductors during disconnect of the umbilical. Since the 38999/31 connector is qualified to 500 mates and de-mates, these pins will experience significantly more disconnections than a normal RF contact would experience. Experience has shown that soldering of the center contact is more rugged than crimp assembly of the center contact.

The /28 contacts are uncontrolled impedance "shielded" contacts and are available from several suppliers. They provide adequate performance for use in HB2, HB3 and HB4 applications but are inadequate for HB1. The M39029/102 contacts provide good performance of both HB1 and HB2 applications due to its matched impedance design. Special care should be taken for applications that can cause a mixture of /102 and /103 contacts with /75 and /28 contacts in HB-2 applications. Testing has shown that /103 contacts will mate with /28 contacts with acceptable degradation of the signal due to the impedance mismatch. But, although /102 contacts will mate with /75 contacts, the signal degradation due to the impedance mismatch is significantly worse. See section 8 (High Bandwidth) for cabling consideration for HB applications.

The original /102 and /103 contacts were somewhat fragile and experienced failures in some applications. More robust designs are now available.

To increase umbilical flexibility, the lay of wires in the harness should form a twist. The lay length should be 8 to 16 times the pitch diameter; i.e. a 1-cm diameter cable layer would have one turn every 8 to 16 cm in length. The cable should be twisted with a unidirectional lay where all cable layers are twisted in the same direction but with different lay lengths. This produces a cable with maximum flexibility and ruggedness. Cable fillers may be used where necessary to fill large voids between wires in each cable layer. A protective jacket around the cable should be used to protect the umbilical from weather and wear. The type of jacket used depends on the environment the umbilical will be exposed to as well as the reparability requirements of the umbilical.

The umbilical harness design must keep the twinaxial and triaxial pins in proper axial alignment. One design concept uses a spider, which supports the twinaxial and triaxial contacts and has openings to permit the wires to pass through as shown in figure 80. The spider is made from non-conductive material such as Teflon and fits inside the connector backshell. Another approach is to pot the back of the connector during harness manufacturing to rigidly hold all pins in alignment. One draw back to the use of potting in the back shell is the loss of repairability of the harness.

14.5.4.2 Auxiliary umbilical assembly.

As with the ASI/MSI auxiliary connectors, care must be taken with proper insertion of the No 10 contacts. The stiffness of Size 10 wire results in a stiff umbilical if the wires are laid in a straight lines parallel to each other and secured to provide a tight bundle. Laying the wires to form a twist will increase umbilical flexibility. The lay length should be 8 to 16 times the pitch diameter; i.e. a 1 cm diameter cable layer would have one full turn for every 8 to 16 cm in length. The umbilical cable should use a unidirectional lay for maximum flexibility and ruggedness. Cable fillers should be used where necessary to fill any large voids in each layer of the cable. A protective jacket around the cable should be used to protect the umbilical from weather and wear. The type of jacket used depends on the environment the umbilical will be exposed to as well as the reparability requires of the umbilical.

14.5.5 Umbilical issues – potted vs repairable.

Several problems were identified with early MIL-STD-1760 umbilicals. Cables have been manufactured with flex conduit covering, with molded rubber coverings, and with heat shrink tubing coverings. Molded cables with potting in the back of the connector cavity are non-repairable. When the potted connectors experience assembly deficiencies or damage in the field, the cables must be replaced vice repaired. While the potting provides excellent protection against moisture penetration from the backside of the connector, as well as proper contact alignment, it hardens to a tough rubber-like consistency that cannot be removed without potentially damaging the grommet insert, wires and contacts. Removable potting, which stays soft enough to be peeled away without damage, may also be an option, however it does not address the contact alignment issue.

Note that the standard connectors required by MIL-STD-1760 are “environment resisting” types, having rubber inserts that are compressed when the connector is tightened to prevent water intrusion at the connector face. The issue with umbilicals is that water can be driven into the backside of the connector if a poured-in potting compound is not used to seal around the wires.

14.5.5.1 Water intrusion.

A design that survives in a desert test environment may experience failures when used in a humid and rainy environment. On a bomber, the connectors are exposed to the airstream outside the aircraft for several hours, both while connected to a store and while dangling open on the return flight. They will be subjected to driving rain travelling at the full airspeed of the aircraft. A re-usable umbilical will be subjected to this environment many times over a period of several years.

One can make arguments for either version (repairable vs non-repairable), based on the severity of the environment and the probability of failure of the connectors or contacts. There is very limited data (mostly hearsay) to back up either argument. We were unable to find any data on any formal trade study or any results from a formal cost analysis to support either argument.

It is strongly recommended that some type of sealant material be used to seal the area between the connector and backshell adaptor, especially if split backshell adaptors are used for repairability. Heat shrink tubing will provide some protection on repairable type designs and over-molding will provide protection for non-repairable type designs.

14.5.5.2 B-52 umbilicals.

The B-52 weapon umbilicals have gone through a design evolution of their own. Development-phase umbilicals were designed and manufactured to support JDAM and WCMD development testing and operational testing. Nineteen of these umbilicals were delivered by the end of Jan 97. Twelve umbilicals, along with retention assemblies went to Barksdale AFB for up-front and early input from the user. Seven went to the flight test center to support advanced weapons fit checks and early JDAM ground testing. The user identified problems with this early flex conduit design. 1) The flex conduit design made the cable too stiff for acceptable usage and 2) The connector did not work well with a recessed weapon receptacle. Production on the remaining development-phase umbilicals was halted and a design panel was convened in March 1997 to address the problems. User involvement was a priority during the redesign effort so that the problems could be fully defined and that the user had an opportunity to influence the follow-on design. The major design attributes that were considered were: cable length, cable stiffness, rotational stiffness, MSI connector access, ejector cable interference, connector pin reparability, ASI connector grip length, cost and ease of manufacture, and material availability and cost.

The follow-on design was determined to be a molded cable with a composite connector and potting in the backshell for in-flight use and a repairable load training cable. Molded cables are more flexible and solved the stiffness problem. The composite connector could be made with more gripping area and this solved the recessed weapon receptacle access problem. It also withstands buffeting against structure very well. The molded cable design drove a reparability design trade off. Also, to make the umbilical stand up to the elements that it was projected to encounter, the connector was potted to prevent the water intrusion and corrosion problems seen on air-to-ground missile and cruise missile umbilicals. Reparability of umbilicals was a strong enough consideration that it was decided to produce training umbilicals to support weapon load training. The repairable training umbilicals are designed for ground use only but have all the functionality of the molded cable production design. Two prototypes of the new design were delivered in June 1997 and used for proof of concept and early fit checks. The design was determined to be acceptable and 42 development-phase-molded cables were produced to support WCMD and JDAM testing. Sixteen molded umbilicals were sent to Barksdale AFB for early user inputs. Formal flight testing with the molded cable design started in March 1998.

In May 1998, it was discovered that the composite pull ring of the connectors was failing at an unacceptable rate. It was determined that the composite pull ring could not handle the loads of weapon separation and the composite pull ring was replaced with an aluminum pull ring. This design change fixed the pull ring failure problem. Later tests revealed that the composite connector coupled with a metal recepticle with the maximum allowable angle on the threads resulted in excessive pull forces. To account for this intermateablity issue, the material used for the internal release mechanizism was changed to provide less friction during the actual release. The aluminum pull ring or the new material for the internal release mechanism did not get incorporated into the load training cable design since the training cables will not be used for actual weapon releases and the composite pull ring connectors were already purchased. Due to this late connector design change, only limited R&M data was obtained from the development and operational test phase. However, umbilicals used for actual weapon drops at the flight test center did not incur connector pin damage and none has been sustained to date (March 1999) during the initial operational test and evaluation effort on JDAM to support the reparability argument. Failure-free usage in this testing does not guarantee that failures will not surface with additional usage. At the urging of the user, the B-52 customer has decided to produce a repairable cable design based in large part on the load training cables. Manufacturing costs, including schedule, are projected to be ¼ less than the molded design.

The investigation of the connector pin problem discovered another area for improvement. The dielectrics of pins 5 and W protruded past the outer contact barrel and had too much play within the contact barrel itself. New contact designs for these specific pins have been identified by the vendor and are being considered for incorporation into the connector design. A design choice by the B-52 customer is to use M39029/102 contacts in all high bandwidth locations. The VSWR deterioration with this combination is not expected to significantly affect the types of data which will be transferred on high bandwith 2, 3, and 4. The current B-52 ASI uses M39029/103 contacts for all four high bandwidth locations. This decision was reached in large measure to reduce the overall number of different parts required for repairability and to ease the manufacturing process. This decision was economically feasible due to the decrease in cost of the M39029/102 contact and the increase in overall quantity purchased.

As a result of going to a non-potted, repairable design, the issue of contact alignment, especially for the twinax contacts, needed to be addressed. Damage to the ASI end of the umbilical was being experienced on the load training cables. These failures have been attributed to contact alignment. The repairable umbilical design, as well as the load training cables, is incorporating the wire spacer discussed previously in this section, for contact stability.

It would be beneficial to have reparability data available to support a repairable design concept. Reparability should be considered as a design constraint on future umbilical purchases if projected usage rates, failure rates, and cost savings justify it. Umbilical design has been an engineering challenge in all aircraft.

14.5.5.3 Other umbilicals.

B-52 AGM-142 umbilicals were molded, apparently due to moisture intrusion and harness fatigue problems. They were only getting about three launches from the unmolded umbilicals before they failed. Moisture intrusion into the connector backshell at bases with high humidity and rainfall caused a high number of aircraft, missile, and pod problems during ground checkout. If it were just moisture, the problem would sometimes clear up during flight. On one or more occasions, the missile end of the umbilical broke due to water intrusion which would not let the release mechanism of the connector function properly due to the water freezing during flight. Based on the success of the repairable umbilicals used for MIL-STD-1760 weapon integration, the B-52 customer is considering incorporating reparability into the design change necessitated by relocation of the umbilical interface connectors.

The F-18/A community has never environmentally potted their weapon umbilical cables. The Harpoon cable has been in use for 7 years and the LAU-115 cable has been in use for nearly 6 years. Over the life of these cables, the Harpoon cable has had 25 failures and the LAU-115 cable has had 70 failures. No data was available on the population size or failure modes of each type of cable, although the users did not attribute failures to water intrusion or corrosion. It is important to note that these cables do not have the complex coaxial and twinaxial contacts that are used in the MIL-STD-1760 interface.

The F-18 JDAM / WCMD / JSOW cables are also not potted. Testing on F-18 umbilicals has shown pull-off force much higher than the specified value for the lanyard-release connector at the high speeds occuring during ejection.

It is believed that the F-15E weapon umbilicals are potted and environmentally sealed.

14.5.6 Keyway orientation.

MIL-STD-1760 defines the orientation (clocking) of the major keyway for the ASI and MSI Primary and Auxiliary connectors. The umbilical connector keys must be oriented to connect the MSI/CSI to the ASI/CSSI in a manner that allows for flexibility of the umbilical, obstructions around the umbilical connection area and the bend radius of the wires contained in the umbilical. Installation of the umbilical by personnel using various cold weather and chemical defense suits should be taken into account.

14.5.7 Environmental considerations.

In many instances, the umbilical is exposed to the environment (temperature extremes, vibration, shock, contaminants, aircraft fluids, icing etc.) while mated and while unmated. The unmated condition occurs prior to a store being uploaded on the aircraft and in flight after separation of the store from the aircraft. After separation, the umbilical may be whipped against surrounding structures due to the buffeting of the air stream. This could result in damage to the outer shell of the umbilical connector as well as exposure of the pins to contamination from the air stream. When the umbilical is not installed, the umbilical connectors should be covered with a protective dust cover. Consideration should be given to use of a dust cover that also acts as an alignment tool for the pins.

Icing around the mated connector pair (MSI and umbilical/buffer) must be carefully examined. Severe icing around a lanyard release connector could degrade the performance of the connector during the separation event. Also, severe icing around the buffer connector may prevent operation or degrade the performance of the buffer during separation of the buffer from the store receptacle.

The specific environments that the umbilical will be exposed to will vary considerably with each application and will, therefore, be defined in the applicable system specifications. Representative environmental considerations are presented in the aircraft environment and store environment sections of MIL-HDBK-244. Noteworthy environments are:

a. High temperature exposure of the umbilical during captive carriage and to the contacts after store ejection.

b. Low temperature exposure during captive carry and to the contacts after store ejection.

c. Induced shocks during store ejection and lanyard snatch.

d. Ice build up around recessed MSI/CSI.

e. High temperature fluids.

f. High velocity rain and particulate matter.

g. Sun exposure.

h. Exposure of the buffer to high temperature rocket motor exhaust and particulate contamination.

14.5.8 EMI/EMC considerations.

For an umbilical connector to provide high EMI shielding effectiveness, the connector should include the following features:

a. A conductive inner shell that provides a good shell-to-shell connection when the EMI fingers of the mating connector contact the inner shell prior to mating of individual contacts in the connector,

b. Conductive finishes on the inner connector shell and connector threads,

c. Provisions for 360 degree braid termination to the inner connector shell,

d. Minimal shield degradation following environmental exposure.

The plugs at the ASI and MSI must be bonded to the gross overbraid to minimize potential differences. Since the umbilical gross overbraid can be one of the paths for lightning currents, bonding between the connectors and the overbraid must be sufficient to handle the expected current. Bonding of the overbraid to the connector backshells of the umbilical should as a minimum meet the requirements of MIL-B-5087 Class R.

14.6 Low bandwidth cable characteristics.

The cabling used for low bandwidth signals should ensure continued overall screening (shielding) of the signal lines. This will reduce the interference both to other signal lines which could be caused by the analog signals on the low bandwidth network and to the low bandwidth signal itself due to noise generated by other signal or power lines. Use of twin-axial or tri-axial cable will ensure the continuity of the signal screening whereas use of coaxial cables will introduce some break in the overall screening of the signals. The cable shield coverage should be 90 percent minimum. Since MIL-STD-1760C specifies concentric twin-axial contacts (MIL-C-39029/90 and 91) for the interface connectors, the two inner conductors are shielded through the interface connector. Maintaining this coverage through connectors other than the ASI and MSI is highly recommended to minimize EMI. For audio signals, the two inner conductors should contain at least 13 twists per meter to provide adequate noise protection. It is also recommended that the wire-to-wire distributed capacitance not exceed 98 picofarads per meter. The selected cable should have a low specified capacitance unbalance of each conductor to shield. A well-balanced cable improves the line-line rejection of noise by equally balancing the line-ground, i.e. shield, capacitance in the two conductors. The recommended size for the inner conductors is 24-gauge minimum. This wire size is compatible with the LB signal and mechanical requirements. It should be noted that MIL-STD-1760C does not specify cable characteristics for any of the AEIS signals to maximize design flexibility and to stay within the concept of an interface standard, not a design standard.

The characteristic impedance of the umbilical cable is 70 ohms minimum (at 1MHz) but this is not relevant to audio frequency applications.

14.7 LB connectors.

Throughout the aircraft installation, the connectors or contacts used for all the low bandwidth signals should ensure continued overall screening (shielding) of the signal lines. Proper shielding will reduce interference to other signal lines which could be caused by the analog signals on the low bandwidth network as well as reduce interference to the low bandwidth line due to noise generated by other signal or power lines. Figure 86 summarizes recommendations for connectors or contacts that should be used for the low bandwidth network. Wherever possible, twin-axial or tri-axial connectors or contacts should be used.

The contact defined by MIL-STD-1760C for this signal is a pin, surrounded (360 degrees) by two rings. It is intended that the active signal (HI) be carried on the pin, with the return (LO) being carried on the first ring. This leaves the second outer ring for a screen (shield) and altogether this provides for a “twisted pair with overall screen” cable, also known as “shielded, twisted pair”.

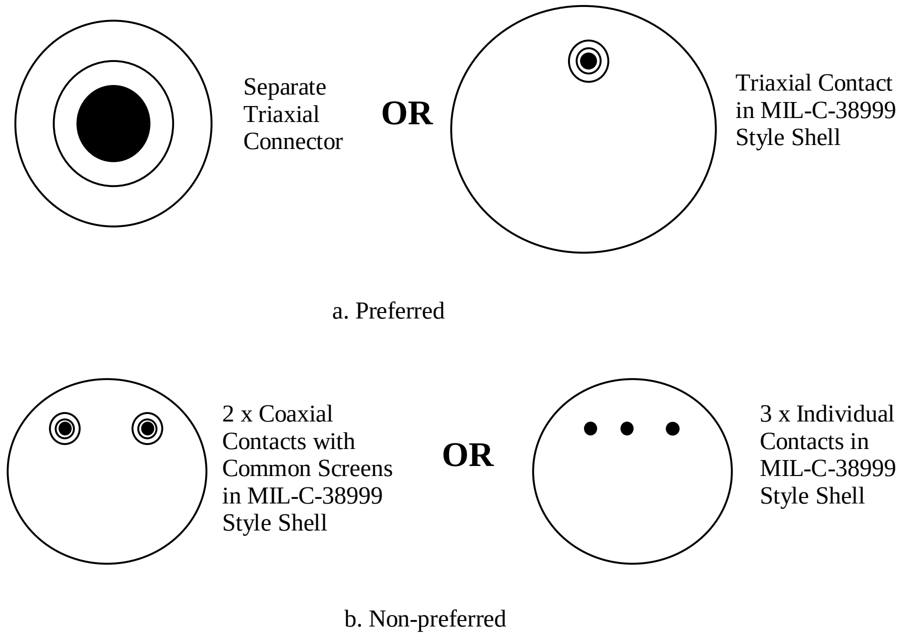


FIGURE 86. Low bandwidth signal connectors.

14.8 Use of existing audio wiring in LB installation.

The existing aircraft wiring used for AIM 9 audio is unlikely to meet the MIL-STD-1760C requirements. Deficiencies are likely to be centered on the need for a screened two-wire signal. Therefore, it must be assumed that a new installation will be necessary.

15. COMMENTARY ON THE REQUIREMENTS OF MIL-STD-1760C.

This section of the Handbook provides the information necessary to understand the requirements of MIL-STD-1760 and tailor it to a specific application. Although most of the requirements of MIL-STD-1760 are firm requirements, essential to the interoperability of stores and aircraft, tailoring of the requirements is sometimes driven by the design of existing equipment or other constraints. This section should assist in this tailoring and in understanding the basic requirements of the standard so that various users have consistent interpretations.

All paragraph numbers (with the MIL-HDBK-1760 section number, “15.” inserted) and titles from Revision C of the standard are repeated. Discussion is provided for most of the paragraphs that contain significant requirements. The discussion generally covers the reason why the requirement exists along with interpretations and explanations of the requirement. It also includes references to other sections of the Handbook that cover each subject in more detail.

FOREWORD

The foreword provides historical and background information.

15.1 Scope.

The Scope paragraph explains what the standard covers.

15.1.1 Scope.

The standard defines common interfacing requirements at the electrical disconnect points between aircraft and stores. The interface characteristics are defined to maximize compatibility while still affording design flexibility and technology advancements in the equipment which implements the interface.

15.1.2 Purpose.

The purpose explains why the standard was written.

15.1.3 Application.

This paragraph explains where the standard should be applied. Like most Military Standards, the decision to require or not require MIL-STD-1760 compliance on any development or procurement contract is determined by the procuring agency.

Due to the number of aircraft and store assets currently in the field and the projected life of these assets, many applications of the standard are for new stores carried on "old", i.e. existing aircraft. These existing aircraft will be (in many cases, have been or are currently being) retrofitted to add AEIS capabilities. The added capabilities will supplement the existing non-AEIS store interface capabilities of these aircraft. While the initial cost for adding more capability, i.e. full AEIS interface, than may currently be needed for operating a specific MIL-STD-1760 store may seem high, longer term benefit for easing the addition of other stores to the aircraft will generally justify the cost difference.

15.2 APPLICABLE DOCUMENTS.

15.2.1 General.

This section, typical of all standards, provides a list of documents referenced in the body of the standard. In compliance with DoD policy, the list generally does not identify the specific revisions or issue of the listed documents, but states that the issue in effect is as cited in the solicitation. If a future revision of one of the referenced documents results in an impact to interface interoperability, the AEIS standard may be revised to limit or eliminate this impact by citing a specific issue of the referenced document or by adding qualifications to the paragraph which cites the document.

Specific reference to Revision B, Notice 4 of MIL-STD-1553 was added in 1995. This is to indicate that if MIL-STD-1553 is changed in any way, any new requirements should be assessed for compatibility with existing MIL-STD-1760 compliant hardware to determine if the new version can be substituted.

15.2.2 Government documents.

15.2.2.1 Specifications, standards and handbooks.

15.2.2.2 Other government documents, drawings and publications.

15.2.3 Non-Government publications.

15.2.4 Order of precedence.

15.3 DEFINITIONS.

15.3.1 Definitions.

Any new terms or non-standard definitions used in the standard are defined in this section. While there are no firm requirements in this section, the precise definition of these terms will affect the meaning of other requirements in the document.

15.3.1.1 Aircraft.

15.3.1.2 Aircraft/store electrical interconnection system (AEIS).

15.3.1.3 Electrical interface types.

15.3.1.3.1 Aircraft Station Interface (ASI).

15.3.1.3.2 Carriage Store Interface (CSI).

15.3.1.3.3 Carriage Store Station Interface (CSSI).

15.3.1.3.4 Mission Store Interface (MSI).

15.3.1.3.5 Routing Network Aircraft Subsystem Port (RNASP).

Prior to Revision C of the Standard, HB and LB signal connections between aircraft subsystems and the ASIs were modeled as sources or sinks (looking into the ASI). With the introduction of the RNASP, each HB or LB signal connection may be modeled as a signal path, or two-port network. This is appropriate because each HB or LB interface at the ASI may support a range of application signals with different electrical characteristics. The required fidelity of each HB or LB signal at the ASI (or RNASP) will depend on the particular application and is not controlled by the Standard. However the transmission quality of the AEIS between the RNASP and ASI is controlled to ensure a level of aircraft-store interoperability for present and future applications. Note that the established aircraft signal path requirements define the de facto maximum signal fidelity that the AEIS can support, worst case.

15.3.1.4 Provisions.

This definition of provisions is an attempt to clarify what is expected of aircraft manufacturers if they are required to include "provisions for MIL-STD-1760" in designated aircraft models or production blocks.

15.3.1.5 Store.

15.3.1.5.1 Carriage stores.

A partial list of existing carriage devices includes multiple station ejector racks, e.g. TER 7, multiple station rail launcher, e.g. LAU 88 and single station launchers, e.g. LAU 7. These stores function as mechanical and electrical adapters that convert a single store, electrical and mechanical, interface into either a multiple store interface or a single store interface which is electrically or mechanically different, e.g. adapting a hook/lug suspension mode to a rail/shoe suspension mode. (See section 16 of this Handbook.)

15.3.1.5.2 Mission stores.

A partial list of mission stores include bombs, missiles, rocket launch pods, mines, torpedoes and electronic pods.

15.3.1.5.3 Dispensers.

This new definition was added in 1760C notice 1, to clarify the role of dispensers, which are similar to carriages stores, but use some interface other than 1760 to the devices they carry.

15.3.1.6 Stores management system (SMS).

The SMS may be implemented by:

a. One or several dedicated electronic equipment items which are formally named SMS,

b. Electronic equipment which is part of another avionic system, but which provides the SMS functions,

Some combination of a. and b. above.

15.3.1.7 Suspension and release equipment (S&RE).

15.3.1.8 Random noise.

Noise requirements were introduced in Revision C of the standard for the HB and LB interfaces. Random noise is non phase-coherent, non spectrally-concentrated noise and may be distinguished from periodic noise by spectral analysis. Pseudo-random noise, which may be generated when the signal path is stimulated, is not included.

15.3.1.9 Periodic noise.

Periodic noise encompasses all forms of unwanted signal interference, including crosstalk from other stimulated HB and LB signal paths. Thus the level of periodic noise which is present at each AEIS interface may be highly dependent on the chosen test method. Periodic noise may be distinguished from random noise by spectral analysis. Unwanted frequency components which arise when the signal path is stimulated (i.e. from non linear distortion) are not included.

15.3.1.10 Impulse noise.

The definition is intended to apply to a continuous stream or burst of impulses rather than to a one-time event caused by, for example, the energization or release of another store. Because impulse noise may be caused by interference from other aircraft equipment, the amplitude and frequency of impulses at each AEIS may be highly dependent on the chosen test method.

Unlike other types of noise, impulse noise is described by its instantaneous peak amplitude and average rate of occurrence rather than by its rms power. However, if the impulse train happens to be periodic and time-invariant then it is also classed as periodic noise and subject to rms power limitations.

Note that the observed peak amplitude of impulse noise may be dependent on the measurement bandwidth, thus energy outside the frequency range of interest must be removed.

15.3.1.11 Stimulated noise.

Stimulated noise may occur from non-linear distortion, plus sampling noise and quantization noise if the signal has been transmitted digitally. Depending on the nature of the stimulated noise, it may appear as pseudo-random noise or periodic noise. Stimulated noise is incremental noise above the un-stimulated noise floor.

15.3.1.12 Common mode noise.

Common mode noise is not actually signal noise. Common mode noise, however, may be responsible for an increase in signal noise further down the system if the common mode noise rejection of the receiving equipment is not ideal.

15.3.1.13 Latency.

15.3.1.14 Delay.

15.3.2 Acronyms and abbreviations.

15.4 GENERAL REQUIREMENTS.

This section provides “General” requirements, that is, those that apply to more than one segment of the AEIS.

15.4.1 Aircraft/store configurations.

This paragraph introduces terminology and explains where in the aircraft-to-store interface the requirements of the standard apply. It contains no firm requirements.

Figure 1 of the standard illustrates, in a very generic manner, the functional location of the various AEIS interfaces. This figure, along with paragraphs 3.1.3.1 through 3.1.3.4 of the Standard, is an attempt to explain where the AEIS interfaces are located. For example, the ASI, is the "last" electrical disconnect or break point that is permanently part of the weapon system, e.g. aircraft. Physically, this disconnect point might be in the bottom of a pylon for pylon carriage modes, behind an access panel for conformal carriage modes, part of a blind mate connector mechanism for a bolted-on rail launcher, etc. In general, the actual physical location is of no concern to the standard.

The actual location of the ASI has been controversial on several aircraft installations. The goal should be to define the ASI at the point that provides the best combination of flexibility and expected life cycle cost. For example, in the B-1B Conventional Munitions Upgrade Program (CMUP), the ASIs are at the end of cables mounted on a rotary launcher inside each bomb bay. While the rotary launcher is not “permanently part of” the B-1, it is unique to the B-1 and expected to be used with other MIL-STD-1760 stores, so having the ASI defined there provides the flexibility to carry these other MIL-STD-1760 stores without a major wiring change to the aircraft.

This paragraph was modified in Revision C to include carriage stores.

15.4.2 Interface classes.

This paragraph defines the four distinct interface classes so the rest of the standard can refer to these classes.

The minimum ASI capability required by the standard is the Class II interface, which is expected to be sufficient for most aircraft air-air stations and light weight, 1000 pound store class, air-ground stations. Class IA is recommended for most aircraft heavy stations and stations expected to carry electronic pods such as Electronic Counter Measures and Forward Looking Infra-Red, or stations expected to carry a carriage store with more than one mission store. Class I and IIA represent intermediate capabilities which may be appropriate for some aircraft stations.

Mission stores and carriage stores, or specifically MSIs and CSIs, are compatible with any of the listed classes, provided that the store uses only those signals (or a subset of the signals) available in the specific class and complies with the standard for those signals used.

Although use of an interface similar to MIL-STD-1760 is now required on several major aircraft and store programs, many of the existing or planned aircraft installations do not fully comply with even the class II interface. Typically, the High Bandwidth (HB) lines are omitted or tailored to the specific signal needed on that aircraft and the Low Bandwidth (LB) line is not provided. This is driven by the cost of installing a HB network in an aircraft and the fact that some planned MIL-STD-1760-compliant stores do not need the HB lines.

15.4.3 Primary interface signal set.

This paragraph and its subparagraphs provide a summary of the number and type of signals passing through the standard interface along with technical requirements that are general in nature, i.e., are not strictly “aircraft” or “store” requirements. Corresponding paragraphs in section 5 (Detail requirements) provide the technical characteristics of these signals.

These paragraphs emphasize the key requirements of the standard, such as the use of MIL-STD-1553 data bus for all digital data communication between stores and aircraft.

15.4.3.1 High bandwidth (HB) interfaces.

The High Bandwidth (HB) interfaces are required to facilitate the transfer of analog signals such as video, high speed synchronization, and Radio Frequency signals that are not compatible with the MIL-STD-1553 digital data bus.

The High bandwidth sections of the standard changed extensively between Revision B and C. Revision C requirements differ from those in Revision B in that they:

a. Define a "Routing Network Aircraft Subsystem Port” (RNASP) which is the interface between aircraft systems and the network, then impose specific performance requirements on the signal path between the RNASP and the ASIs (Revision B only covered things measurable at the ASI and ASI-to-ASI transfers).

b. Limit Type A signals to 1.3V (Revision B allowed up to 12.0V).

c. Impose return loss and insertion gain limitations that are tighter than those imposed by the VSWR and attenuation requirements in Revision B. These new requirements imply use of an active (includes amplifiers) aircraft network while the requirements in Revision B could be met with passive cables and switches in some cases.

d. Limit noise in the network.

e. Change the signal return grounding scheme.

These requirements set performance requirements for a network that could satisfy a wide variety of uses, while the requirements in Revision B only defined the interface at the ASI and MSI, leaving the aircraft network performance to be defined by other documents such as the stores management system specification. Network capacity is further discussed under 5.1.1.

Figure 4 of the standard suggests possible signal paths, for information only - specific requirements are all called out in “shall” statements in the standard.

This paragraph alerts the designer that the interface specifications for the ASI include the effects of the ASI mating connector. Inclusion of the mating connector is important primarily for

HB requirements such as return loss and insertion gain limits. (See section 8 of this Handbook.)

15.4.3.1.1 Type A signal requirements.

Signal voltage, out-of-band power level and slew rate are limited by this paragraph to ~~i~~ensure various aircraft and stores will use compatible signals.

Electrical requirements for the High Bandwidth interfaces are divided into low frequency band (Type A) and high frequency band (Type B) characteristics to simplify the interface definition. Both Type A and Type B requirement sets apply to the HB1 interface port while only the Type A requirement set applies to the other three ports (HB2, HB3 and HB4).

15.4.3.1.2 Type B signal requirements.

Type B signal requirements are not yet fully defined by the Standard. They currently consist only of the maximum power level allowed.

15.4.3.1.3 Signal assignment.

This paragraph limits which signal types may be assigned to each of the four HB interfaces. This paragraph of MIL-STD-1760C replaces requirements that were in section 5.1.1.1 and 5.2.1.1 of Revision B.

The assignment restrictions are applied for two primary reasons. First, if the use of the HB interfaces were not restricted, the HB ports might be used for assorted custom functions, imposing direct obstacles to achieving interoperability.

Secondly, the assignment restrictions prevent shuffling of a common set of signals between the four HB ports with each new application. As an example, composite video is a Type A signal. All four HB ports are specified to handle Type A signals. Therefore, without the restrictions of this paragraph, one store could place video on HB1 and some other store could select HB3. The aircraft would then be required to provide signal distribution paths to the cockpit displays from HB1 at each ASI in addition to HB3. Thus, the assignments in the paragraph help limit the aircraft's distribution network complexity.

It is expected that if viable applications for the HB ports evolve, which are not covered by the listed signals, then the standard would be revised to incorporate the new signals.

15.4.3.2 Digital data bus interface.

The redundant MIL-STD-1553 compatible data bus connections at the AEIS interfaces provide the highly robust data transfer "utility" in the interconnection system. Through this command-response, serial, digital, time division multiplexed data bus, a flexible mechanism is available for primary control of stores and for transferring data between aircraft and stores. Due to peculiarities in the application of MIL-STD-1553 to the aircraft/store interface, several additional requirements are imposed on the data bus interface that are not covered in MIL-STD-1553. (See section 6 of this Handbook.)

15.4.3.3 Low bandwidth (LB) interface.

The general LB signal characteristics are specified as a low power level, low bandwidth signal. (This was in section 5 of Revision B of the standard)

The nominal impedance of this interface was changed to 600 ohms in Revision C because 600 is compatible with a greater variety of audio systems. The fact that it is sent through cable with a 70 Ohm characteristic impedence is of little significance at audio frequencies.

15.4.3.3.1 LB signal requirements.

The signal voltage characteristics are defined for both line-to-line and line-to-ground to accommodate different types of line drivers and receivers. The standard only requires a transmission passband of 300 Hz to 3.4 kHz (basic voice-grade audio, like a telephone). A specific signal generated by a store is not, however, required to span this entire range. For example, an audio tone could be constrained to an even smaller band. The defined frequency range should be interpreted as the passband within which signals can be transferred. Any frequency components outside of this band, such as harmonics, may or may not be transferred. The store must not, therefore, rely on the transfer of any higher frequencies, beyond 3.4 kHz, for system operation.

Revision B covered a significantly wider band because there was once a plan to use this line as a lower speed data bus.

15.4.3.3.2 Signal assignment.

The only application currently permitted for this twisted shielded pair Low Bandwidth (LB) interface is to transfer tones, e.g. AIM 9 audio, and voice grade audio to recorders in pods or to/from data link pods.

This paragraph in Revision C replaces statements here, and in section 5.1.1.3 and in 5.2.1.3 of Revision B, prohibiting use of the LB interface for a discrete signal. In Rev B, the LB interface was defined with a DC capability, and concerns existed that the LB port would be used as a general purpose discrete. Since such a use would undermine the interoperability enhancement objective of the AEIS, a specific sentence was included disallowing this. (See section 9 of this Handbook.)

15.4.3.4 Release consent interface.

The name "Release Consent" is a carry-over from MIL-STD-1760 dated July 1981. Based on its application, a better name might be "Safety Critical Consent". Two important points are contained in this paragraph:

The first point is that the consent signal, in and of itself, does not result in a store state change, but enables or inhibits a store state change that is commanded by the aircraft through the data bus.

The second point is that the consent discrete is provided solely as a safety interlock for the aircraft. The intent is that the aircraft can establish the enable state on the discrete at any time prior to the needed employment sequence. As two extreme examples, one aircraft might establish the consent enable state at "wheels up" while another aircraft might establish consent enable only milliseconds before a fire command is sent over the data bus. In both cases the store is compatible, but in the first case the safety of the aircraft may be at risk for a longer time. (See section 7.1 of this Handbook.)

15.4.3.5 Primary interlock interface.

The interlock interface is provided as an indicator of whether the electrical interface between the aircraft and store is electrically connected. The aircraft is not required to use the interlock interface.

A single point failure, e.g. broken wire, contaminated contact etc., could yield an indication of "interface not mated". Therefore, the aircraft must not use this interface as the only criteria for actions that have safety implications. The primary concern here is the use of the interlock as an indication that a store has physically separated from the aircraft. A false indication could lead to collisions between stores during release, severe asymmetrical loading of the aircraft, etc. (See section 7.2 of this Handbook.)

15.4.3.6 Address interface.

These six address discretes, plus return, allow the assignment of a unique data bus address from 0 through 30 to the MIL-STD-1553 remote terminal in each store. This address is assigned at the time that the store is "powered up" on a specific aircraft station. The store can then communicate with the aircraft in the normal MIL-STD-1553 command-response mode whenever the store receives a command word with a terminal address field which matches its assigned address. Broadcast mode communication, which does not make use of the address, is also allowed in some cases. A parity signal is included in the address discrete set to provide an error or fault detection capability for single point failure, such as shorted or broken wires, at the interfaces. (See section 7.3 of this Handbook.)

15.4.3.7 Primary structure ground.

A structure ground between the aircraft and store is required to prevent an electrical shock hazard. Prior revisions referenced a military specification, which in turn imposed a maximum resistance requirement of 0.1 Ohm on bonding. Since that specification was canceled, the requirement has been changed to state only the performance requirement, i.e., provide a safety ground.

The last sentence (prohibiting use of this connection for a signal or power return) could lead to some confusion. Because the standard does not define specific relationships between various grounds in the aircraft or in the store, it is possible that the aircraft will connect 28V DC and 115/200V AC returns to aircraft structure. It is also possible that the store will connect its 28V DC and 115/200V AC load returns to store structure. Under these two legal, i.e. AEIS compliant, design conditions, some power supply currents will flow through the structure ground line. The last sentence does not disallow this condition. It is intended to disallow two other possibilities:

a. An aircraft or store using structure ground as the reference ground for an AEIS signal,

b. An aircraft or store using structure ground instead of installing dedicated 28V DC return or 115/200V AC neutral lines through the interfaces.

15.4.3.8 Primary power.

Power is required from the aircraft to operate stores while they are attached to the aircraft.

Growth provisions are included in the AEIS for future implementation of 270V DC power systems. MIL-STD-704, the US military standard that defines electrical power characteristics, includes 270V DC as a military standard voltage. However, aircraft currently (1999) do not distribute this voltage level to store stations. Because 270V DC is included in MIL-STD-704 and may be implemented in the future, growth provisions are included in the AEIS.

During development of MIL-STD-1760C, serious consideration was given to reducing the power voltages required at the MSI. This change was not made, primarily because of US Army concerns that it would complicate efforts to use off-the-shelf equipment within pods and because it would make new aircraft incompatible with the specified power requirements of existing MIL-STD-1760B stores like JDAM and JSOW.

The last sentence is included in this paragraph to disallow the use of the power lines, particularly the 28V DC lines, as general purpose discretes. For example, since the aircraft has the ability to turn a 28 V DC line on and off, someone might want to apply power to the 28 V DC line momentarily as a signal to the store to change modes. This is prohibited in order to encourage all to use the interface in the way it was intended, i.e., with power through the power lines and signals through the data bus and discrete lines.

(See section 10 of this Handbook.)

15.4.3.9 Fiber optic (FO) interfaces.

This paragraph identifies a dedicated growth provision in the AEIS for addition of a fiber optic interface capability to the standard. Fiber optic physical interface characteristics were developed for MIL-STD-1760C, but were not included in the final version because of lack of any installation proving that the available termini would operate reliably in the AEIS environment and limited availability of hardware meeting the proposed requirements. Logical requirements, assigning specific functions or data to be transmitted by the fiber optics, are also not yet established. (See section 12 of this Handbook.)

15.4.4 Auxiliary power signal set.

Sub-paragraphs of 4.4 provide an overview of the auxiliary power interface electrical and physical requirements. Detailed requirements are contained in 5.1 and 5.2 for the aircraft and mission store, respectively.

15.4.5 Auxiliary power.

The auxiliary power interface is provided to supply additional electrical power to those store applications which require a higher power capacity than is available through the primary interface. Generally, the store types, which fit this category, are electronic pods, e.g. ECM equipment, or multiple station carriage stores.

Growth provisions are included in the AEIS for future implementation of 270V DC power systems. See 15.4.3.8 herein.

As discussed in 15.4.3.8 herein, the last sentence is included in this paragraph to disallow the use of power lines as general-purpose discretes.

(See section 10 of this Handbook.)

15.4.5.1 Auxiliary interlock interface.

Similar to the commentary on 15.4.3.5, an interlock interface is also included for the auxiliary power signal set. This interlock provides a capability for the aircraft to monitor the electrically mated status of the auxiliary power connector. The auxiliary connector mated status indication is independent of the interlock interface contained in the primary signal set. (See section 7.2 of this Handbook.)

15.4.5.2 Auxiliary structure ground.

Refer to the commentary on 15.4.3.7 above.

15.4.6 Interface connectors.

This requirement establishes, by reference to other paragraphs in the standard, two specific connectors and one insert arrangement as the standard primary signal set connector for ASIs and MSIs.

It also establishes, by reference to other paragraphs in the standard, one specific connector and insert arrangement as the standard connector for the auxiliary interface connector of all ASIs and MSIs.

Note that in MIL-STD-1760C, the requirement is only to meet the "form, fit, and function requirements" of the connector specifications, i.e., be interchangeable with the MIL-C-38999 and 83538 connectors. This is in contrast to the prior revisions, which specifically required use of the military connectors on the aircraft side of the interface. This was changed because MIL-C-38999 and 83538 are "design" specifications, and, as a result of government acquisition reform, military specifications and standards are no longer allowed to reference them as firm requirements. This still achieves the interoperability goal of MIL-STD-1760, but transfers responsibility for connector hardware design, reliability, environmental qualification, etc., to the aircraft or store designer/manufacturer.

15.5 DETAILED REQUIREMENTS.

The main body of MIL-STD-1760 consists of a "General" requirements section and a "Detailed" requirements section. The detailed section includes subsections dedicated to Aircraft, Mission Store, Carriage Store, Umbilical cable and Connector requirements. This arrangement results in some duplication between sections, but generally allows each specialized group (e.g., aircraft designer or store designer) to find nearly all the applicable requirements for their side of the interface in one section.

15.5.1 Aircraft requirements.

This paragraph introduces the requirements which the aircraft must meet and makes a key point about the intent of the standard.

The requirements specified for the aircraft and stores are defined and measurable at the appropriate interface, i.e. RNASP, ASI, CSI, CSSI or MSI. In most cases, if the characteristic is not measurable at an AEIS interface or between AEIS interfaces, then it is not included in the standard. (Exceptions to this philosophy occur in the HB, LB and Data bus area, where some essential characteristics of the aircraft network are included.) The importance of this "interface standard" approach is that any technology or design can be used to implement the interface as long as the interface requirements are met.

The capabilities of a store (such as its guidance technology) or an aircraft system (such as its ability to display video from a store to a pilot) are tailored to the mission of the system and are intentionally not covered in the standard.

15.5.1.1 Aircraft HB interfaces.

This paragraph establishes the general requirements on the HB network and signals. Detailed discussion of the HB requirements is in section 8 of this Handbook.

The aircraft is to provide a high frequency signal distribution network with access ports at each ASI and at applicable aircraft avionics equipment areas. The distribution network must support signal transfer through the ASIs in either direction but in a simplex mode. Bi-directional duplex operation is not required by the standard. (a duplex system is like a telephone line where signals travel both directions at the same time). Each HB interface is specified as a coaxial, or two connection, interface consisting of a signal connection and signal return connection. If a coaxial cable is used, then the signal return is the coaxial shield. However, the interface specification also allows a triaxial, or three connection, interface consisting of a signal connection, a signal return connection and a grounded shield. This grounded shield, however, is not "visible" at the ASI or MSI.

15.5.1.1.1 Minimum transfer capacity.

This paragraph establishes the minimum required HB network capacity at a single ASI. Aircraft mission requirements may impose requirements for a higher level of HB network capacity than required by this standard. The actual network capacity required (that is, the number of simultaneous HB signals flowing through the aircraft system, possibly from more than one ASI) will tend to vary with each aircraft and with each store load-out on a given aircraft.

This paragraph covers three points. First, two signal types, Type A and Type B, are assigned to specific HB ports. Type A signal requirements are applied to HB1, HB2, HB3 and HB4 while Type B signal requirements are applied to HB1 only.

The second point is that, although HB1 is to be compatible with Type A and Type B signals, it is not required to transfer Type A and Type B signals through the HB1 port at the same time. This means that a specific signal is not permitted to overlap both the Type A and Type B characteristics - a signal is either Type A or Type B, but not both.

The third point is that the aircraft's high bandwidth signal distribution network must be designed with sufficient capacity to transfer signals through all HB ports at a given ASI. The distribution capacity of the aircraft network for supporting simultaneous operation of more than one ASI is not defined by the standard, although it is a useful capability in some missions and is recommended. (See section 8 of this Handbook.)

15.5.1.1.2 Type A signal path requirements.

15.5.1.1.2.1 Return loss.

Return loss is an alternative to Voltage Standing Wave Ratio (VSWR) as a way to express the limitation on reflections on a signal transmission line. The return loss requirements in this paragraph are much more severe than the VSWR requirements that were in Revision B. A larger value of return loss represents a greater attenuation of reflected signals, which implies better signal quality.

15.5.1.1.2.2 Transient response.

The transient response requirements control both linear distortion and some forms of non linear distortion. If the network response falls within the limits shown in the series of figures, one can be confident that the network will transmit video and other HB signals with acceptably low distortion.

15.5.1.1.2.3 Insertion gain.

Insertion gain limits control the change in signal amplitude between the input and output.

15.5.1.1.2.4 Representative pulse delay.

When time correlation signals are passed through the network, the delay will contribute to latency and latency error at the sink equipment. This requirement limits both the total delay and the variation in that delay.

The nominal delay can be accounted for by passing information about the delay to the sink (via the MIL-STD-1553 data bus), leaving only the delay variation as an error.

15.5.1.1.2.5 Equalization.

The equalization requirements are to ensure that the signal path is capable of transmitting all signal frequency components between 20 Hz and 20 MHz and to control the amplitude of transient response artifacts (e.g., ghosts) outside the nominal passband.

This equalization requirement controls essentially the same thing as the transient response requirement, such that it may not be necessary to apply and test for both requirements. The transient response requirements, however, give direct indication of the waveform distortion introduced by the signal path which is not easily deduced from the equalization requirements. The two sets of requirements are therefore useful.

15.5.1.1.2.6 Dynamic range.

This dynamic range requirement is to ensure that the network can accommodate the voltage excursions of the signal, including excursions which occur under transient conditions. For example, a 1 Vpp signal which is AC-coupled may bounce up to +1.35 V or down to -1.35V if there is a 1V shift in its useful DC component and there is an AC-coupling circuit with a large number of poles. In addition, the source and carriage store may introduce a DC error after AC-coupling.

15.5.1.1.2.7 Signal path DC offset.

Maximum DC offset is specified to limit the range of common mode voltages the receiving circuitry must deal with.

15.5.1.1.2.8 Noise requirements.

These requirements are to ensure that signals are not excessively corrupted by noise inserted by the HB network

15.5.1.1.2.8.1 Random noise.

This requirement limits random noise (“white” noise, which would be called “hiss” in an audio system) to a level that should not be visible in video.

15.5.1.1.2.8.2 Periodic noise.

This requirement limits periodic noise (would be called "hum" in an audio system). It treats crosstalk from other HB and LB signal sources as a form of periodic noise.

The weighted periodic noise requirement corresponds with a peak white to peak-to-peak noise voltage ratio of 50 dB for 1 Vpp STANAG 3350 video.

15.5.1.1.2.8.3 Impulse noise.

This requirement limits impulse noise (would be called "pop" in an audio system).

15.5.1.1.2.8.4 Stimulated noise.

Stimulated noise occurs as a result of harmonic distortion, intermodulation distortion, quantization noise and aliasing. The stimulated noise requirements correspond with a second harmonic distortion of 2.5% for both the 50 ohm and 75 ohm interfaces for a full amplitude sinusoidal input signal (assuming only second harmonic distortion is present). For video signals this equates to a differential gain distortion of 10%, which follows CCIR Recommendation 567-2. Differential phase distortion is also important and this is controlled by the incidental phase modulation requirement.

15.5.1.1.2.8.5 Common mode noise.

This requirement limits common mode noise, which is AC or DC voltage that occurs simultaneously on both lines of a differential signal and can therefore be canceled out by a differential receiver.

15.5.1.1.3 Type B signal path requirements.

Type B signals include RF signals, such as the GPS signal received by an antenna on top of the airplane being sent to a store which is in a weapon bay or under a wing. Only the overall signal passband and peak envelope power are specified (in paragraph 4.3.1 and 4.3.1.2) at this time.

15.5.1.1.4 Ground reference.

This paragraph requires a differential, unbalanced transmission scheme for the Type A interfaces, which provides improved immunity to magnetic field interference. Revision B called for HB 1 and 2 to have grounded returns and HB3 and 4 to have isolated returns.

The HB1 signal path is required to be compatible with both Type A and Type B signals, but they have conflicting grounding schemes. Therefore, a system which switches grounding schemes, as discussed in section 8 of this Handbook, will generally be needed.

15.5.1.2 Aircraft digital data bus interface.

This paragraph covers requirements on the MIL-STD-1553 digital multiplex data bus ("Mux" or "data bus") which is essential to passing data through the MIL-STD-1760 interface.

15.5.1.2.1 Functional characteristics.

This paragraph is to clearly allocate the MIL-STD-1553 terminal responsibilities between the aircraft and mission store.

The aircraft is assigned the responsibility for controlling the data transfers through each ASI. This control is defined by MIL-STD-1553 as residing in a Bus Controller (BC) terminal. This paragraph strongly implies that the BC is physically located within the aircraft by stating that the aircraft is responsible for the BC function. It is plausible, however, that the BC could be located elsewhere, such as in a special fire control system electronic pod. However, even in this special case, the aircraft is still responsible for activating the pod and has in essence delegated its BC responsibility to a known, aircraft-controlled piece of equipment. The complementary side of this requirement is that a mission store or carriage store is required to provide a MIL-STD-1553 Remote Terminal (RT) capability.

Four other major points are contained in this paragraph. First, the aircraft, as BC, not only controls BC-RT and RT-BC data transfers, as defined by MIL-STD-1553, but also controls certain transfers between stores at different ASIs. This store-to-store transfer can be achieved with an RT-RT transfer as defined in MIL-STD-1553. However, the standard does not require the aircraft to implement RT-RT modes. The intent of the standard is to not disallow any SMS architectures, particularly hierarchical SMS architectures. In a hierarchical SMS, the aircraft could transfer data from one store to another through a two step process of RT-BC followed by BC-RT. Therefore, the requirement in the fourth sentence is for the aircraft to be able to move data from one store to another store - not necessarily by MIL-STD-1553's RT-RT transfer mode.

The second major point is that communication with a store using the MIL-STD-1553 broadcast command is permitted. Use of broadcast messages provides only a limited communication capability, i.e. no status response and data cannot be received from the store. See also paragraph B.40.1.5.11.1 which deals with use of broadcast mode on MIL-STD-1553.

The third major point is that the aircraft must limit the use of all MIL-STD-1553 command words "visible" at any ASI such that subaddress 19 and 27 commands will only be sent to nuclear weapons. This does not imply that nuclear weapons will only use subaddresses 19 and 27. It does, however, impose limitations on either the bus architecture in the aircraft, or the subaddresses used by other equipment connected to an aircraft bus network, if command words on that network are transmitted to any ASI. This restriction is intended to increase overall system safety when nuclear warheads or nuclear bombs are carried on the aircraft. (See section 6 of this Handbook.)

The fourth point is the blanket reference to Appendix B of the standard in the last sentence. This sentence invokes all the requirements of Appendix B, even though these requirements are not mentioned in the numerous other places in the standard where they apply.

15.5.1.2.2 Electrical characteristics.

This paragraph and the following three subparagraphs identify several clarifications and additions to requirements contained in MIL-STD-1553B.

Data high and data low connections of the data bus stub are defined. This definition assures proper connection of a MIL-STD-1553 RT to the interface connectors, i.e. prevent reversed polarity connections, when taken in conjunction with Note 2 in Table III of the standard.

ASI test conditions for Mux A and Mux B. The following termination conditions were recommended in paragraph 6.3.4 of Revision B for evaluating compliance with the output characteristics (5.1.2.2.1) and input characteristics (5.1.2.2.2) requirements for the Mux A and Mux B ASI interfaces. These recommendations are moved to this Handbook in Revision C:

a. All ASIs terminated with a 1000 Ohm ±5 percent resistive load at the end of the 6.1 m (20-foot) long MIL-STD-1553 compliant cable,

b. All ASIs (except ASI under test) disconnected (that is Mux A and Mux B open circuited), and

c. All ASIs in the terminated conditions expected (such as opened or shorted) during aircraft operation, including stores release.

The three configurations listed attempt to represent a wide range of termination conditions. The 6.1 m (20 foot) cable test of subparagraph a. is selected to represent a long cable run from ASI to mission store remote terminal. This length includes not only the internal store cable but also any ASI-MSI interconnected umbilicals. To exceed this length in an actual application probably requires a long store connected to the aircraft through an intermediate carriage store or adapter.

Subparagraph b. represents the opposite extreme, i.e. no cables connected to the ASI. This configuration results from missions which do not include AEIS stores at some, or all, stations.

Subparagraph c. represents a more aircraft-dependent case where specific termination conditions may need to be tested. Included in this is recognition that umbilical cables can become damaged as a result of store release or a cable/connector failure and result in a shorted data bus interface. (See section 6 of this Handbook.)

15.5.1.2.2.1 Output characteristics.

The point of MIL-STD-1553 waveform characteristics measurement is defined at the ASI which is the interoperable point for the aircraft. In contrast, MIL-STD-1553 defines waveforms at the RT input/output connections.

Associated with the interface definition being moved from RT to ASI, the waveform voltage required is defined by the envelope of figure 14 in the standard. This waveform is basically a conversion of MIL-STD-1553 requirements into a figure with one exception. The minimum allowed output voltage required at an ASI is 1.4 volts p-p. This compares to the 1.0 volts p-p minimum required by MIL-STD-1553 for data buses to deliver to RTs. This additional safety margin is added due to the extra cable length and change in load impedances possible between the ASI point and the store's RT.

The paragraph further restricts the 150 nanosecond zero crossing distortion allowance in MIL-STD-1553 to 120 nanoseconds when applied at the ASI. One Hundred Twenty nanoseconds was a consensus reached by a group of MIL-STD-1553 experts. They did not produce an analysis documenting why they chose the number. Their explanation was that you could get any answer you wanted by adjusting the input assumptions, so the analysis would still come down to accepting expert opinion. They also claimed that 120 nanoseconds is very reasonable with current off-the-shelf hardware.

This change is intended to avoid setting unique requirements for MIL-STD-1553 hardware in stores. Zero crossing deviation starts out small at a MIL-STD-1553 transmitter and increases with cable runs, connectors, stubs, etc. If we allow 150ns at the ASI it will be worse than 150 after traveling through the umbilical and connectors to the RT in a store, but a standard receiver only tolerates 150, so you would need a special one. On the other hand, the airplane could limit it to 120 with an off-the-shelf RT and “good design practice”.

15.5.1.2.2.2 Input characteristics.

This paragraph clarifies that the transformer coupled stub option of MIL-STD-1553 applies to the ASI.

15.5.1.2.2.3 Shield grounding.

A requirement is imposed on the aircraft that the shield for each data bus must be connected to aircraft structure ground. This shield grounding is not specifically defined by MIL-STD-1553. The companion requirements in section 5.2.2.2 of the standard, for the mission store, also require grounding of the shield in the mission store. Between these two sets of requirements, a multiple point shield grounding concept is specified for the data bus. (See section 6 of this Handbook.)

15.5.1.3 Aircraft LB interface.

The LB interface is provided to transfer low frequency, low power level signals which for various reasons are inappropriate for transfer over the data bus interface.

Tones and voice grade audio are currently the only allowed signals on the LB interface. The LB interface characteristics in prior revisions were defined to accommodate its potential use for transferring low speed serial digital data using balanced line differential receivers and drivers such as those defined by EIA Standard RS-485. This application, as a low cost alternative to the MIL-STD-1553 data bus, is no longer being considered.

Where a small number of audio tones must be sent through the interface and LB wiring or switching hardware is not installed, it may be more practical to send the information about which tone the pilot should be hearing through the MIL-STD-1553 data bus, then convert this information to a tone in the intercom system. This may not be practical if a complex tone, like the tone from the seeker on a missile, must be reproduced.

The lack of use of the LB interface has led to several aircraft installations of MIL-STD-1760 hardware that do not include low bandwidth lines.

(Old) 5.1.3 (of Revision B) Electromagnetic compatibility (EMC).

EMC requirements that were in previous versions were deleted in Revision C because these requirements attempted to impose requirements upward on the aircraft. Also, MIL-HDBK-235 was called out as a requirement. It is a compilation of emitter characteristics, useful in defining a required environment but, being a handbook, it cannot be called out as a requirement.

The addition of stores and store station equipment to the aircraft must not degrade the electromagnetic environmental effects characteristics of the aircraft. The design and installation of stores and stores station equipment must be compatible with the aircraft, and must be such that the aircraft can still meet its electromagnetic environmental effects requirements.

15.5.1.3.1 Minimum transfer capacity.

The aircraft is required to install a distribution network for bi-directional LB signals. The network must be capable of rerouting these LB signals between any ASI and the applicable aircraft equipment. The specific equipment that is "applicable" is determined by each aircraft based on that aircraft's weapons capability. “Rerouting” means that the signal path must be changeable in flight, i.e., not implemented with a “patch panel” approach. Generally, as a minimum, the aircraft will provide a network path for the LB signal to the aircraft intercom system.

15.5.1.3.2 Input/output impedance.

The impedance of the LB network was changed to 600 ohms in rev. C to be compatible with common audio systems.

In rev. B, the input and load impedances, line-line, were specified by a minimum value only, which allowed the impedance to be as high as an "open circuit". This range encompassed typical 600 ohm audio impedances as well as the 120 ohm point-to-point serial data link impedance, which was at one time envisioned as an alternate use of the LB network.

15.5.1.3.3 Insertion gain.

15.5.1.3.4 Equalization requirements.

15.5.1.3.5 Signal path DC offset.

15.5.1.3.6 Noise.

15.5.1.3.6.1 Periodic and random noise.

15.5.1.3.6.2 Impulse noise.

15.5.1.3.6.3 Stimulated noise.

15.5.1.3.6.4 Common mode noise.

15.5.1.3.7 Ground reference.

The shield grounding method for the LB port is a multi-point shield ground scheme. The shield termination measurable at the interface connector is connected to aircraft structure ground on the aircraft side of the ASI and to store structure ground on the store side of the MSI or CSI. This grounding scheme provides optimum shielding for a balanced line twisted pair network at audio frequencies. The standard only requires that the shield be grounded somewhere on the aircraft side of the ASI and on the store side of the MSI or CSI, and does not specify the physical location of shield connection or the method of termination. (See section 9 of this Handbook.)

15.5.1.4 Aircraft release consent interface.

The release consent signal is required at each ASI. It provides an enabling or inhibiting function to be used in conjunction with safety critical commands sent to the store over the data bus. Release consent is only an enable or inhibit signal and is not to be used by itself to command a store into a specific state or to start an irreversible process in a store. The release consent signal is provided to "gate" safety critical data bus commands, such as fire, arm, etc., into a store's subsystem. The store design documentation, or Interface Control Document identifies those commands which are safety interlocked with release consent. The point in time at which release consent is set to the enable state will be determined by the aircraft based on the aircraft's safety criteria, i.e., the aircraft will determine when it is safe to remove some of the last safety interlocks to a store. Also see comments in paragraph 15.4.3.4 and 15.5.2.4 herein and additional technical points in 15.5.1.4.2

The isolation requirement is included for fail-safe purposes. It is to prevent a fault (release consent shorted to 28V DC in one store or at one station) from activating the enable state at other ASIs. (See section 7.1 of this Handbook for schematic examples and additional detail.)

15.5.1.4.1 Voltage level.

This paragraph deals with voltage levels, as indicated by the paragraph title, and defines the interface line which is to be used as the release consent reference. This reference, 28V DC Power 2 return, is selected as a compromise between providing an additional line for a dedicated return, with the resulting connector impact, and sharing a 28V DC power return, with resulting EMI considerations. Since the release consent "signal" is defined with MIL-STD-704 voltage levels which are already extremely noisy, sharing the 28V DC return is a reasonable compromise.

The voltage characteristics of the release consent signal must comply with the transient limits of MIL-STD-704 defined over-voltage and under-voltage limits from 50 microseconds to several seconds at which point the steady state conditions apply. Within the steady state domain, the aircraft is required to supply at least 19V DC at the ASI for an enable state.

The aircraft is also required to limit the voltage into a release consent load, provided by the store, to less than 1.5 volts for a valid inhibit state. This provides a well-defined band within which the store's release consent detection circuitry can set enable and inhibit thresholds. (See section 7.1.2 of this Handbook.)

15.5.1.4.2 Current level.

The major point of this paragraph is to provide upper and lower bounds for the current levels which the aircraft must be capable of supplying while maintaining the voltage levels of the previous paragraph. A lower limit of 5 milliamperes is selected to ensure sufficient current flow to break down film and other contaminants on electrical contact surfaces and to “load down” noise voltages. This lower limit does not, however, mean that all stores will draw at least 5 milliamperes of current from an enabled release consent discrete. Stores which do not use the release consent signal can provide no load, i.e. open circuit, across the release consent lines. Stores that use release consent will, however, demand at least 5 milliamperes when an enabled release consent is applied.

The 100 milliampere upper limit is established to allow use of solid state drivers or small electromechanical relays in the aircraft for switching the release consent discrete between enable and inhibit states. The primary driver is electromechanical relays. To ensure low contact resistance and thus small voltage drops, under low current conditions, the maximum switched current must be kept within the "intermediate current" rating of relays. This rating is typically 100 milliamperes. (See section 7.1.2 of this Handbook.)

15.5.1.4.3 Stabilization time.

The primary purpose of this stabilization time specification is to limit the transition time between the two release consent states. This limit defines the duration that a store's release consent detection or buffer circuit operates in the "linear amplifier" region between the two states. The stabilization time is sufficiently long to account for contact bounce phenomena if electromechanical relays are used in aircraft for release consent switching. The stabilization time is also sufficiently long to allow filtering or other methods of rise/fall time control for compliance with EMC requirements typically imposed on aircraft.

15.5.1.4.4 Enable lead time.

15.5.1.4.5 Inhibit delay.

These two paragraphs account for delays between the application and removal of an enable signal at an ASI and the actual operation of the enabling and inhibiting function within the store. Part of this delay is the response time of the store circuitry. See 5.2.4.4 and 5.2.4.5 of MIL-STD-1760C. Part of the delay is allocated to a carriage store for the case where a carriage store is inserted between the aircraft and mission store. In essence, a 10 millisecond maximum time is allowed for the carriage store to pass the signal through and 10 millisecond maximum is allowed for a mission store to respond. This response time is sufficiently long to allow significant filtering of the input or output lines or to allow use of electromechanical relays.

15.5.1.4.6 Ground reference.

The ground reference paragraph simply re-emphasizes which interface line is to be used as the reference for release consent. (See 7.1.2.6 of this Handbook.)

15.5.1.5 Aircraft interlock interface.

This paragraph (and the corresponding 4.3.5 and 5.2.5) provide for a discrete signal indicating electrical connection between the store and aircraft and points out that separate interlock interfaces are contained in the primary and auxiliary signal sets.

The first sentence of paragraph 5.1.5 of the standard needs to be interpreted in conjunction with the phrase that says “IF the aircraft monitors the interlock...”. The aircraft is not required to use (i.e., apply an excitation signal and monitor to determine mated status) the interlock interface. If the aircraft does monitor the interface, the aircraft must comply with the detail requirements in this paragraph.

5.1.5a defines limits on the excitation voltage supplied by the aircraft. These voltage limits apply under the condition of an open circuit between interlock and interlock return on the store side of the ASI. The voltage range defined allows MIL-STD-704 28V DC voltage levels and also allows application of "logic circuit level" voltages down to 4.0V DC. Open circuit voltages below this 4 volt level are disallowed to minimize erroneous reading due to contaminated contacts.

For a similar reason, the "closed circuit" current range is bounded between 5 and 100 milliamperes. The 5 milliampere limit would apply if a 2 ohm load is connected across the store side of the ASI. The 100 milliampere limit applies to a short circuit (zero ohms) across the ASI.

5.1.5c defines the two impedance levels at which the "interface disconnected" and "interface connected" states must be detected. The actual aircraft detection circuit threshold(s) can be set at any point between these two limits. (See 7.2 of this Handbook.)

See also the discussion in 15.5.1.6.

15.5.1.6 Aircraft address interface.

This paragraph (and the corresponding 4.3.6 and 5.2.6) provide for discrete signals to indicate the data bus RT address assigned to the store on a specific station. Assignment of an address is essential to the operation of the MIL-STD-1553 "command-response" bus protocol.

This address is provided by a set of discretes which allows the connected store's RT address to be uniquely assigned automatically by connecting the store to any specific ASI. These address coding contacts are contained in the ASI since it is not practical to program a store's address during manufacture or during store preload preparation.

15.5.1.6.1 Address assignment.

The rules for assigning addresses with the five address bit lines are defined here by establishing the binary weight of each line. Additionally, an odd parity check is defined allowing detection of single line faults including loss of the common return. If an even parity check were specified, the check would pass if the address return opened.

The last sentence clarifies that if an aircraft uses an address interface design in which the assigned address at an ASI is modifiable, e.g. under software control, then the aircraft must not change the assigned address at an ASI as long as that ASI is powered. It is expected that most aircraft applications will simply hardwire the address for an ASI with connections in the wire at a point that stays in a fixed location on the aircraft. If, however, the ASI is physically part of a Store Station Equipment (SSE) black box and the SSE is interchangeable at different stations, then some type of address modification system might be used. A similar condition could exist if the entire pylon or a wire harness is interchangeable at different stations. (See 7.3 of this Handbook.)

15.5.1.6.2 Address signal.

The characteristics of the store sourced excitation signals are defined to encompass a range of circuit designs from "logic level" signals through higher level MIL-STD-704 28V DC derived excitation. The standard simplifies ASI circuit design requirements by clamping the MIL-STD-704 type 28V DC excitation to a maximum voltage of 31.5V DC. The aircraft address circuitry is not required, therefore, to withstand the higher (50V DC) power surges defined by MIL-STD-704. This clamping requirement is levied on the mission store by 5.2.6.2 of MIL-STD-1760C.

The levels of current that the store is allowed to source and the aircraft is required to support are constrained within the same 5 to 100 milliampere range discussed above for the release consent signal. While the use of electromechanical relays are not necessarily recommended for address modification circuitry, the excitation current and voltage levels allow their use.

The 600 milliampere current flow in the address return line is based on an erroneous address, i.e. 0 with failed parity. The aircraft must still support this current, however, to ensure that the store will correctly detect the address as erroneous.

The rise and fall time maximum limits are included to limit the time that an excitation signal is in the "active" region of the aircraft's address modification circuit. This rise/fall time is more important if particular stores periodically sample the address interface, i.e. pulse the excitation signal, in order to reduce power requirements or internal heat dissipation. This maximum time is of no concern to aircraft which hardwire the address with jumper wires behind the ASI. (See 7.3 of this Handbook.)

15.5.1.6.3 Logic thresholds.

The aircraft is required to provide logic states with specific characteristics when the excitation signals are sourced by the store.

Sub-paragraph a. defines the Logic 1 state as a function of allowed maximum current flow between each address line and the address return. For aircraft designs which hardwire, open or short, the address lines at the ASI, this requirement can be converted to an impedance requirement. That is, the impedance between a Logic 1 set address line and its return must be at least 105 kilohms looking into the ASI. If the aircraft uses solid state devices to establish the address states, then the requirement can be interpreted as an "off-state" maximum leakage current over the range of open circuit voltages.

Sub-paragraph b. defines the Logic 0 state as a function of maximum allowed voltage drop with the applied excitation current into each address line. For hardwired ASI designs, this voltage drop, 1.0 volts maximum, can be converted into an impedance, but care needs to be exercised in considering the higher current flows in the address return. Knowledge of relative distribution of resistance between an address bit line and the return line is needed before an equivalent impedance can be determined. If solid state, or any non-linear, devices are used to establish the ASI address, then a voltage drop measurement over the excitation current range is the only meaningful specification. (See 7.3.2 of this Handbook.)

15.5.1.6.4 Response characteristics.

This response time requirement is included to establish limits on any filtering the aircraft might place on the address lines. In addition, the aircraft is not permitted to use the address interface or to establish the address characteristics in any manner that would require continuous sourcing of the excitation signal by the store. Again, for the simple aircraft address implementation of using hardwired jumpers at the ASI, these response characteristics are not significant. Aircraft which use active circuits for establishing the ASI address must consider the constraints of this response requirement. (See 7.3.2 of this Handbook.)

15.5.1.6.5 Address isolation.

This isolation is imposed to minimize ground loop induced noise problems in the store's address excitation and detection circuits. The isolation is easily achievable in hardwired ASI address designs. Active ASI address designs could be slightly more complex due to this isolation requirement. (See 7.3.2 of this Handbook.)

15.5.1.7 Aircraft structure ground.

The structure ground line in both primary and auxiliary AEIS connectors is included to provide a higher level of assurance that the aircraft and store structures are electrically interconnected. It is to ensure that hazardous voltage is not present on a store, just as the third conductor in residential wiring and appliances connects all chassis to ground to prevent shocks in the event of an electrical short. Other structure ground paths should exist between the aircraft and store due to mechanical connections, gross shields on interconnecting umbilicals and possibly power return connections, i.e. 28V DC Power 1 return etc. These other connections may, however, not exist (especially during ground or lab operation) or may be poorly controlled.

The last sentence in 5.1.7 may lead to confusion. The intent of this sentence is that power and signal circuits through the AEIS interfaces must not rely on the existence of the structure ground line for proper operation. However, it is possible for power and signal currents to flow through structure ground. For example, it is likely that the aircraft will connect its 28V DC power source to aircraft structure. It is also possible that the store will connect the 28V DC return to store structure. Neither condition is required or disallowed by the standard. Under this combination of aircraft and store conditions, 28V DC return currents will, indeed, flow in both the 28V DC Power 1, or DC Power 2, return and in the structure ground line. This condition does not violate the intent of the last sentence.

Revision C deleted the requirement to comply with MIL-B-5087, since it has been canceled. It also changed 5.1.7 to require the ability to carry the “overcurrent levels defined in figures 17 and 18”, rather than the rated current. This better reflects the intent of a safety ground (to carry a large fault current long enough to trip a circuit breaker) and makes this paragraph consistent with 5.2.8 of the standard.

15.5.1.8 Aircraft 28V DC power interface.

This paragraph and subparagraphs, along with 4.3.8 and 5.1.9 (and subparagraphs), place requirements on the 28 V DC power provided by the aircraft in order to ensure that aircraft power sources are compatible with all stores.

In addition to sourcing two 28V DC power inputs in the primary ASI and when applicable, one in the auxiliary ASI, the aircraft is required to independently control, turn-on and/or turn-off, each power output. This independent control is required primarily for safety reasons.

15.5.1.8.1 Independent control.

Some existing systems do not have the ability to individually apply and remove power from store stations and therefore do not comply with this requirement. These systems should still function properly with MIL-STD-1760-compliant stores, but may require additional procedures for safe loading and maintenance.

Deadfacing (ensuring no power is applied to the connector when it is disconnected) of 28 V DC is widely recommended as a way to ensure greater safety during maintenance and prevent arcing of connector pins in flight. Deadfacing was recommended as a requirement in MIL-STD-1760C, but was not adopted because of concern that safety interlocks in some nuclear weapons could be dependent on power at the connector up to the instant of disconnect. Note that the standard does not prohibit the aircraft from removing power from connectors before disconnect, as long as it is not required by the particular store being carried.

15.5.1.8.2 Voltage level.

Paragraph 5.1.8.2 of Revision C states the actual voltage required at the ASI, rather than stating voltage relative to MIL-STD-704, as prior versions did. During development of Revision C, serious consideration was given to allowing additional voltage drop at the ASI and MSI, based on an analysis of the voltage drops to be expected in stores management or armament control equipment and the connectors and wiring between this equipment and the store. The voltages were not reduced for two reasons. First, this would have made the existing generation of MIL-STD-1760B stores incompatible with Revision C and second, it would make use of aircraft avionics inside stores more difficult because they would have to be redesigned to accommodate the lower voltage.

The ASI required voltages are the "utilization equipment" input terminal voltages from MIL-STD-704 (later revisions). Possible points in the AEIS network to be considered as the utilization equipment range from the input to the aircraft's Stores Management System to the input to equipment installed inside the mission store. The ASI was selected in prior revisions, primarily because it is the last point in the AEIS network that is directly controlled by the aircraft.

This paragraph defines the voltage levels in both steady state and transient conditions. The voltage transient requirements are as defined in MIL-STD-704. Transients down to 50 microseconds are limited by MIL-STD-704. (See 10.5.2 of this Handbook.)

15.5.1.8.3 Current capacity.

15.5.1.8.3.1 Primary signal set.

15.5.1.8.3.2 Auxiliary power signal set.

This set of paragraphs and the referenced figures define the levels of 28V DC currents that the aircraft is required to be capable of providing. The required levels are defined for both continuous and short term conditions. While actual current on the 28V DC power lines is partially dependent on the store's load, the aircraft must be capable of supporting the loads defined by the "maximum load current" curves in the figures. The note below figures 17 and 18 provides additional clarification on the meaning of the load current curves.

This paragraph set also requires the aircraft to be capable of simultaneously providing the full 10 continuous amperes through both 28V DC Power 1 and Power 2 interfaces in any ASI. (See 10.1 of this Handbook.)

15.5.1.8.3.3 Simultaneous current.

The total power which can be sourced simultaneously through all ASIs is dependent on the aircraft's power generation and distribution capacity. While it might be desirable that the aircraft be capable of supporting the full rated load at each ASI simultaneously, store loadout limitations, carriage configurations and the number and location of ASIs on each aircraft may result in this full loading being unnecessary. The standard recognizes this condition and, to avoid potential misinterpretation, clarifies that total power capacity through all ASIs is determined uniquely by each aircraft system specification.

The paragraph also clarifies that aircraft stations which implement the auxiliary ASI are not required to source 50 amperes, i.e. 10 plus 10 plus 30, as might be interpreted by the combination of paragraphs 5.1.8.3.1 and 5.1.8.3.2 of the standard. (See 10.1 of this Handbook.)

15.5.1.8.4 Overcurrent protection.

The aircraft is required to provide protection against excessive current flow out of each power line, as defined in figure 17 and 18.

The figures were modified in rev. C to extend all the way to zero time, and to limit maximum load current at about 6 times rated current. This change was initiated to make the curves more compatible with the use of solid state power controllers in the aircraft.

To some extent, this requirement is the first known case where a standard, or specification, requires an aircraft to provide some level of fault protection for its connected utilization equipment. The general mode is for the aircraft to protect its distribution wiring from faults to prevent total loss of aircraft electrical power, to prevent aircraft fires and to limit the extent of damage to other subsystems. The utilization equipment is generally left to protect itself, if it is to be protected at all. The AEIS standard goes against this general mode by requiring a specific overcurrent protection level at the ASI primarily to help protect the connected store. This protection assistance is imposed because of the potential destructive capability of the store, i.e. many contain explosive warheads, or rocket motors, etc. which have significant safety impact on the aircraft and its crew. Without some limitations on the amount of fault induced energy which can be dumped into the store, it is not considered practical for the store to always protect itself. Given that the aircraft already provides protection for its distribution wiring, based on compliance with aircraft wiring standards and safety requirements required by aircraft system specifications, plus safe operation of explosive stores is in the best interest of the aircraft and crew, the standard imposes an overcurrent protection requirement at the ASI.

In designing the aircraft's overcurrent protection mechanism, devices may be selected that remove power, i.e. trip, at any point within the current-time band bounded by the Maximum Load Current and Maximum Overcurrent curves. In essence, the Maximum Load Current curve defines the no-trip limit, while the Maximum Overcurrent curve defines the must-trip limit.

(See 10.5.5 of this Handbook.)

15.5.1.8.5 Off-state leakage current.

Requirements on the quality of power turn-off are defined in this paragraph through an off-state leakage current maximum limit. The requirement is directed primarily at aircraft designs which use solid state switching devices for controlling the 28V DC power interfaces. The requirement is primarily of benefit to the aircraft designer in that it prevents extremely low leakage current conditions from being required by store designers. A companion requirement on stores is contained in 5.2.8.5 of the standard. The leakage level is sufficiently low to avoid shock hazards but high enough to allow practical solid state switch designs. (See section 10 of this Handbook.)

15.5.1.8.6 Stabilization time.

This paragraph and the referenced figure define the maximum rise and fall times permitted for the 28V DC power interfaces. This limit addresses stabilization delay sources such as filters, relay contact bounce and solid state switch controlled (ramp) turn-on. Excessively slow rise and fall times complicate store power supply designs, or designs of other active solid state devices, in the store which can be connected to the power interfaces.

15.5.1.8.7 Ground reference.

This paragraph simply states that a power return must be provided for each 28V DC power output.

15.5.1.8.8 Power application.

This paragraph allocates 28V DC Power 2 and auxiliary 28V DC to potentially safety critical functions. It alerts the aircraft designer that activation of either of these power interfaces could degrade the safety of the connected store. This safety degradation results not from the store using power application as a command for some safety critical action, e.g. arming, but from the store using 28V DC Power 2, or auxiliary 28V DC power, as the energy source for carrying out safety critical functions commanded over the MIL-STD-1553 data bus.

15.5.1.9 Aircraft 115V/200V AC power interface.

This set of paragraphs introduces the requirement for the aircraft to provide three phase AC power at each ASI. The AC power is further divided into primary and auxiliary interface requirements which are expanded in the associated sub-paragraphs of the standard. The aircraft is also required to provide independent control of the primary and auxiliary AC power sets. The standard does not, however, require that each AC phase also be independently controlled, i.e. ganged three phase switching is permitted. Since some stores may not require all three phases of AC power for store operation, aircraft designers should consider the safety advantages of providing separate phase switching. There would, however, be some reliability and space disadvantages in the aircraft equipment for providing separate switching of each phase. (See section 10 of this Handbook.)

15.5.1.9.1 Independent control and dead facing.

Deadfacing of 115 Vac power was required in the previous versions of MIL-STD-1760 and is required in Revision C. The last two sentences mandate precautions that the aircraft must take, to eliminate dielectric breakdown of the connector insert due to high voltage arcing at altitude and to avoid the hazard of dangerous voltages being present on exposed connector pins during ground operations.

15.5.1.9.2 Voltage level.

Same rationale and guidance as 5.1.8.2.

15.5.1.9.3 Current capacity.

This set of paragraphs and the referenced figures define the level of currents that the aircraft must be capable of simultaneously sourcing out each phase connection. The referenced figures, one for the primary ASI and one for the auxiliary ASI, specify the capacity of the current source for short term loads as well as continuous loads. The aircraft must be capable of sourcing at least the current levels defined by the Maximum Load Current curve in the figures.

15.5.1.9.3.1 Primary signal set.

15.5.1.9.3.2 Auxiliary power signal set.

Similar to requirements of 5.1.8.3.2, except applied to 3 phase AC.

15.5.1.9.3.3 Simultaneous current.

Similar to the commentary on 28V DC simultaneous current requirements (5.1.8.3.3), this paragraph is included to clarify two points. First, the total power simultaneously sourced out to all ASIs is not controlled by MIL-STD-1760C, but is aircraft dependent and controlled by the system specification for each aircraft model. Second, the aircraft stations which include an auxiliary ASI are only required to source a total simultaneous current of 30 amperes per phase through the combination of the primary and auxiliary ASIs.

(See section 10 of this Handbook.)

15.5.1.9.4 Overcurrent protection.

This paragraph imposes an overcurrent protection requirement on the AC power outputs of the ASI similar to that discussed for the 28V DC power outputs.

(See commentary on MIL-STD-1760C paragraph 5.1.8.4.)

15.5.1.9.5 Off-state leakage current.

The quality of power turn-off is defined in this paragraph for the 115V AC interfaces. The allowed leakage currents are higher than those permitted for the lower voltage 28V DC interfaces due to solid state switch design considerations.

15.5.1.9.6 Stabilization time.

This paragraph and the referenced figure define the maximum rise and fall times permitted for the 115V AC power interfaces. This limit addresses stabilization delay sources such as filters, relay contact bounce and solid state switch controlled (ramp) turn-on. Excessively slow rise and fall times complicate store power supply designs, or designs of other active solid state devices, in the store which can be connected to the power interfaces.

15.5.1.9.7 Phase rotation.

The aircraft is required to furnish AC power at the ASI interfaces for each phase with the phase sequence defined by MIL-STD-704. Although the sequence A-B-C is defined, the specific line or ASI contact that is defined as Phase A is relative. For example, the Phase A interface at one ASI may not be synchronized, i.e. zero phase difference, with the Phase A interface at another ASI. These two ASIs might be powered by two different unsynchronized AC alternators. The second sentence of this paragraph establishes a relationship between the power phase at the primary and auxiliary ASIs which are located at the same aircraft station. That is, the voltage on the interface designated as Phase A in the auxiliary connector and the voltage on the interface designated as Phase A in the primary connector must have a nominal zero phase difference. This, in turn, synchronizes Phases B and C in the two connectors at a specific ASI. Beyond this local ASI phase synchronization, the standard does not define phase synchronization requirements between different aircraft stations. This then allows the aircraft to "rotate" phases at the different ASIs as an aid in improving the total power system phase balance. (See 10.3 of this Handbook.)

15.5.1.9.8 Load power factor.

This power factor requirement is included in MIL-STD-1760C because revisions to MIL-STD-704 (in the MIL-STD-1760B timeframe) removed the utilization equipment power factor limits. Some control of a load's power factor is necessary to minimize disturbances to power generators and conversion equipment and to assist the aircraft designer in controlling the total, system level, connected load power factor. The power factor curve shown is extracted from earlier revisions of MIL-STD-704.

15.5.1.9.9 Phase power unbalance.

The aircraft is required to support phase unbalanced loads within the limits of MIL-STD-704. Phase rotation permitted by MIL-STD-1760C provides a method by which an aircraft designer can cancel some of the phase unbalance at the aircraft power system level. This is discussed paragraph 15.5.1.9.7 herein.

15.5.1.9.10 Ground reference.

This paragraph requires that an individual power return or neutral be provided by the aircraft as a separate reference for the primary and auxiliary 115/200V AC interfaces.

15.5.1.9.11 Power application.

This paragraph clarifies that the 115/200V AC power interfaces can be activated, to MIL-STD-1760 stores, without significant safety degradation. This paragraph, when used in combination with MIL-STD-1760C Paragraph 5.1.8.8, establishes a top level allocation between safety and non-safety critical functions for the different AC and DC ASI power outputs. (See 10.5 of this Handbook.)

15.5.1.10 Aircraft 270V DC power interface.

This requirement identifies top level electrical characteristics for a 270V DC power interface. The characteristics are defined only in sufficient detail to allow selection of appropriate ASI connector hardware. The relevant revision of MIL-STD-704 defines 270V DC electrical characteristics as it is used on aircraft such as the F-22 and AH-66. However, since current aircraft do not provide 270V DC power to stores stations, stores are not permitted, by MIL-STD-1760C, to require a 270V DC power input. Likewise, to avoid potential compatibility problems, or fault modes, the aircraft is prohibited from applying 270V DC to the ASI. (See section 11 of this Handbook.)

15.5.1.11 Aircraft fiber optic interface.

This paragraph, along with 5.2.11 and 4.3.9 reserve space in the interface for fiber optics lines, and in the future should define the fiber optic terminals and cable to be used. This would allow a standard fiber optic network to be installed in new or modified aircraft before the actual use of the fiber optic interface is defined. (See section 12 of this Handbook.)

Similar to the 270V DC case, aircraft with Class I ASIs are required to install ASI connectors which include contact provisions for two 16 gauge fiber optic termini. The aircraft is not required to include fiber optic cables as part of the AEIS wiring.

15.5.1.12 Initialization.

15.5.1.12.1 Pre-initialization conditions.

These two paragraphs define the requirements on the aircraft prior to initialization.

15.5.1.12.2 Power application.

This paragraph requires the aircraft to provide the store with both 28V DC and 115V AC power so that the aircraft can ascertain which type of store is being carried. This is necessary because the standard provides for the present store-aboard inventory mechanisms to be eliminated when the aircraft is only required to carry MIL-STD-1760 compliant stores. After store identification has been made, the aircraft will probably deactivate the interface and at the next power up only apply the required power.

15.5.1.12.3 First communication.

This paragraph requires the aircraft to ask the store for its store ID message and wait up to 150 milliseconds after power application for a store response indicating that the store RT is capable of communication. It does not require the store to be capable of responding with a valid store description if it is not ready.

This paragraph also mandates that the aircraft wait up to 500 milliseconds from power application for the store to respond to an aircraft request with a valid Store Description message. Action taken by the aircraft in the event that this does not occur is not controlled by MIL-STD-1760C.

15.5.2 Mission store requirements (measured at the MSI).

This introduction emphasizes, in the title, that the requirements apply to the MSI and are measurable at the MSI. Within this constraint, the internal store subsystems can be designed using a multitude of technologies and internal subsystem architectures. MIL-STD-1760 only requires standard characteristics to be supplied at the mission store interface.

15.5.2.1 Mission store HB interfaces.

This paragraph provides introductory points on the High Bandwidth (HB) interface in the MSI, in addition to the general requirements in section 4.3.1 and the aircraft requirements in section 5.1.1.

It clarifies that the mission store is not required to actually use any of the HB ports in the interface, but if any port is used, then the requirements of the sub-paragraphs apply. The only HB electrical requirement imposed on stores which do not use one or more of the HB ports is a simple impedance requirement. All unused ports must provide a signal-to-signal return impedance of at least 45 ohms (HB1 and HB2) and 68 ohms (HB3 and HB4). An open circuit meets this requirement. The unused ports do not, therefore, need to be physically terminated into any load. In fact, the connector paragraph of the standard states that the connector cavities of unused signals may be plugged, i.e. insertion of a contact into the cavity is not required. (See section 8 of this Handbook.)

15.5.2.1.1 Electrical characteristics (Type A).

15.5.2.1.1.1 Return loss.

15.5.2.1.1.2 Dynamic range.

15.5.2.1.2 Electrical characteristics (Type B).

15.5.2.1.3 Ground reference.

This paragraph establishes the HB signal grounding approach visible at the MSI. This scheme requires a store which is receiving a type A signal to isolate it from ground, while MIL-STD-1760B required the store to ground the signal return for both Type A and Type B signals, regardless of whether receiving or sending a signal.

Note that, for Type B signals, both the source and load ends of the path have grounded returns. (See section 8.3.6 of this Handbook.)

15.5.2.2 Mission store data bus interface.

This paragraph establishes the top level requirements for a MIL-STD-1553 remote terminal interface in the store.

15.5.2.2.1 Functional characteristics.

This paragraph defines top level functional characteristics which apply if the store uses the data interface. It is expected that nearly all MIL-STD-1760 stores will use this data interface. A dual standby redundant MIL-STD-1553 compliant remote terminal is required in the store. This terminal is required to respond to commands addressed to it under the rules of MIL-STD-1553. The store is required to use as its terminal address, the address decoded by the address discretes defined in paragraph 5.2.6 of the standard. This allows assignment of the store address at the time of operation on a given aircraft station. This permits optimum flexibility in allowing different bus architectures in the aircraft. The issue of whether the store responds, within the restrictions of MIL-STD-1553, to broadcasted, i.e. Address = 31, messages is controlled by section B.1.5.11 of the standard.

15.5.2.2.2 Electrical characteristics.

This paragraph emphasizes that the characteristics addressed apply, i.e. are measured, at the MSI. This contrasts with MIL-STD-1553 which defines characteristics at the input to the remote terminal hardware. The main difference between MIL-STD-1553 and MIL-STD-1760 is that MIL-STD-1760 addresses characteristics which would be seen at the end of a piece of MIL-STD-1553 cable connected to a MIL-STD-1553 remote terminal. This length of cable, between the MSI and the actual remote terminal transceiver buried within the mission store, changes some characteristics as defined by MIL-STD-1553. It is highly desirable to allow use of existing remote terminal hardware in the store. Without clarifying the effects of the cable on these characteristics, some stores would be forced into using special remote terminals simply to meet RT requirements at the MSI.

The second point is to define the polarity of the data interface connections, data high referenced to data low. This avoids reverse polarity connections between the aircraft and the store. This polarity definition, in combination with Note 2 of Table III in the standard, avoids this connection problem.

15.5.2.2.2.1 Output characteristics.

Two main points are made in this paragraph. MIL-STD-1553 defines two types of remote terminals based on the method of coupling the terminal's stub to the main bus. These two methods are direct coupled and transformer coupled. This paragraph requires the store to contain a transformer coupled style remote terminal. Transformer coupled stubs are selected because the stub length from the bus coupler in the aircraft to the remote terminal in the store is nearly always too long to use direct coupled stubs.

This paragraph also imposes a requirement on the mission store data interface over what is required by MIL-STD-1553. MIL-STD-1553 requires the terminal output voltage of transformer coupled remote terminals to be in the range of 18 to 27 volts p-p, line-to-line when connected to a 70 ohm ± 2 percent load. In contrast, MIL-STD-1760 requires the store to output at the MSI a line-to-line voltage of 20 to 27 volts p-p into the same test load. This higher minimum output voltage is required for two reasons. Firstly, the possible load impedance seen by the store at the MSI can be lower than the 70 ohm test load referenced in MIL-STD-1553. Increasing the minimum output voltage raises the design margin. Secondly, a higher minimum voltage is defined because:-

The losses in the AEIS bus network of some aircraft are expected to be higher than losses for typical MIL-STD-1553 avionic applications.

The electromagnetic noise environment at the aircraft/store interface areas is also expected to be higher than typical noise levels.

Raising the minimum voltage is seen as necessary to maintain reasonable signal-to-noise ratios. (See section 6 of this Handbook.)

15.5.2.2.2.2 Input characteristics.

This paragraph requires the store to accept MIL-STD-1553 compliant input signals when applied at the MSI. As with the output characteristics, the input parameters of transformer coupled stubs are designated for the MSI. In addition, this requirement expands on the remote terminal input impedance requirement of MIL-STD-1553. The paragraph clarifies that the MIL-STD-1553 requirement still applies at the input to the remote terminal contained in the store. However, due to the effects of the cable connected between the MSI and remote terminal, measurements at the MSI will indicate a lower, below 1000 ohms, impedance even though a MIL-STD-1553 compliant terminal is installed in the store. To avoid custom designed remote terminals, the MSI measured impedance is lowered to compensate for the interconnecting cable. (See 15.5.2.2.2.1 of this Handbook.)

15.5.2.2.2.3 Shield grounding.

This paragraph addresses an interface detail implied, but not specifically required, by MIL-STD-1553. Mission stores are required to connect the data shield to the store structure ground at some point on the store side of the MSI. Since the aircraft is also required to ground the data shield on the aircraft side of the ASI, a multiple point shield grounding scheme is imposed for the data interface. (See section 6 of this Handbook.)

15.5.2.3 Mission store LB interface.

This paragraph introduces the Low Bandwidth (LB) interface requirements on the mission store. Similar to the data bus interface, the LB interface contains three connections: a non-inverting connection, an inverting connection and a shield connection. Likewise, the mission store is not required to use the LB interface port but if it does use the port, the store must comply with the requirements in the associated subparagraphs. If the store does not use the LB interface, it is required to maintain at least 540 ohms between the non-inverting and inverting connections on the store side of the MSI. As with the store's HB, Mux A and Mux B interfaces, an open circuit meets the intent of this unused interface "termination" impedance.

The transfer requirement paragraph that was in MIL-STD-1760B is combined with this paragraph in MIL-STD-1760C. This paragraph clarifies that the store can be a signal source or a signal load.

15.5.2.3.1 Input/output impedance.

Revision B paragraph 5.1.1.3.2.1 identified a 150 milliampere maximum current limit, which, in conjunction with the old ± 12 volt maximum signal voltage, resulted in an 80 ohms minimum impedance if maximum voltage level signals were transmitted. This no longer applies with the impedances and voltages defined in Revision C. (See section 9 of this Handbook.)

15.5.2.3.2 Ground reference.

The shield grounding method selected for the LB interface is a multiple point shield grounding scheme. The shield termination, as measured at the MSI looking into the store, is connected to mission store ground. Likewise, the LB shield is connected to aircraft ground on the aircraft side of the ASI. This grounding scheme provides optimum shielding for a balanced line twisted shielded pair signal path. As with all the other characteristics, the standard only requires that the shield "appear" to be grounded when measured at the MSI. The standard does not define the actual internal store circuitry or shield termination location and procedures. (See section 9.4 of this Handbook.)

15.5.2.4 Mission store release consent interface.

This paragraph provides a lead-in for the mission store's release consent interface. Several points are made:

A release consent interface is included in the MSI connector,

This interface contains the signal (release consent) and its return (28V DC Power 2 return),

Except for the requirement against bits D8 and D10, the store is not required to use the interface, in which case the store must provide at least 100 kilohms impedance between the signal and return lines, but if it uses the interface, the store must comply with the requirements in the associated subparagraphs. These requirements allow stores which do not use release consent to leave the connector contact assigned to release consent open circuited, or even to plug the contact cavity in the MSI connector with a sealing plug, i.e. not even install a contact.

This paragraph clarifies that, functionally, the release consent signal is an enabling or inhibiting signal used in conjunction with the MIL-STD-1553 data bus interface. The actual command to achieve a safety critical function is sent over the data bus interface. In contrast, release consent, if high, allows any interlocked MIL-STD-1553 commands to be acted on and, if low, to be ignored. The activation of release consent, i.e. transition to the enable state, must not by itself result in any safety critical action or irreversible action. It is expected that an aircraft may grant consent and then later remove consent. Therefore, the store must be able to return to the inhibited state with release consent removal, provided that some irreversible command was not sent to the store while the enable condition existed.

The caution note is included to alert the store designer that release consent is not a general purpose discrete but an aircraft safety interlock signal. This signal may be applied early in a flight timeline or late in the timeline depending on specific aircraft safety criteria. The only requirement expected of the aircraft is that consent will at least be granted shortly before the aircraft issues an interlocked command. The specific commands that are interlocked with release consent, including D8 and/or D10, must be identified in the store design documentation or ICD. (See see section 7.1 of this Handbook.)

15.5.2.4.1 Voltage level.

The voltage levels are defined for both release consent signal states, i.e. enable and inhibit states. With one exception, the enable signal is basically voltage levels which can be expected from a MIL-STD-704 compliant power source. The minimum steady state voltage seen at the ASI, for a valid enable signal, is 15V DC. The inhibit signal is basically the lack of an enable signal, but is defined as a 1.50V DC maximum steady state voltage between the release consent connection and the 28V DC Power 2 return connection at the MSI. While it has been suggested, see 5.1.4.2 of this Handbook, that the aircraft should tie the release consent line to Power 2 return during the inhibit state, some aircraft may simply provide an open circuit to achieve the inhibit state. In extremely high electromagnetic environments, the resulting noise induced voltage may be above the 1.50V level if the line is not tied to ground in the inhibit state.

The store is required to set its detection threshold(s) for the enable/inhibit states at a voltage level(s) such that an enable state will be assured if the applied voltage is 15 volts or greater and an inhibit state will be assured if the applied voltage is less than 1.5V DC.

Revision B had a requirement limiting voltage spikes for durations up to 50 microseconds, as defined in MIL-E-6051. These transients are not specifically discussed in Revision C. (See section 7.1 of this Handbook.)

15.5.2.4.2 Current level.

The current level imposed by the store's load must be constrained within the limits of 5 milliamperes to 100 milliamperes based on applied steady state enable voltages, 15V DC to 31.5V DC. This requires that the effective steady-state impedance applied by the store at the MSI must range between 315 and 3000 ohms. This current range was selected to allow the aircraft to use electromechanical relays for the release consent switching function. If the relay contact switching exceeds 100 milliamperes, then contact arcing may damage the low current switching capability of the relay. This 100 milliampere level is sometimes referred to as the "intermediate current" rating of a relay. The 5 milliampere lower level was set to ensure sufficient current flow to operate with partially contaminated contacts. The lower current level also reduces the minimum power dissipation a missile release consent monitor circuit must provide. (See section 7.1 of this Handbook.)

15.5.2.4.3 Stabilization time.

This stabilization time covers state transition duration due to filtering, contact bounce and other factors. The mission store circuitry needs to be capable of operating with the linear region of its release consent monitor circuit for the stabilization time duration.

The 6 milliseconds listed is twice as long as the aircraft's 3 millisecond stabilization requirement. This additional delay or instability is to allow for potential insertion of a carriage store between the aircraft and the mission store. (See section 7.1 of this Handbook.)

15.5.2.4.4 Enable lead time.

15.5.2.4.5 Inhibit lead time.

These two paragraphs establish limits on the response time of the store's enable/inhibit circuit. A limit is defined in order for the aircraft to know how early, in advance of transmitting a critical command, release consent must be placed in the enable, or inhibit, state for the critical command to be accepted, or rejected. The response time does not, however, imply that critical commands must be carried out by the store within the 10 millisecond limit.

The response time specified allows use of:

a. Electromechanical devices in the store,

b. Filtered inputs,

c. Signal sampling,

d. Other techniques in the store's release consent circuit.

15.5.2.4.6 Ground reference.

This paragraph clarifies that the 28 V DC 2 return line is the reference for measuring the above stated voltages.

15.5.2.5 Mission store interlock interface.

The introductory paragraph to the interlock interface requirements has one significant difference from the introduction to other mission store interface lines. The other lines are identified with an option for the mission store to use, or not use, the signal. The interlock interface does not provide the store with this option. If a store requires any MIL-STD-1760 interface, i.e. if the store contains an MSI, then the store must include the interlock interface in the implemented MSI. If both primary and auxiliary MSIs are required by the store, then two sets of interlock interfaces are required, one set for each MSI connector.

The interlock interface consists of an interlock connection and an interlock return connection. The mission store is required to provide continuity between these two connections and must meet the defined electrical requirements. Normally, the mission store will contain a wire link behind the MSI connector to provide this continuity.

This paragraph defines the effective impedance that the store must provide through the interlock link. The effective impedance must be supplied with the listed excitation voltage and current ranges and at frequencies up to 4 KHz. The impedance value defined essentially prohibits the insertion of any component in the continuity loop between interlock and interlock return. Furthermore, the electrical isolation requirement and the fact that the store can not be assured that the aircraft is even applying an excitation signal, precludes the store using this interface for any internal store function. For example, the store must not monitor the interlock interface to determine whether it is connected to an aircraft. The store can achieve this "aircraft mated" monitor function by using the address discretes. (See section 7.2.3 of this Handbook.)

15.5.2.6 Mission store address interface.

These introductory paragraphs to the address interface include the following parts:

a. The address discretes are to be used primarily for assigning the store its remote terminal address,

b. The address interface can also be used to determine the mated status of the mission store's connection with either an aircraft or a carriage store,

c. The address interface contains seven specific connections,

d. Stores which use the data bus interface in the MSI must also use the address interface.

As with other interfaces, if the store uses the address interface then it must comply with the requirements in the associated subparagraphs.

15.5.2.6.1 Address assignment.

The rules for assigning addresses with the five address bit lines are defined here by establishing the binary weight for each line. In addition, the store is required to check the parity connection for proper parity and accept the address only if the parity check passes. This parity check operation may be conducted with dedicated circuitry or can be determined by using address decode circuitry in some of the available MIL-STD-1553 protocol chip sets. Some chip sets load the remote terminal address through a software interface between the chip set and a host processor. For these systems, a separate address read circuit is required in the store. However, even if the store's remote terminal hardware contains a discrete address decode capability, the noise environment, required address signal characteristics and detection thresholds must be considered prior to directly connecting these on-chip decoding circuits to the external world address discretes. (See section 7.3 of this Handbook.)

15.5.2.6.2 Address signal.

The electrical characteristics are divided into excitation signal limits, required detection thresholds and a response time requirement.

The characteristics of store sourced excitation signals are defined to encompass a range of potential circuit designs. This range runs from "logic level" signals through higher level MIL-STD-704 28V DC derived excitation. The mission store, however, is required to clamp the maximum open circuit excitation voltage to 31.5V DC. For example, the store can use 28V DC Power 1 input (MIL-STD-704) to source the address excitation signal. However, since MIL-STD-704 allows this input voltage to rise to 50 volts during power system transients, the store must clamp this voltage to 31.5V to meet the maximum voltage requirement.

The store is required to meet the rise and fall times on the excitation signals to minimize the power dissipation in any potential aircraft circuitry used to establish the address states. This power dissipation can be high when the aircraft's circuitry is transitioned through an active region of a device such as a transistor in a line driver. This rise/fall time limit is of particular importance if the store is periodically pulsing the address interface to sample the address and thereby minimizing store circuitry power dissipation. For example, continuously exciting all address lines at the maximum allowed power requires the store to source over 16 watts out to the address interface.

The closed circuit, or Logic 0, current levels sourced by the store are constrained to the same 5 to 100 milliampere range used for other interface discretes. Since the store circuitry determines the excitation voltage, the short circuit (Logic 0) current can be controlled through pull-up resistors in the store or by other means. The store must also be capable of sourcing enough power to properly operate the address detection circuitry even under conditions of erroneous addresses. For example, address zero with a failed parity would be an invalid address but the store's circuitry must be capable of determining that the address is invalid. Therefore, the store must be capable of sourcing Logic 0 currents into all six address lines.

15.5.2.6.3 Logic threshold.

Subparagraph a. specifies the Logic 1 state by a maximum current flow between each address line and the address return. Since the store circuitry's open circuit voltage and pull-up resistance value is known by the store designer, this maximum "leakage" current can be converted into an address line Logic 1 voltage. Setting the Logic 1 detection threshold below this voltage assures detection of a valid Logic 1 state.

The Logic 0 voltage is directly specified and determines the maximum voltage value for the threshold of a Logic 0 state.

As an example, a store which uses an address monitor circuit with a 5 volt open circuit voltage and a 500 ohm pull-up resistor expects to see a Logic 1 voltage of 4.85 volts or greater and a Logic 0 voltage of 1.50 volts or less. Therefore, the Logic 1 threshold of the circuit is set below 4.85 volts and above the Logic 0 threshold, assuming a detector with hysteresis. Likewise, the Logic 0 threshold is set above 1.5 volts and below the Logic 1 threshold.

15.5.2.6.4 Response characteristics.

The response time is specified to require the store to wait 10 milliseconds after application of the excitation signal to allow the aircraft circuitry and interconnecting cabling to stabilize. This is particularly important if the aircraft contains filters on the address lines at the ASI or in some other aircraft equipment. For cases where the aircraft simply provides jumpers at the ASI for coding the address, signal filtering by the aircraft is not expected. In general, however, the store designer does not know if an aircraft, on which his store is to be installed, uses jumper wires or some other design for address assignment.

15.5.2.7 Mission store structure ground.

The structure ground connection in both primary and auxiliary connectors is included to provide a higher level of assurance that the store structure is electrically connected to the aircraft structure. The connection is provided for shock hazard protection of personnel, e.g. during electrical faults, and to reduce low frequency noise voltages between the aircraft and store structures. Other electrical paths may also exist between the store and aircraft structure, e.g. umbilical cable shield or store mechanical attachment points, but these paths cannot be assumed to always be present, particularly during ground or lab testing.

Revision B required bonding of this wire to ground by reference to MIL-B-5087, which has since been canceled. No justification for the specific bonding resistance called out in MIL-B-5087 was found, so the requirement was changed to state the intent, i.e., ability to carry maximum fault current and therefore trip the circuit protection to take the system to a safe state.

The intent of the last sentence is to highlight that power and signal circuits through the AEIS must not rely on the structure ground line for proper operation. Each power or signal line must have a return which is exclusive of structure ground. Due to grounding approaches used in the aircraft and store, it is highly probable that some power or signal current will flow through the structure ground connections. That is of course acceptable

15.5.2.8 Mission store 28V DC power interface.

This paragraph and subparagraphs, along with paragraph 5.2.9 and subparagraphs, place limitations on the electrical power used by the store while it is connected to the aircraft in order to ensure that all stores are compatible with the available power.

The 28 V DC power interface consists of 28V DC Power 1 and Power 2 in the primary MSI and auxiliary 28V DC power in the auxiliary MSI. Each of the three power sources require a dedicated return. As typical with other interfaces for the mission store, the paragraph clarifies that the mission store is not required to use any of these power interfaces, but if used, the store must comply with the associated subparagraphs. Stores which do not use any 28V DC power interface must maintain at least 100 kilohms, e.g. an open circuit, between the power line and its associated return.

It is highly recommended that mission stores be designed to:

a. minimize the power required from the aircraft,

b. use 115V AC for the principal power source and 28V DC #1 and 28V DC #2 for continuous low power applications or for short duration (less than 100 ms) high power applications,

c. allow aircraft to do power management (timeline control) from power-on to release and

d. use only the primary connector (Class I or II) for store power requirements. Use of only the primary connector is recommended because the auxiliary power signal set is optional and therefore will not be available at all ASIs.

Current (1999) installations of MIL-STD-1760 on aircraft have not included use of the auxiliary power signal set and connector. Several aircraft are also not able to provide the full 10 Amps of both DC and AC required, therefore store power consumption must be further limited if compatibility with these existing aircraft is required.

15.5.2.8.1 Voltage level.

This paragraph states the MSI voltages with which the store must be compatible. Given the aircraft's requirement to provide 22 V DC at the ASI (complying with MIL-STD-704E normal characteristics for steady state voltage of 22 to 29 V DC), the 20.0 V DC requirement in this paragraph allows for 2 V of drop in umbilicals and carriage stores.

The reference to normal, abnormal and transient characteristics of MIL-STD-704 covers the time domain for non-steady state voltages down to 50 microseconds. Revision B had a reference to MIL-E-6051, which covered transients shorter than 50 microseconds, but this requirement is deleted in Revision C.

15.5.2.8.2 Load current.

The maximum overcurrent and maximum load current curves of figures 17 and 18 of the standard were derived from the trip and no-trip calibration data for MIL-STD-1498 circuit protection devices, with modifications to accommodate other devices. These curves represent a locus of time-current points (such as a 23 ampere current for one second duration, or a 13 ampere current for ten seconds duration). The curves are not intended to be a continuous profile of current versus time.

Under fault free conditions, a store must limit its applied load (as measured at the MSI) such that the maximum load current locus is not exceeded. A conservative indication of this compliance would occur if the maximum true RMS of the load current profile averaged over all time intervals does not exceed the current associated with the same time intervals as defined by the maximum load current locus. Under conditions of internal store power interface faults, the store must be capable of safely withstanding (operational impairment expected) overcurrents for the duration defined by the maximum overcurrent locus.

The flat part of the maximum load current curve (durations less than one second on figure 17 and 18) was added in Revision C. Note that solid state power controllers often have a current limit characteristic in addition to a trip characteristic for short duration, high current loads. The flat part of the curves represents a situation where the power controller may either limit current (by reducing voltage) or trip to the off state.

15.5.2.8.2.1 Primary signal set.

15.5.2.8.2.2 Auxiliary power signal set.

These two paragraphs and the referenced figures 17 and 18 define limits on fault-free current that a store is permitted to draw from the aircraft. These current limits are applicable when the MSI voltage is between 20 and 29V DC.

For stores with linear loads, the 10 ampere steady state limit of figure 17 in conjunction with the 29V DC upper voltage limit requires that the store load not exceed 2.9 ohms on Power 1 and 2.9 ohms on Power 2. At 20V DC, a store with 2.9 ohm input resistance will draw less than 7 amperes, or 140 watts, from the 28V DC Power 1 or Power 2 circuits. Since the store may be supplied voltages anywhere in the 20 to 29V DC range, the linear load type store cannot fully utilize the available 10 amperes defined by the figure. Likewise, linear load type stores can only rely on approximately 20 amperes or 400 watts from the auxiliary MSI connections to the aircraft. This discussion does not apply for modern switching-mode power supplies, which are not linear loads, i.e., they typically draw more current (offer a lower input resistance) as the supply voltage decreases.

Even with these relatively small power ratings from the auxiliary 28V DC interface, only a small percentage of aircraft stations are expected to contain the auxiliary power connector. This forces the decision that stores which require relatively large amounts of power should use the 115/200V AC interface as the power source, rather than 28V DC.

The maximum load current curves of figures 17 and 18 allow the store to apply higher short term loads to the ASI than permitted by the 10 and 30 ampere continuous ratings for primary and auxiliary MSIs, respectively. These higher short term loads allow the store to draw higher currents for load in-rush, firing Electro-Explosive Devices (EEDs), driving seeker head motors, or other short power burst applications.

(See section 10 of this Handbook.)

15.5.2.8.2.3 Simultaneous load.

Mission stores which use the 28V DC interfaces in both primary and auxiliary MSIs must limit the total 28V DC power currents in these three interfaces (28V DC power 1, power 2 and auxiliary power) to the maximum load current curve of figure 18. This limit is required because aircraft do not generally generate very much DC power. It is not unusual that the total DC power available on a tactical aircraft for all systems is less than 200 amperes. Without the simultaneous power limit, the standard could significantly drive the total power conversion capacity of the carrier aircraft. (See section 10 of this Handbook.)

15.5.2.8.3 Load isolation.

This requirement is included to ensure that a store does not connect the 28V DC power inputs together inside the store in a manner that:

- Allows current into one power input to exit a second power input,
- Allows current to divide unequally between the various inputs such that overload of one of the power interfaces could occur.

Isolation between the power inputs is required because voltage differences can easily exist between 28V DC power interfaces due to:-

- Power being supplied from different generators or converters,
- differences in voltage drops in power distribution wiring and switching devices.

(See section 10 of this Handbook.)

15.5.2.8.4 Overcurrent compatibility.

The maximum overcurrent curves in figures 17 and 18 define the maximum current-time limits at which the aircraft disconnects, e.g. trips, the power source from the faulted load. The store must be capable of sinking fault currents up to these trip out levels. The fault current level is determined by the source and distribution impedance plus the actual impedance of the fault. If the fault is in the store, the fault currents will flow into the store and, by some path, back out. This paragraph requires the store to withstand these potential fault currents without becoming unsafe. The standard does not define the specific methods that a store must use to "not become unsafe". (See section 10 of this Handbook.)

15.5.2.8.5 Off-state leakage current.

An off-state leakage current compatibility requirement is imposed on the store because solid state switching devices are sometimes used in the aircraft or carriage store, for 28V DC power switching. The leakage currents listed assume a very low impedance connection between 28V DC and its associated return. As the load impedance increases, the leakage current will drop. The main point of this paragraph is that stores should not connect current sensitive devices such as EEDs directly across the 28V DC power interfaces. Additional isolation of these devices from the power input is required. For example, it is not assured that the 28V DC power inputs on all aircraft will meet the requirements for EED firing circuits.

15.5.2.8.6 Stabilization time.

This paragraph and the referenced figure 19 (see paragraph 5.4.5 of this Handbook) define the maximum time for the MSI voltage to rise, or fall, to its final value. This rise/fall time is due to circuit aspects such as power line filters in the aircraft and contact bounce of electromechanical relays. The stabilization time is twice as long as that required at the ASI due to additional delays that could be caused by a carriage store connected between the aircraft and mission store.

The store designer should also recognize that MIL-STD-704 allows voltage drop-out of up to 50 milliseconds during power transfers within the power generation, conversion and distribution systems. (See section 10 of this Handbook.)

15.5.2.8.7 Ground reference.

This paragraph re-emphasizes that power return connections are provided in the two MSI connectors for each 28V DC power line, i.e. Power 1 and Power 2 and auxiliary power. MIL-STD-1760C does not specifically require the aircraft, or the store, to connect the 28V DC returns to vehicle structure. As a result, the store is required to be compatible with aircraft which isolate the returns from structure and with aircraft which connect the returns to structure. (See section 10.7 of this Handbook.)

15.5.2.8.8 Power utilization.

This requirement on mission stores is the store side equivalent of the aircraft power application requirement in 5.1.8.8 of MIL-STD-1760C. Any safety critical store function for which the store needs additional safety interlocks, over those available through MIL-STD-1553 commands or release consent or other methods, can be powered from 28V DC Power 2 and auxiliary 28V DC. In contrast, the store can expect the aircraft to activate 28V DC Power 1 on the assumption that the store functions powered are not safety critical, or are adequately interlocked, such that store safety degradation does not result. However, even with these safety qualifications, the store must withstand without functional damage the application of any or all power interfaces at the MSI. This set of requirements is established with two concepts in mind. Firstly, 28V DC Power 1 is expected to be applied as part of store initialization, while 28V DC Power 2 and auxiliary power remain off until store identity, and possibly status, is determined. Secondly, the application of power must not directly result in the store executing any actions other than power-up. Recall that paragraph 4.3.8 of MIL-STD-1760C requires that the 28V DC power interface not be used as a discrete. As a result, the activation of any 28V DC power interface must not result in store functional damage.

15.5.2.9 Mission store 115V/200V AC power interface.

This set of paragraphs introduces the 115/200V AC power interface requirements imposed on the mission store. The introduction begins by defining the lines included in the primary and auxiliary MSI. Each MSI contains three power phases and a neutral.

The paragraph also clarifies that the mission store is not required to use any of these power interfaces, but if used the store must comply with the requirements in the associated subparagraphs. Stores that do not use specific 115V AC interfaces must maintain at least 100 kilohms, e.g. an open circuit, between the power phase connection and the neutral connection. The last sentence allows the aircraft to keep AC power off the connector whenever the connector is unmated ("deadfacing").

15.5.2.9.1 Voltage level.

This paragraph states the MSI voltages with which the store must be compatible. Given the MIL-STD-704E normal characteristics for steady state voltage of 108 to 118 V rms, the store must be compatible with 105 to 118 V rms. The requirement in this paragraph therefore allows for 3 V of drop in umbilicals and carriage stores.

The reference to normal, abnormal and transient characteristics of MIL-STD-704 covers the entire time domain for non-steady state voltages down to 50 microseconds. Revision B had a reference to MIL-E-6051, which covered transients shorter than 50 microseconds, but this requirement is deleted in Revision C. (See section 10.7 of this Handbook.)

15.5.2.9.2 Load current.

15.5.2.9.2.1 Primary signal set.

15.5.2.9.2.2 Auxiliary power signal set.

This set of paragraphs and the referenced figures 17 and 18 define limits on fault free current that a store is permitted to draw from the aircraft. These current limits are applicable with the MSI voltage between 105 and 118 volts rms.

As with the 28V DC MSI power interfaces, less current is actually available, i.e. can be relied upon, than implied by the figures. If one assumes that the store contains a linear load such that current is directly proportional to applied voltage, then the assured continuous per phase current and power available to the store is approximately 9 amperes, 900+ volt-amperes, for the primary MSI and 26 amperes, 2700+ volt-amperes, for the auxiliary. This discussion does not apply for modern switching-mode power supplies, which typically draw more current as the supply voltage decreases.

Since only a small number of aircraft stations will contain the auxiliary interface, the store designer should attempt to limit the power needs to the 2700 volt-ampere level, i.e. 900 volt-amperes per phase. Generally, this level is sufficient for most stores.

The maximum load current curves of figures 17 and 18 allow the store to apply higher short term loads to the ASI than permitted by the 10 and 30 ampere/phase continuous rating for the primary and auxiliary MSI, respectively. These higher short term loads allow supporting actuator drives, power supplies and other equipment requiring large in-rush currents or current pulses.

In order to allocate some power for operating carriage store internal loads, ten percent of the AC current that is normally available at the primary ASI is taken away from the mission store. This reduction applies only to mission stores designed for operation from carriage stores. In many cases, a mission store can be operated from a carriage store, given availability of the carriage store, but whether it will be so operated is generally not known during mission store design. As a result, the store designer should assume that his store is a candidate for carriage store operation unless good rationale exists to the contrary. As a result of this carriage store power allocation, the per phase current available at the primary MSI of a linear load type store is further reduced to 8 amperes (840 volt-amperes). (See section 10 of this Handbook.)

15.5.2.9.2.3 Simultaneous load.

Mission stores which use the 115/200V AC interfaces in both primary and auxiliary MSIs must limit the total 115V AC power currents for each of the three phases to the maximum load current curve of figure 18. Even with this limitation, over 8400 volt-amperes total AC power is available to the mission store, again assuming linear loads. If the mission store is expected to be carried on a carriage store and uses the auxiliary interface, an unlikely combination, the total AC power available at the MSI is reduced to 8100+ volt-amperes for the linear loads. (See section 10 of this Handbook.)

15.5.2.9.3 Load isolation.

As with the commentary on 5.2.8.3 above, busing together the primary and auxiliary AC power interfaces is not permitted, because the two power sources may be electrically isolated and un-synchronized. The store may either divide its loads among the two AC power sources available at the aircraft side of the MSI, or switch the loads between the two sources. (See section 10 of this Handbook.)

15.5.2.9.4 Overcurrent compatibility.

The maximum overcurrent curves in figures 17 and 18 define the maximum current-time limits at which the aircraft will disconnect, e.g. trip, the power source from the faulted load. This paragraph requires the store to withstand these potential fault currents without becoming unsafe. The method(s) that the store uses to remain safe during these faults is not specified by the standard. (See 10.7 and 10.10 of this Handbook.)

15.5.2.9.5 Off-state leakage current.

These off-state leakage current compatibility requirements are imposed on the store to allow use of solid state switching devices in the aircraft, or carriage store. The 2 and 5 milliampere leakage currents listed assume a very low connected impedance between the power phase and the neutral. As the connected load impedance increases the leakage current will drop.

15.5.2.9.6 Stabilization time.

This paragraph and the referenced figure 19, defines the maximum time for the MSI voltage to rise, or fall, to its final value. The rise/fall time is due to aircraft components such as power line filters and contact bounce of electromechanical relays. The 6 millisecond stabilization time is twice as long as the stabilization time required at the ASI. This doubling is due to additional delays that can be introduced if a carriage store is inserted between the mission store and aircraft.

In addition to this turn-on delay, the store designer is reminded that MIL-STD-704 allows total loss of voltage for up to 50 milliseconds during power transfers within the power generation, conversion and distribution systems.

15.5.2.9.7 Load power factor.

This requirement is included in the standard because control of load power factor is necessary to minimize disturbances to generators and conversion equipment. This requirement, figure 20, is extracted from earlier revisions of MIL-STD-704. The current release of MIL-STD-704 no longer includes power factor limits. (See 10.7.6 of this Handbook.)

15.5.2.9.8 Phase unbalance.

Similar to load power factor, excessive phase unbalance causes power generator or invertor operational problems. As a result, MIL-STD-704 includes limits on the amount of current imbalance permitted between the power phases. These unbalance limits are imposed on the mission store. (See 10.7.6 of this Handbook.)

15.5.2.9.9 Ground reference.

The store is required to provide a separate neutral connection at the MSIs for the primary and for the auxiliary 115/200V AC power interfaces. This separate neutral provides different current return paths so that the aircraft and store can use grounding and current return techniques that minimize EMI.

In addition, the standard does not specifically require the aircraft or the store to connect the 115/200V AC neutrals to vehicle structure. As a result, this paragraph requires that the store be compatible with aircraft that isolate the neutrals from structure and with aircraft which connect neutrals to structure. (See 10.8 of this Handbook.)

15.5.2.9.10 Power utilization.

This requirement on mission stores is the store side equivalent of the aircraft power application requirement in 5.1.9.11 of the standard. The store can expect the aircraft to activate the 115/200V AC power interfaces on the assumption that the store functions powered are not safety critical or are adequately interlocked such that store safety degradation does not result. This requirement is included to set power use ground rules for the interface initialization process with which all future AEIS stores must be compatible.

This initialization process begins with the application of 115/200V AC power along with 28V DC Power 1. As a result, the aircraft crew needs some assurance that 115/200V AC power and 28V DC Power 1 can be applied without any undesirable effects.

The last sentence of 5.2.9.10 is directed at stores which use multiple power phases for energizing specific equipment within the store, e.g. three phase power converters, two or three-phase actuators or heaters etc. Since the aircraft provides three power phases through three sets of wiring, connector contacts, relay contacts, circuit breakers etc., the loss of one, or more, power phase(s) at the MSI while the other(s) is still energized is not an unusual occurrence. This partial power "loss" can occur after the store has been powered for some time. This partial power "loss" can also occur during the initial activation of three-phase power such that only one or two phases is ever powered.

The store designer should not assume that the aircraft SMS contains sufficient monitor circuits to detect this power loss. It follows then, that partial phase power can remain at the MSI for an indefinite time. From a safety perspective, this partial power loss must not result in damage to the store, including the store transitioning into an unsafe condition. In addition, this "withstand without damage" requirement is desirable from a logistics viewpoint to avoid "wasting" a store due to a somewhat common aircraft failure.

The store designer should particularly consider the effects of partial phase loss on three phase power converters and electromechanical actuators. If one phase is lost, the power converter, depending on the design, might produce:

a. No output (safe),

b. Out of tolerance voltage magnitude, or

c. Out of tolerance ripple.

Items b. and c. can be devastating to processor or other digital logic operation. The primary problem with the actuators is overheating due to long duration of applied stall or near-stall currents. (See 10.7 of this Handbook.)

15.5.2.10 Mission store 270V DC power interface.

Top level requirements are identified for the store to include growth provisions for 270V DC power. These provisions are included in the form of contact cavities in the Class I MSI primary interface and Class IA MSI auxiliary interface for a 270V DC power contact and a 270V DC power return contact. These contacts and the connector must be compatible with carrying MIL-STD-704 270V DC power voltages at continuous current ratings of 10 and 30 amperes for the primary and auxiliary MSIs, respectively. In reality the Class II interface defined for stores also contain this contact cavity provision, except that the store is only required to be intermateable with the designated connectors and could conceivably use a special insert which did not include the 270V DC cavities.

Although 270V DC is defined in MIL-STD-704 as a "legal" power voltage standard, mission stores are required by the standard to not utilize this power interface. The intent of this requirement is that the mission store must not require the aircraft to furnish 270V DC in order for the store to operate. It was not intended to strictly forbid a store from including an internal power conversion capability by which the store could be powered from either 270V DC or one of the other power interfaces. (See section 11 of this Handbook.)

15.5.2.11 Mission store fiber optic interface.

This paragraph is a fiber optic equivalent of the 270V DC provisions defined in the commentary on 5.2.10. The same comments apply on the Class I and Class II MSI interfaces and on the intent that the store not require the aircraft to send data over the fiber optic channels in order for the store to operate. Since a fiber optic multiplex standard is not yet identified in MIL-STD-1760, a store designer who includes a fiber optic multiplex terminal in his store must accept the risk that his fiber optic terminal may be incompatible with any future fiber optic system included in this standard.

15.5.2.12 Store initialization.

15.5.2.12.1 Pre-initialization conditions.

These two paragraphs provide an assurance to the store, that prior to the activation of the power interfaces, at the MSI, all the other interfaces that should be deactivated will actually be in that state.

15.5.2.12.2 Power application.

This paragraph indicates to the store that both 28V DC and 115/200V AC power interfaces will be activated so that the aircraft, or carriage store, can ascertain which type of store is being carried. This is necessary because the standard provides for the present “store-aboard” inventory mechanisms to be eliminated when the aircraft is only required to carry MIL-STD-1760 compliant stores. The last sentence prohibits any "store unique" power requirements from effecting initialization and identification.

15.5.2.12.3 Address determination.

This paragraph requires the store to be ready to receive valid commands as required by the succeeding paragraphs.

15.5.2.12.4 First response.

This paragraph requires the store to provide the aircraft with data, within 150 milliseconds of power application, indicating that the store RT is capable of communication. It does not require the store to be capable of responding with a valid store description if it is not ready.

15.5.2.12.5 First required non-busy response.

This paragraph mandates that the store be capable, within 500 milliseconds of power application, of sending to the aircraft a valid Store Description message. Action taken by the aircraft in the event that this does not occur is not controlled by the standard.

This time restriction is to ensure that an aircraft carrying a large number of stores can do an electronic inventory of stores aboard in a short enough time that it will not impact store loading and checkout time in a wartime fast-turnaround situation.

Note that in the event that the first response in 5.2.12.4 indicated a store busy state, then the aircraft can continually poll the store, up to the 500 millisecond limit, in order to obtain the required data as quickly as practical.

15.5.3 Carriage store requirements.

This new section on CS was added in Revision C to standardize the way a carriage store behaves when connected between the aircraft and the mission store(s).

Detail interface requirements for carriage store interfaces (CSI and CSSI) are included in MIL-STD-1760C and are compatible with the detail ASI and MSI requirements in the standard, which include signal loss allocations for the carriage store (and any associated umbilical cables).

A “standard” carriage store should comply with MIL-STD-1760 so it can carry MIL-STD-1760 mission stores. If it is more unique, like a launcher to carry non-1760 rockets or small bombs, then it would have the standard CSI interface on the airplane side and the unique small store interface on the other side.

15.5.3.1 Carriage store HB interfaces.

This paragraph establishes the requirements on the HB network and signals.

The carriage store is to provide a high frequency signal distribution network with access ports at each CSI and CSSI. The distribution network must support signal transfer through the carriage store in either direction but in a simplex mode. Bi-directional duplex operation is not required by the standard. Each HB interface is specified as a coaxial, or two connection, interface consisting of a signal connection and signal return connection. If a coaxial cable is used, then the signal return is the coaxial shield. However, the interface specification also allows a triaxial, or three connection, interface consisting of a signal connection, a signal return connection and a grounded shield. This grounded shield, however, is not "visible" at the CSI or CSSI. (See section 8.0 of this Handbook.)

Note that HB signals are allowed to be bi-directional, i.e., can come from a source in the aircraft or a source in the store. They are also “simplex”, meaning the signal only travels in one direction at a time, as opposed to a duplex system like a telephone line where signals travel both directions at the same time.

15.5.3.1.1 Minimum transfer capacity.

The transmission quality of each carriage store Type A signal path has been standardized to promote interoperability between the AEIS and present and future mission stores. The following requirements apply to all Type A signal paths implemented between the CSI and CSSI(s). Note that additional signal path electrical characteristics are covered in the general requirements in 4.3.1.

15.5.3.1.1.1 Return loss.

Return loss is an alternative to Voltage Standing Wave Ratio (VSWR) as a way to express the limitation on reflections on a signal transmission line. A return loss of 20dB corresponds with a VSWR of 1.22. The requirement does not include a test cable or either of the umbilicals but does include the mating contact pair. The mating contact pair should not therefore be calibrated out.

15.5.3.1.1.2 Transient response.

The transient response requirements control both linear distortion and some forms of non-linear distortion. If the network response falls within the limits shown in the series of figures, one can be confident that the network will transmit video and other HB signals with acceptably low distortion. (See section 8 of this Handbook.)

15.5.3.1.1.3 Insertion gain.

Insertion gain limits control the change in signal amplitude between the input and output.

15.5.3.1.1.4 Representative pulse delay.

When time correlation signals are passed through the network, the delay will contribute to latency and latency error at the sink equipment. This requirement limits both the total delay and the variation in that delay.

The nominal delay can be accounted for by passing information about the delay to the sink (via the MIL-STD-1553 data bus), leaving only the delay variation as an error.

15.5.3.1.1.5 Equalization.

The equalization requirements are to ensure that the signal path is capable of transmitting all signal frequency components between 20 Hz and 20 MHz and to control the amplitude of transient response artifacts (e.g., ghosts) outside the nominal passband.

This equalization requirement controls essentially the same thing as the transient response requirement, such that it may not be necessary to apply and test for both requirements. The transient response requirements, however, give direct indication of the waveform distortion introduced by the signal path that is not easily deduced from the equalization requirements. The two sets of requirements are therefore useful.

15.5.3.1.1.6 Dynamic range.

This dynamic range requirement is to ensure that the network can accommodate the voltage excursions of the signal, including excursions that occur under transient conditions. For example, a 1 Vpp signal that is AC-coupled may bounce up to +1.35 V or down to -1.35V if there is a 1V shift in its useful DC component and there is an AC-coupling circuit with a large number of poles. In addition, the carriage store may introduce a DC error after AC-coupling.

15.5.3.1.1.7 Signal path DC offset.

Maximum DC offset is specified to limit the range of common mode voltages the receiving circuitry must deal with.

15.5.3.1.1.8 Noise.

These requirements are to ensure that signals are not excessively corrupted by noise inserted by the HB network.

In the rationale and guidance to the specific noise paragraphs, the signal-to-noise ratios indicated are based on a nominal signal path gain of 0 dB. The actual signal to noise ratios may therefore be degraded by a further 5 dB for an aircraft and carriage store if the insertion gain is the lowest permitted.

15.5.3.1.1.8.1 Random noise.

This requirement limits random noise (“white” noise, which would be called “hiss” in an audio system) to a level that should not be visible in video.

15.5.3.1.1.8.2 Periodic noise.

This requirement limits periodic noise (would be called “hum” in an audio system). It treats crosstalk from other HB and LB signal sources as a form of periodic noise.

The weighted periodic noise requirement corresponds with a peak white to peak-to-peak noise voltage ratio of 50 dB for 1 Vpp STANAG 3350 video.

15.5.3.1.1.8.3 Impulse noise.

This requirement limits impulse noise (would be called “pop” in an audio system).

15.5.3.1.1.8.4 Stimulated noise.

Stimulated noise occurs as a result of harmonic distortion, intermodulation distortion, quantization noise and aliasing. The stimulated noise requirements correspond with a second harmonic distortion of 2.5% for both the 50 ohm and 75 ohm interfaces for a full amplitude sinusoidal input signal (assuming only second harmonic distortion is present). For video signals this equates to a differential gain distortion of 10%, which follows CCIR Recommendation 567-2. Differential phase distortion is also important and this is controlled by the incidental phase modulation requirement.

15.5.3.1.1.8.5 Common mode noise.

This requirement limits common mode noise, which is AC or DC voltage that occurs simultaneously on both lines of a differential signal and can therefore be canceled out by a differential receiver.

15.5.3.1.2 Signal path electrical characteristics (Type B). (none specified).

Type B signals include RF signals, such as the GPS signal received by an antenna on top of the airplane being sent to a store which is in a weapon bay or under a wing. Only the overall signal passband and peak envelope power are specified (in para. 4.3.1 and 4.3.1.2) at this time.

Presently, no performance requirements are provided by MIL-STD-1760C for HB Type B signal paths, however it is expected that detailed Type B requirements will emerge in a later revision or notice of the standard.

15.5.3.1.3 Ground reference (Type A).

The only need to ground the HB signal return path in a carriage store is if the signal is amplified or used. If the signal is just routed through the carriage store, the ground reference should be carried through the same as the signal.

This paragraph requires a differential, unbalanced transmission scheme for the Type A interfaces, which provides improved immunity to magnetic field interference. Revision B called for HB 1 and 2 to have grounded returns and HB3 and 4 to have isolated returns.

The HB1 signal path is required to be compatible with both Type A and Type B signals, but they have conflicting grounding schemes. Therefore, a system that switches ground schemes will be needed.

15.5.3.1.4 Ground reference (type B).

The only need to ground the HB signal return path in a carriage store is if the signal is amplified or used. If the signal is just routed through the carriage store, the ground reference should be carried through the same as the signal.

15.5.3.2 Carriage store data bus interface.

MIL-STD-1760 requires that the data bus network provide a medium for connecting the SMS to stores. Communication between the SMS and stores mated at the ASI, including carriage stores, is required. In addition, communication between the SMS and mission stores connected at a CSSI is also required. The communication level from the SMS through the ASI interface points on the aircraft can be defined as Level 1.

A second level can also be defined to cover carriage stores. This level fans out the digital information received at the CSI, through the CSSI interface points down to mission store remote terminals. Also, if a hierarchical, or second tier, data bus is installed in the carriage store, the carriage store must terminate the data links (stubs) of Level 1, control traffic on the data link of the secondary level (Level 2) and retransmit, reformat as necessary, all traffic between levels. Since MIL-STD-1760 requires electrical characteristics for the ASI and MSI to be consistent with MIL-STD-1553 transformer coupled stubs, with the additional requirements of MIL-STD-1760, certain data bus interface requirements are required for the carriage store. When a carriage store is installed between the aircraft (ASI) and mission store (MSI), the MIL-STD-1553 stub must be functionally extended from the ASI to one or more CSSIs. In order to achieve interoperability, the carriage store must contain electronics to interconnect CSI stubs with CSSI stubs while maintaining MIL-STD-1553 characteristics. Electrically, this requires terminating the stub segment crossing the ASI and CSI interfaces and providing isolated data path(s) to remote terminals below the CSSI interface(s). The bridging electronics within the carriage store could include bus controller and remote terminal hardware or could include special electronic repeater circuits.

15.5.3.2.1 CSI.

The electrical requirements required for the carriage store at the CSI are identical to the requirements imposed on the mission store at the MSI. Thus, electrically the carriage store electronics as seen from the CSI is equivalent to an MSI, i.e. a MIL-STD-1553 remote terminal. If a repeater is used, the CSI side of this repeater would have remote terminal electrical characteristics

15.5.3.2.2 CSSI.

The electrical requirements required for the carriage store at the CSSI are identical to the requirements imposed on the aircraft at the ASI. Thus, electrically the carriage store electronics as seen from the CSSI is equivalent to an ASI, i.e. a MIL-STD-1553 bus controller coupled to a stub. If a repeater is used, the CSSI side of the repeater would have data bus stub, or bus controller, characteristics.

15.5.3.3 Carriage store LB interface.

This paragraph establishes the requirements for the LB network and signals.

The carriage store is to provide a low frequency signal distribution network with access ports at each CSI and CSSI. The distribution network must support signal transfer through the carriage store in either direction but in a simplex mode. Bi-directional duplex operation is not required by the standard.

If the carriage store uses or conditions the LB signal, the requirements for the ASI are to be used for the CSSI and the requirements for the MSI are to be used for the CSI; otherwise the LB signal is routed through without effecting the electrical characteristics.

15.5.3.3.1 Minimum transfer capacity.

The carriage store is required to install a distribution network for bi-directional LB signals. The network must be capable of routing these LB signals between the CSI and the CSSI(s). The specific equipment that is "applicable" is determined by each Carriage store.

15.5.3.3.2 Input/output impedance.

If the carriage store sinks or sources the LB signal, the MSI requirements are to be used for the CSI and the ASI requirements are to be used for the CSSI.

15.5.3.3.3 Insertion gain.

If the carriage store sinks or sources the LB signal, the MSI requirements are to be used for the CSI and the ASI requirements are to be use for the CSSI.

15.5.3.3.4 Equalization.

If the carriage store sinks or sources the LB signal, the MSI requirements are to be used for the CSI and the ASI requirements are to be use for the CSSI.

15.5.3.3.5 Signal path DC offset.

If the carriage store sinks or sources the LB signal, the MSI requirements are to be used for the CSI and the ASI requirements are to be use for the CSSI.

15.5.3.3.6 Noise.

If the carriage store sinks or sources the LB signal, the MSI requirements are to be used for the CSI and the ASI requirements are to be use for the CSSI.

15.5.3.3.6.1 Periodic and random noise.

If the carriage store sinks or sources the LB signal, the MSI requirements are to be used for the CSI and the ASI requirements are to be use for the CSSI.

15.5.3.3.6.2 Impulse noise.

If the carriage store sinks or sources the LB signal, the MSI requirements are to be used for the CSI and the ASI requirements are to be use for the CSSI.

15.5.3.3.6.3 Stimulated noise.

If the carriage store sinks or sources the LB signal, the MSI requirements are to be used for the CSI and the ASI requirements are to be use for the CSSI.

15.5.3.3.6.4 Common mode noise.

If the carriage store sinks or sources the LB signal, the MSI requirements are to be used for the CSI and the ASI requirements are to be use for the CSSI.

15.5.3.3.6.5 Ground reference.

If the carriage store sinks or sources the LB signal, the MSI requirements are to be used for the CSI and the ASI requirements are to be use for the CSSI.

15.5.3.4 Carriage store release consent interface.

The release consent interface is required at the CSI and each CSSI of a carriage store. The release consent signal is an enabling or inhibiting signal in conjunction with the MIL-STD-1553 data bus interface. The actual command to achieve a safety critical function is sent over the data bus.

15.5.3.4.1 CSI.

Except for the requirement against bits D8 and D10, the carriage store is not required to use the release consent signal, in which case the carriage store must provide a method for applying the release consent signal to the commanded CSSI. The carriage store CSI must comply with the requirements in the MSI associated subparagraphs.

15.5.3.4.2 CSSI.

The release consent signal is required at each CSSI. It is to provide an enabling or inhibiting function to be used in conjunction with safety critical commands sent to a mission store over the data bus. The carriage store CSSI must comply with the requirements in the ASI associated paragraphs except that the enable lead time and inhibit delay is reduced to 10 milliseconds.

15.5.3.4.3 CSI to CSSI transfer.

This paragraph is to ensure the carriage store does not to activate the CSSI release consent interface until after the aircraft activates the CSI release consent interface. The carriage store must include interlocks that ensure the CSSI release consent signal will follow the CSI release consent signal.

15.5.3.5 Carriage store interlock interface.

The interlock interface is required at the CSI and each CSSI of a carriage store.

15.5.3.5.1 CSI.

The carriage store interlock interface at the CSI must comply with the electrical requirements in the MSI associated subparagraphs.

15.5.3.5.2 CSSI.

The carriage store is required to use the interlock interface to determine if a mission store is electrically connected via the CSSI. The carriage store then makes this data available on the Mux bus for the aircraft to monitor as required.

The carriage store interlock interface at the CSSI must comply with the electrical requirements in the ASI associated subparagraphs.

15.5.3.5.3 Isolation.

It is important that isolation be provided between the CSI interlock interface and the CSSI interlock interface to prevent interaction between the connector interfaces.

15.5.3.6 Carriage store address interface.

The carriage store must energize and monitor a set of six address discrete signal lines, plus a dedicated address return line, at the CSI. This set is used to assign the terminal address for the internal carriage store MIL-STD-1553 remote terminal.

For conditions where the aircraft assigns terminal addresses to mission stores attached to the carriage store, the aircraft must accomplish this lower tier address assignment via the Mux bus. The carriage store would then need to contain circuitry similar to figures 15.5.1.4.3.2-1b and 15.5.1.4.3.2-1c, to set-up address discretes at each CSSI based on these assigned lower tier addresses.

For configurations where the carriage store determines the assigned terminal address for attached mission stores any address except 31 may be assigned to any CSSI.

15.5.3.6.1 CSI.

The address discretes are to be used for assigning the carriage store its remote terminal address, The address interface can also be used to determine the mated status of the carriage store's connection with an aircraft,

The carriage store address interface at the CSI must comply with the electrical requirements in the MSI associated subparagraphs.

15.5.3.6.2 CSSI.

This address is provided by a set of discretes that allows the connected store's RT address to be uniquely assigned automatically by connecting the store to any specific CSSI. These address coding contacts are contained in the CSSI since it is not practical to program a store's address during manufacture or during store preload preparation.

The carriage store address interface at the CSSI must comply with the electrical requirements in the ASI associated subparagraphs.

15.5.3.7 Carriage store structure ground.

The structure ground connection is included to provide a higher level of assurance that the carriage store structure is electrically connected to the aircraft and mission store structures. The connection is provided for shock hazard protection of personnel, e.g. during electrical faults, and to reduce low frequency noise voltages between the carriage store, aircraft and mission store structures. Other electrical paths may also exist between the carriage store, aircraft and mission store structures, e.g. umbilical cable shield or mechanical attachment points, but these paths are normally poorly controlled.

The intent of the last sentence is to highlight that power and signal circuits through the AEIS must not rely on the structure ground line for proper operation. Each power or signal line must have a return that is exclusive of structure ground. Due to grounding approaches used in the carriage store, aircraft and mission store, it is highly probable that some power or signal current will flow through the structure ground connections. That is of course acceptable.

15.5.3.8 Carriage store 28V DC power interface.

The impact of carriage stores is covered in Revision C of the Standard. For example, mission stores that may be carried on carriage stores must be compatible with the slightly reduced power available at the CSSI.

More than one mission store may be connected to a carriage store. If these mission stores need to be powered simultaneously, they must either share the power required by the standard at an ASI or the ASI would need to have power capacity over and above that required by the standard (or make use of the auxiliary power interface). Also, some voltage drop will occur across the carriage store (see 5.1.8, 5.1.9) and the carriage store itself may use some power, as allowed by 5.3.9.2 c.

15.5.3.8.1 CSI.

The impact of carriage stores is covered in Revision C of the standard. For example, the carriage store is required to supply 28V DC power to the CSSI such that mission stores meet the requirements of paragraph 5.2.8.1 of MIL-STD-1760C.

More than one mission store may be connected to a carriage store. If these mission stores need to be powered simultaneously, they must either share the power required by MIL-STD-1760 at an ASI or the ASI would need to have power capacity over and above that required by the standard (or make use of the auxiliary power interface). Also, some voltage drop will occur across the carriage store (see 5.1.8, 5.1.9) and the carriage store itself may use some power, as allowed by 5.3.8.2a.

The carriage store has the option of containing a power supply to generate 28V DC 1 power for supplying the mission stores. This could allow for sufficient power to simultaneously power more than one mission store. This is the reason the CS is only required to deliver 90% of the 115 V AC power to CSSIs - some may be converted to 28V DC.

The carriage store CSI must comply with the requirements in the MSI associated subparagraphs except that an allowance is made for the carriage store resistance in the 28V DC power voltage drop. The carriage store designer needs to take into account the power supplied by the aircraft and the voltage drop in the umbilical connecting the ASI to the CSI. (See figure 24 MIL-STD-1760C.)

15.5.3.8.2 CSSI.

The carriage store CSSI must comply with the requirements in the ASI associated subparagraphs except that an allowance is made for the CSSI to MSI umbilical cable resistance in the 28V DC power voltage drop. The carriage store designer needs to take into account the power supplied by the aircraft and the total voltage drop between the ASI and MSI including the ASI to CSI umbilical, the carriage store itself, and the CSSI to MSI umbilical. (See figure 24 MIL-STD-1760C.)

Adding circuit protection in the carriage store increases design complexity and makes it more difficult to meet the ASI-to-MSI voltage drop limits for 28V DC circuits established by MIL-STD-1760C. For this reason, MIL-STD-1760 does not require circuit protection to be added to the carriage store though it is allowed. If current protection is added, the "Maximum Load Current" limits must still be provided at the CSSI.

Applications that include a power supply within the carriage store, to generate 28V DC, must provide circuit protection at the power supply output. This arrangement provides fault isolation between power circuits. Current requirements at the CSSI are the same as those defined for the ASI.

Primary interface CSSI power may be derived from the Auxiliary CSI interface. However, the following caution must be observed:

CAUTION
Aircraft protective devices used to protect the auxiliary circuits will not provide adequate protection to CSSI primary power interfaces derived from auxiliary power.

15.5.3.9 Carriage store 115V/200V AC power interfaces.

The impact of carriage stores is covered in Revision C of the standard. For example, mission stores that may be carried on carriage stores must be compatible with the slightly reduced power available at the CSSI.

More than one mission store may be connected to a carriage store. If these mission stores need to be powered simultaneously, they must either share the power required by MIL-STD-1760 at an ASI or the ASI would need to have power capacity over and above that required by MIL-STD-1760 (or make use of the auxiliary power interface). Also, some voltage drop will occur across the carriage store (see 5.1.8, 5.1.9) and the carriage store itself may use some power, as allowed by 5.3.9.2 b.

15.5.3.9.1 CSI.

The carriage store CSI must comply with the requirements in the MSI associated subparagraphs except that an allowance is made for the carriage store resistance in the 115V AC power voltage drop. The carriage store designer needs to take into account the power supplied by the aircraft and the voltage drop in the umbilical connecting the ASI to the CSI. (See figure 24 MIL-STD-1760C.)

15.5.3.9.2 CSSI.

The carriage store CSSI must comply with the requirements in the ASI associated subparagraphs except that an allowance is made for the CSSI to MSI umbilical cable resistance in the 115V AC power voltage drop and the power used in the carriage store. The carriage store designer needs to take into account the power supplied by the aircraft and the total voltage drop between the ASI and MSI including the ASI to CSI umbilical, the carriage store itself, and the CSSI to MSI umbilical. (See figure 24 MIL-STD-1760C.)

Adding circuit protection in the carriage store increases design complexity and makes it more difficult to meet the ASI-to-MSI voltage drop limits for 115V AC circuits established by MIL-STD-1760C. For this reason, MIL-STD-1760 does not require circuit protection to be added to the carriage store though it is allowed. If current protection is added, the "Maximum Load Current" limits must still be provided at the CSSI.

15.5.3.10 Carriage store 270V DC power interfaces.

Top level requirements are identified for the carriage store to include growth provisions for 270V DC power. These provisions are included in the form of contact cavities in the CSI and CSSIs for a 270V DC power contact and a 270V DC power return contact. These contacts and the connector must be compatible with carrying MIL-STD-704 270V DC power voltages at continuous current ratings of 10 and 30 amperes for the primary and auxiliary, respectively.

270V DC is defined in MIL-STD-704 as a "legal" power voltage standard, but the standard does not require carriage stores to provide a routing network between the CSI and the CSSIs. It would be good design foresight for the carriage store designer to include a network for routing the 270V DC from the CSI to the CSSIs.

15.5.3.11 Carriage store fiber optic interface.

Two Size 16 contact locations in the primary interface connector (contacts U and Y) are reserved by MIL-STD-1760 for future applications of fiber optics and are not to be used for any other function. When required, the characteristics of these optical links will be added to the standard.

15.5.3.12 Carriage store initialization.

This paragraph requires the aircraft to power the carriage store, initialize it and determine what it is prior to activating the CSSI. The carriage store CSI must comply with the requirements and procedures in the MSI associated subparagraphs.

The aircraft can then command the carriage store to initialize the mission store. The carriage store CSSI must comply with the requirements and procedures in the ASI associated subparagraphs.

15.5.4 Umbilical cable requirements.

This new section was added in Revision C. It places requirements on the umbilical cables, in order to standardize the cables (reducing the number of different cables needed) and standardize the characteristics of the interface at the end of the cable to reduce the number of variations that stores and aircraft need to deal with.

Any umbilical will be compatible with any ASI/MSI/CSI/CSSI, except that different lengths may be required for different applications. The number of different lengths should be kept to a minimum as far as practical. Umbilicals should not contain provisions to be secured to tie-points other than the connector lanyard, since this would typically make them unique to one installation. If additional tie-points are necessary, these provisions should be part of the aircraft (or carriage store). Umbilicals should not be pre-formed to a specific shape; they should be flexible enough for all intended applications consistent with the full connectivity required.

15.5.4.1 Primary umbilical HB interfaces.

15.5.4.2 Primary umbilical data bus interface.

15.5.4.3 Primary umbilical LB interface.

15.5.4.4 Primary umbilical release consent interface.

15.5.4.5 Umbilical interlock interface.

15.5.4.6 Primary umbilical address interface.

15.5.4.7 Umbilical structure ground.

15.5.4.8 Umbilical 28V DC power interfaces.

15.5.4.9 Umbilical 115V AC power interface.

15.5.4.10 Umbilical 270V DC power interface.

15.5.4.11 Primary umbilical fiber optic interface.

15.5.4.12 Umbilical gross shield.

15.5.5 Power interface interrupts.

This section collects together the power interface interrupt requirements so the interactions that occur when power is interrupted can be clearly defined.

Paragraph 5.1 requires stores to operate through interruption of the AC power for up to 200 microseconds with no effect on store function. These 200 microseconds are less than 1/12 th of one cycle of the 400 Hz power, which most AC-to-DC power supplies can tolerate without problem. Such transients might be caused by, for example, a dirty connector contact that is moving under the effects of vibration in flight.

Some stores include functions (such as inertial navigation systems) that require significant time to align and thus must not be interrupted during critical parts of the mission. In these cases, it may be appropriate for the store's system specification to require operation through, or at least immediate recovery from, longer transients.

It was suggested that MIL-STD-1760 should require all stores to operate through longer transients, such as a transient of up to 50 ms that might occur on some aircraft during power system switching. It was decided that requiring this capability on all stores (including simple stores that can re-start after a transient with no impact on capability) is not cost effective. A store's performance specification should define its capabilities, including its ability to tolerate long power transients.

15.5.5.1 Mission store compatibility.

15.5.5.2 Carriage store compatibility.

15.5.5.3 Aircraft compatibility.

15.5.5.3.1 Full initialization.

15.5.5.3.2 Partial initialization.

15.5.5.4 Store power interrupt notification.

15.5.6 Connector characteristics.

The following paragraphs, along with section 4.5, require use of specific connector types, insert arrangements, and contact functional assignments for the primary and auxiliary interfaces. Consistent use of compatible connectors is essential for an interoperable standard interface.

Note that in MIL-STD-1760C, the requirement is for ASI connectors to meet the "form, fit, function and interface requirements" of the MIL-C-38999 and 83538 connectors, while MSI connectors must be "intermateable" with MIL-C-38999 and 83538. This is in contrast to the prior revisions, which specifically required use of the military connectors on the aircraft side of the interface. This was changed because MIL-C-38999 and 83538 are "design" specifications, and, as a result of the Perry memo, mil specs and standards are no longer allowed to reference them as firm requirements. This still achieves the interoperability goal of MIL-STD-1760, but transfers responsibility for hardware design, reliability, environmental qualification, etc., to the aircraft or store designer/manufacturer.

Meeting the "form, fit, function and interface requirements" of a mil-spec part is equivalent to saying the parts are physically interchangeable, i.e., the standard military connector could be substituted for a failed original equipment connector in the field with no design change. Therefore, the government would not need to stock different brand-name connectors for different aircraft.

The MIL-C-38999 series III connector is a "scoop-proof, triple-start, self locking threaded" connector according to paragraph 1.3.1 of 38999. The fact that it is triple-start means that it has threads three times as coarse as normal, and will mate completely with about one turn of the shell. The self locking feature means that it will withstand the full range of shock and vibration at store stations with no safety wire. It has colored rings on the shell to visually verify that it is properly tightened. When it is tightened, the rubber insert is compressed against the pins to form a watertight seal.

The connector paragraphs (5.6.1) call out requirements for a Type 2 connector, (added by rev. B Notice 2) for use in blind-mated applications, such as on rail launchers. It should be noted that the Type 2 connector has a special-to-type shell, but both the insert and contacts are the same as for the Type 1.

A similar (but not compatible) connector, made only by Hi-Rel, is used on the AMRAAM (AIM-120).

Buffer plugs are used between the launcher receptacle and MSI receptacle of the type II connector. The buffer has pins on both sides and is a “throwaway” item, since the heat of the missile exhaust often damages the exposed side of the buffer during launch. The standard buffer is described in MIL-C-83538. A buffer has been designed that would allow an AMRAAM to plug into a MIL-STD-1760 type II connector, and it is now (1999) being documented in a slash sheet to MIL-C-83538.

A buffer has also been designed to connect a MIL-STD-1760 type II store connector to an AMRAAM (Hi-Rel) ASI. Because there is a bolt in the center of the AMRAAM connector, occupying the space where pins 5 and W (HB 1 and 3) normally are, this buffer configuration does not allow use of these two signal lines.

Paragraph 5.6.1 defines two connector types for the primary signal set. The Type 1 connector is used to make the visible connection to an eject launched store. The Type 2 connector is used to make the blind mate connection to an eject launched store and a visible or blind mate connection to a rail launched store.

The Type 1 Connector complies with the requirements of MIL-C-38999, Shell Size 25 and is satisfied by using MIL-C-38999/20 and MIL-C-38999/24 Receptacles mating with the MIL-C-38999/31 Plug Connector. The slash 31 mechanism requires that the connector is mated by hand (360 degree tri-start lock) and de-mated by the ejected store tensioning the lanyard on its bail lug, retracting the mechanism. The store may also be disconnected from the aircraft by reversing the mating procedure.

The Type 2 Connector is defined by MIL-C-83538 with the MIL-C-83538 /1 through /10 accessories. The Type 2 mechanism retains the basic two-part philosophy of the Type 1, but no thread is involved in the mating or its retention. The mating is achieved by uploading the store onto the launcher and engaging the connectors with a wrench activated mechanism that locks them together. De-mating is achieved by:

Unlocking the umbilical latch by depressing the manual release pin.

Electrically operating the umbilical retract mechanism during a rail launch of the store.

The AMRAAM missile uses an interface similar to MIL-STD--1760 in that it uses MIL-STD-1553 as the digital data interface, and MIL-STD-1760 type discretes, but it uses a different type connector. The AMRAAM connector can be adapted to the MIL-C-83538 connector with a conversion buffer as discussed above.

15.5.6.1 Primary interface connector.

15.5.6.2 Auxiliary power interface connector.

These two paragraphs and the referenced tables define requirements that connectors on the aircraft, store, carriage store and umbilical must meet. These paragraphs specify requirements on the MSSI and CSI connector differently to that for the ASI and CSSI connector. While the aircraft is required to use connectors that meet the “form, fit, and function requirements” of MIL-C-38999, the MSI is only required to provide a connector, with inserts and contacts, which meets the intermateability dimensions of the listed specifications. The intent is that since the aircraft’s connectors will be in the field over a longer time, connectors interchangeable with the standard military piece parts should be used to facilitate logistics support.

In contrast, the store is generally a "one shot" device with possibly unique, or more critical, connector design requirements. It was therefore decided to allow the store to use other connector designs as long as the connector "front end" is intermateable with the designated specifications of tables III and V. Two examples of unique MSI connector considerations are:

A fail safe, shear mechanism, receptacle that allows aircraft store separation even if the umbilical cable's lanyard mechanism fails, e.g. ground crew forgot to connect the lanyard to the bail bar,

A special low profile accessory area on the back of the receptacle, to minimize penetration of the receptacle into the store warhead, rocket motor or other subsystems.

This intermateability concept applies to the contacts as well as the connector shell. The MIL-C-39029 contacts listed are rear insert/removable crimp contacts. A store designer might choose to use a connector with fixed contacts that are soldered, such as those used with hermetically sealed connectors. See also the discussion of high bandwidth contracts in 14.1.3.2.

15.5.6.3 Connector receptacle.

This paragraph defines the gender of the ASI and MSI connectors, i.e. the connector mating half that is "permanently" attached to the aircraft or store. To minimize exposed contacts and maximize ruggedness of this permanently attached connector, a receptacle style connector shell with socket contacts is specified. This paragraph also reminds designers that contact cavities for unused interface signals can be plugged as well as installing the contacts. This plugging is of particular advantage for the twinaxial and coaxial contact cavities. In order to install an unused twinaxial or coaxial contact into a connector, the contacts must be assembled onto a twinaxial or coaxial cable stub. Plugging the cavities is therefore allowed for manufacturing cost reasons. If the connector contains plugged cavities, sealing plugs must be used that allow the coupling of a mating plug that has pin contacts installed opposite to the plugged cavities. A "hole" needs to be provided in the receptacle's interfacial plate to allow the plug's pin contacts to pass through the plate when mated. These special plugs were introduced into the standard at Revision C, as an extension to Table I.

15.5.6.4 Umbilical primary interface connectors.

15.5.6.5 Umbilical auxiliary interface connectors.

15.5.6.6 Connector keyway orientation.

15.5.6.6.1 ASI and CSSI.

15.5.6.6.2 MSI and CSI.

These paragraphs orient the ASI, MSI, CSI, and CSSI connector major keyway for compatibility with the corresponding connector orientation at the other end of the appropriate umbilical. Consistent keyway orientation is also very helpful to maintenance and store loading personnel, since they soon learn where the key is and can mate the connectors quickly without studying them visually. (see 5.4.5 of this Handbook).

15.5.6.6.3 Umbilical cable.

15.5.6.7 Connector location.

15.5.6.7.1 ASI and CSSI.

15.5.6.7.2 MSI and CSI.

15.6 NOTES

Nothing in this section of the standard is binding. This section, like the handbook, contains information to the users and maintainers of the document.

15.6.1 Intended use.

15.6.1.1 Implementation.

15.6.2 Issue of DoDISS.

15.6.3 International standardization agreements.

15.6.4 Tailoring guidance.

15.6.5 Keyword listing.

Keywords are used by some filing and document retrieval systems to provide additional information about subject areas that a document covers.

15.6.6 Changes from previous issue.

This paragraph usually states whether change bars are included in the margins of the documents and warns users that change bars are rarely perfect. In the case of Revision C, the Government is now using computers and electronic file transfer to prepare documents, so new capabilities (such as a computer file with all the changes marked in color) are becoming available. Released documents will be distributed in a form that is not easily edited (such as

PDF). Anyone who needs to see exact changes from the previous issue or is involved in editing or rewriting the document should contact the preparing organization to obtain the original word processor file.

The word processor file of MIL-STD-1760C was created in Microsoft Word™ from MIL-STD-1760B with the "track changes" feature turned on, so one can go to "Tools", choose "track changes", and "highlight changes on screen" to see how Revision C compares to Revision B. These markings are not complete or correct where major sections were moved or rewritten, but in general make it easier to see what changed. There are also "Comments" in the text. These comments about what changed and why show up in brackets, numbered like "[NOTE1]" ("Hidden text", under "Tools", "Options", "View" must be turned on). They can be displayed at the bottom of the screen (go to "View", select "comments"), and are printed at the end of the published standard as appendix C. The figures were created in Microsoft Power Point™ and pasted into the electronic copy.

15.B HANDBOOK FOR APPENDIX B TO MIL-STD-1760

This section of the Handbook provides rationale and background information for the key requirements paragraphs of APPENDIX B, "Digital multiplex communications rules and message requirements", of MIL-STD-1760C. Paragraph numbers and titles from the standard are duplicated here, with rationale and explanation for many of the significant or confusing requirements.

15.B.1 SCOPE

15.B.1.1 Purpose.

15.B.2 APPLICABLE DOCUMENTS

15.B.2.1 References.

15.B.2.2 Government documents.

15.B.2.3 Other Government documents, drawings, and publications.

15.B.2.4 Non-Government publications.

15.B.3 DEFINITIONS

15.B.4 REQUIREMENTS

15.B.4.1 Communication rules.

15. B.4.1.1 Command word.

The command word requirements are basically those in MIL-STD-1553B. Certain field requirements are enforced or mandated. Within the address field the broadcast option is limited to mode commands. Within the sub-address/mode field the following mode commands are mandated:-

a.	Reset Remote Terminal	(stores only)
b.	Transmit Last Command	(stores only)
c.	Transmitter Shutdown	(stores only)
d.	Override Transmitter Shutdown	(stores only)
e.	Transmit Vector Word	(aircraft and stores)
f.	Synchronise With Data Word	(aircraft and stores)
g.	Transmit Status Word	(stores only)

Further to this the following mode commands are prohibited; Dynamic Bus Control and Reserved Mode Codes. All other mode commands are permitted with the provision that implementation of a permitted mode code by the aircraft or store does not require the store or aircraft to reciprocate. Note that certain permitted mode commands are required to be paired. Within the sub-address/mode field the following sub-addresses have been allocated:-

a.	Store Description	01
b.	Nuclear Weapon	19 and 27
c.	Test	08
d.	Mission Store Control/Monitor	11
e.	Linked Messages/Mass Data Transfer	14

15.B.4.1.2 Status word.

The status word requirements are basically those in MIL-STD-1553B. The implementation of the Service Request, Busy, Sub-system Flag and Terminal Flag bits are regulated by the standard.

15.B.4.1.3 Data words.

15.B.4.1.4 Internal state change.

15.B.4.1.5 Protocol execution.

15.B.4.1.5.1 Protocol checks.

Protocol checks are listed below. The store is required to conduct protocol checks on all receive messages that can initiate safety critical actions. A "protocol check" failure reporting mechanism is included.

Verification of Checksum (if implemented)

Verification of Header

Verification of Critical Authority and Control

15.B.4.1.5.2 Checksum requirement.

A checksum algorithm (Rotated Modulo 2) is specified in the standard to insure that aircraft and stores will use the same algorithm. This is the only algorithm that may be used. Its use is mandated on all three standard messages and is the last word, but is optional on all other messages. This is a store option. When implemented, under the option rule, it is positioned as the last word, but when not implemented the last word is a data entity.

15.B.4.1.5.3 Execution time.

The maximum time for which busy may be set is 50 microseconds. Other busy bit implementations, including time maximums, are included in this paragraph.

15.B.4.1.5.4 Service request notification.

Service request notification uses the service request bit in the Status word. The implementation is specified.

15.B.4.1.5.5 Request servicing.

The aircraft extracts the servicing required information by demanding the Vector word. It should do this on a high priority basis. Appendix B uses a figure to show the general forms of service request protocol.

15.B.4.1.5.8 Mass data transfer.

This requirement was re-written in Revision C, to limit it to one specific implementation.

Mass Data Transfer uses sub-address 14. A full protocol is specified for bi-directional data transfer called out as Download Mode (aircraft to store) and Upload Mode (store to aircraft). (Upload mode is not yet in MIL-STD-1760C Notice 1) Allowance has been made for transfer of up to 255 files each containing up to 255 records where a record is up to 255 blocks of 29 words, that is 29 x 255 x 255 x 255 or 1,885,725 data words per file. Three basic types of messages are used:-

a. Transfer Control (TC) - The aircraft uses this message to control the mass data transfer protocol.

b. Transfer Monitor (TM) - The store uses this message to advise the aircraft of transfer status.

c. Transfer Data (TD) - This is used by either aircraft or store for the actual data transfer.

15.B.4.1.5.9 Carriage store routing.

The procedure is undefined, except provisions were inserted in Revision C to allow for the use of a "peeling" protocol. The message length is established as 30 (thirty) words to allow introduction of this facility at a later date.

15.B.4.1.5.11 Broadcast.

The optional broadcast mode of MIL-STD-1553 is allowed by MIL-STD-1760C for potential use where bus loading or timeline requirements cannot be met with the normal MIL-STD-1553 command-response protocol. Broadcast might be useful where a large block of data must be transferred to several stores in a short period of time.

Restrictions to broadcast were added in Revision C in B.40.1.5.11. The following guidance is needed to minimize problems with use of broadcast mode.

Use of broadcast is strongly discouraged because:

MIL-STD-1553B's centralized control network protocol relies on the use of a parity bit and return of status for each transmission/reception to detect and correct (via re-transmission) data errors. The use of broadcast in the more recent buses (like High Speed Data Bus) requires a distributed control network protocol which uses a combination of parity bits, token frame check sequences, message frame check sequences, and a variety of fault tolerant schemes such as synchronous redundancy to produce a robust protocol. These networks achieve both a broadcast mode and a robust protocol by taking advantage of their higher data rates to minimize the effects of added overhead. Use of broadcast mode in MIL-STD-1553B systems allows terminals to either miss messages or receive messages with errors unless each broadcast is followed by a request for status from each terminal, to verify that the message was received correctly.

There is risk that existing aircraft systems built before MIL-STD-1553B Notice 2 will be seriously impacted. These systems will not recognize broadcast transmissions and may interpret them improperly.

There is risk that a store designed to accept broadcast messages would end up on an aircraft where the broadcast subaddress used by the store is already being used for something else. A store programmed to accept broadcast messages will have this risk even if the airframe integrator has no plans to use broadcast messages with the store. There are only 30 subaddresses (actually 24 since six of these are restricted because they include safety critical information) and there is no agency controlling who uses them. Therefore, each time a new store is integrated onto an aircraft, the integrator who wishes to use broadcast will be obligated to verify that no other store can accept or misinterpret his broadcast messages.

15.B.4.2 Message requirements.

The requirements for both standard and non-standard data messages are fully defined, with the former restricted to those for Critical Control, Critical Monitor and Store Description.

15.B.4.2.1 Base message formats.

The message is defined as a 30-word (32 for carriage stores) message consisting of:

a. Word 01 -Header (some header words already defined/reserved).

b. Word 02 and Word 03 -Invalidity words (1 bit per word) if used; otherwise, data words.

c. Word 04 thru Word 29 -Data words (up to 26 data words, 28 if Invalidity is not used, are available for use).

d. Word 30 -Checksum LAST WORD if less than 26 data words are in use.

15.B.4.2.2 Standard messages.

15.B.4.2.2.1 Mission store control.

This is a 30-word message, used as follows:

Header (0400 HEX)
Validity
Control Words (21)
Reserved Words (6)
Checksum

15.B.4.2.2.2 Mission store monitor.

This is a 30-word message, used as follows:-

Header (0420 HEX)
Validity
Monitor Words (15)
Reserved Words (6)
Checksum

15.B.4.2.2.3 Store description message.

This message provides for store identification, either binary or alpha-numeric and store IBIT time. It also provides for identification of store configuration, such as the version of software installed (added in Revision C), since some systems are controlled by software which can be loaded in the field, and the software might change the way the store is employed.

Store identity is provided to the aircraft so the aircraft can do an automatic store inventory, display the stores load-out to the pilot and use the appropriate software for control of the data interface with the store, calculation of launch zone, ballistic or guidance information, etc.

15.B.4.2.2.4 Nuclear weapon control message.

These are not standard messages required by MIL-STD-1760, but may of course have such a requirement specified in the System 2 Specification. However, MIL-STD-1760 does specify that receive sub-addresses 19 and 27 are reserved for these messages.

15.B.4.2.2.5 Nuclear weapon monitor message.

These are not standard messages required by MIL-STD-1760, but may of course have such a requirement specified in the System 2 Specification. However MIL-STD-1760 does specify that transmit sub-addresses 19 and 27 are reserved for these messages.

15.B.4.2.2.6 Aircraft description.

This message, added in Revision C Notice 1, provides a standard way to identify the aircraft to the store, for cases where this is necessary. It is patterned off of the store description message.

15.B.4.2.3 Mass data transfer messages.

Mass data transfer provides a means to pass larger blocks of data, such as complete files, between the aircraft and store. This section was rewritten in Revision C.

15.B.4.2.4 Protocol for time tagging.

This section was added in Revision C to standardize the way time tags are passed from the aircraft to stores.

15.B.4.3 Standard data entities.

The large group of subparagraphs that defined each data entity was deleted in Revision C. The requirements from these paragraphs were incorporated into table B-XXVI.

Several new entities were also added.

The standard defines (in table B-XXVI) over 170 standard data entities, which are to be used whenever possible, so the same terminology, units, and meaning can be used on multiple systems.

With the data entities are eight diagrams defining:

- Aircraft Body Axis
- Earth Axis
- Aircraft, Target and Waypoint Position XYZ to fixed point
- Earth - Aircraft Alignment
- Aircraft-Store Alignment
- Store Body Axis
- Target and Waypoint Position XYZ
- Target Position/Store Trajectory (polar)
- Target Sector and Segment Position

15.B.5 Table B-XXXI.

This table defines the invalidity word, which is part of some of the standard messages. Although it seems strange to mark the invalid words while leaving all reserved, spare and unused bits set to "valid", this is the intended mode of operation. It follows the convention, used throughout the standard, of setting all unused bits to zero. The system ICD will clearly define which words in a message contain data and which are Reserved, Spare or Unused. When a message is received and checked for invalidity, the system software can quickly test the invalidity word (words) for any bit set to invalid. This is preferred to checking a lookup table to determine which bits are supposed to be set invalid/valid and then testing.

16. CARRIAGE STORES

The Carriage Store element of the Standard was not added until MIL-STD-1760C and therefore little guidance for carriage store implementation has been written. It is hoped that a carriage store implementer will lead the effort to prepare this section of the Handbook.

Carriage stores can provide the ability to extend the store carriage capability of an Aircraft Station Interface (ASI), i.e., like the TER (Triple Ejector Rack) and MER (Multiple Ejector Rack) that are in use with pre-1760 weapons. Other carriage stores can also act as a converter between an ASI and a missile, as the LAU 7 does with pre-1760 air to air missiles.

Carriage Stores will have a Carriage Store Interface (CSI) and Carriage Store Station Interface(s) (CSSI) which can be likened to the Mission Store Interface (MSI) and ASI respectively. The requirements are not directly transferable, however, and section 16 will provide guidance on this aspect.

Section 16 will also include general implementation guidance. It will address various carriage store architectures and issues, such as the merits of using a bus controller if there are other legal ways of managing mission stores on a carriage store (as long as the carriage store is responsible for the movement of the data from CSI to CSSI and vice versa).

17. Logical definition.

This section of the Handbook deals with the information passed over the MIL-STD-1553 data bus in the MIL-STD-1760 interface.

Standardizing major elements of the logical definition provides a standard method of transferring data between mission stores, carriage stores, and the aircraft. Now that the standard connector, wiring, and other hardware interface facilities are installed on numerous aircraft and on the current generation of smart stores, the logical definition becomes the key to improved interoperability between multiple stores and aircraft.

The logical section of the Standard (Appendix B) provides a fully interoperable method of transferring data between a mission store and its carrying platform. Ensuring that the approaches used were practical and implementable and that interoperability was achieved, meant that it was the last major section of the Standard to be introduced (MIL-STD-l760A Notice 3). This has meant that, unlike the bulk of this Handbook, section 17 is being prepared without the benefit of existing material.

Some subjects not yet adequately covered in this first version of Section 17 include:

a. How interoperability has been achieved across many stores by the utilization of a common ICD, wherever practical, controlled by Interface Working Group(s).

b. Use of broadcast data should be discussed. While MIL-STD-1553 does not endorse use of the broadcast mode, MIL-STD-1760 allows broadcast in some situations, and this Handbook should provide guidance on what data may/may not be broadcast.

c. The Standard provides a “real time” approach for the store to notify the aircraft that it is in some difficulty. This approach has not been well understood and has led to under-utilization of this feature. The handbook should provide a full explanation of the implementation of the approach.

The three examples above are intended to show the approach that section 17 will take and should not be construed as its total content. Indeed, any thoughts on its content, initiated by current implementation problems for example, would be welcomed.

17.1 Scope.

This section provides more in-depth discussion of issues dealing with the logical interface. Note that section 15 (the paragraph-by-paragraph commentary) provides a brief overview of requirements on some of the logical section paragraphs.

This is only the first edition of this section and is not complete, in fact, major sections are not yet written, and are not included in this version of the handbook.

17.2 Approach.

The intent of the standard is that aircraft and stores use a pre-defined (by MIL-STD-1760) set of communication rules and the same message requirements as far as possible to minimize the changes in software and data definition needed to implement each new aircraft-store combination.

The initial approach of the developers of MIL-STD-1760 was to define a large number of “standard” messages/words/fields. This quickly grew out-of-hand and the approach dropped back to standardizing critical and safety related messages/words/fields. The standard also defines a set of standard data entities, which should be used as far as practical, but are not specifically required.

Unoffical standardization has occurred with numerous similar “User defined” messages, words and fields between several current smart air-to-ground weapons. These weapons’ Interface Control Working Groups have worked to keep similar interfaces common between weapons to save limited resources in integrating these weapons on several aircraft types.

17.3 MIL-STD-1760 communication rules.

MIL-STD-1760 requires use of MIL-STD-1553, with some specific limitations and tailoring of the MIL-STD-1553 requirements for interoperability and flexibility.

Communication rules relate to the command, status, and data words and the protocol execution.

17.3.1 Store description message.

This message provides for store identification, either binary or alphanumeric, and store IBIT time. It also provides for identification of store configuration, such as the version of software installed (added in Revision C). The store description message is broken down as follows:

a. Header (0421 HEX)

b. Country Code

c. Store Identity (BINARY)

d. Store Identity ASCII (8)

e. Maximum IBIT Time

f. Store configuration identifier (3)

g. Reserved Words (14)

h. Checksum

The eight store-type ASCII words give sixteen alpha-numeric characters because each 16 bit word is split into 2, 8 bit segments. Store Identity ASCII and Store Identity Binary are not intended to be used together, but are not, in fact, mutually exclusive.

Store identity is provided to the aircraft so the aircraft can do an automatic store inventory and display the stores load-out to the pilot. It allows the aircraft to use the appropriate software for control of the data interface with the store, calculation of Launch Acceptability Region (LAR), and handling of any other store-specific ballistic or guidance information. The fact that the aircraft software receives the store ID from the OFP in the store eliminates the potential for human error that is always present when store load-out is entered manually.

Either the binary or ASCII form of store ID (or both) are allowed by the standard. The ASCII form is intended to be the store's type designation, such as "AGM-154", assigned by the US DOD (or appropriate agency in other countries). The inclusion of country code in the message ensures that store type designations assigned by two different countries will not be confused even if they happened to use the same characters. Thus, country code refers to the country that assigned the store nomenclature, and is often not the same as the country that is using the store. The binary form is allowed by the standard as a way to simplify the software and reduce the amount of memory required in the store, since it only requires a single word.

The US DOD nomenclature control point is in ASC/ENS at Wright-Patterson AFB. They control the nomenclature assigned to ensure that it is unique to each store type. The controlling regulation and standard also require assignment of a new revision or variant any time a system is modified in a way that affects form, fit, or function. They do not assign and control binary IDs, so the use of binary IDs is discouraged.

The store configuration identifier entity was added in Revision C to allow stores to identify specific configuration data, such as the software version loaded in the store, to the aircraft. There is no central control point for this entity, therefore it is up to each program office or system contractor to assign and control configuration identities if they are used. Configuration identifier is particularly useful with systems that are controlled by software that can be loaded in the field. This might change the way the store is employed (by enhancing launch acceptability region, for example) and is therefore important to the aircraft, but would typically not result in a change to the store identity.

17.3.2 Nuclear weapon control.

There are no standard nuclear weapon control messages required by MIL-STD-1760, but there may, of course, be such a requirement in the System 2 Specification. MIL-STD-1760 does, however, specify that receive sub-addresses 19 and 27 are reserved for these messages. Having the sub-addresses limited to nuclear-only would probably not be necessary, with all the other safeguards against improperly receiving messages intended for something else. However, it might simplify the safety analysis that is required to prove the extremely high levels of confidence of correct message routing needed when dealing with such weapons.

17.3.3 Nuclear weapon monitor.

Like the Nuclear weapon control message, there are no standard nuclear weapon monitor messages required by MIL-STD-1760, but there may, of course, be such a requirement in the System 2 Specification. MIL-STD-1760 does specify that transmit sub-addresses 19 and 27 are reserved for these messages.

17.3.4 Aircraft description.

Revision C Notice 1 of the standard added the Aircraft description message, to be used by stores which need information about the carrying aircraft. This message is patterned after the Store ID message and follows most of the same rules. It allows the aircraft to tell the store which specific aircraft and station the store is on, facilitating things like use of different separation maneuvers or time delays as a function of store location. Including these functions in the store may avoid the need to modify aircraft software to accommodate the different separation characteristics of various store types.

17.3.5 Protocol for time tagging.

Time tagging requirements were added in Revision C Notice 1 of the standard to reduce the proliferation of functionally equivalent but technically different ways to pass time tags. Many data entities (e.g., aircraft position) vary rapidly with time, and, because of the delays inherent in calculating, storing, and transmitting digital data, must have a time tag to identify the point in time when the data was valid.

The requirements in Revision C Notice 1 are only for aircraft-to-store time tagging. A similar procedure for store-to-aircraft time tagging has been drafted but not yet included in the standard (July ‘99).

Stores often employ system timekeeping devices independent of the aircraft system time in order to preserve the continuity of function timelines. Time tagging permits the store to determine the time when a piece of data was valid by translating time of validity recorded in aircraft system time into store system time values.

The data latency of time tagged data is the delta time between data validity and the transmission time of the data to the store. The system specification or interface control document should define the maximum allowed data latency of each time tagged data message or entity. On many aircraft, the aircraft system time is periodically discontinuous at the convenience of the aircraft. In this type of system, the aircraft clock counts up to some predefined number, then resets, so aircraft time is not synchronized to time-of-day. The aircraft system time clock must have a maximum value that is greater than the maximum allowed data latency. This assures that the store can determine if the reported Aircraft system time at reset is significant to a specific Synchronize with data word mode code (real time format) and Aircraft system time at reset pair. These values are used by the store to resolve time tags in the event that the discontinuity event occurs between the time reference event described in B.4.2.4.1 and time tag event described in B.4.2.4.3.

The aircraft establishes time of validity by associating an aircraft system time clock value with a data message or data entity within a message and reporting that value as a Time tag along with the message or data entity. The store then uses the Time tag and Aircraft system time at reset, along with the most recent Synchronize with data word mode code (real time format) received, to translate the aircraft data time of validity into the store system time.

The store may determine if the aircraft system clock was discontinuous between a specific Synchronize with data word mode code (real time format) and Time tag pair by computing data latency. The algorithm is as follows:

S_A = data word value of most recent Synchronize with data word mode code (real time format)

S_S = store system time at receipt of last Synchronize with data word mode code (real time format)

T_R = highest value of aircraft system time before most recent reset event

T_A = aircraft system clock value at time of validity for data message or entity

T_{S1} = store system clock value at time of validity for data message or entity assuming no reset

T_{S2} = store system clock value at time of validity for data message or entity assuming reset

T_S = resolved store system clock value at time of validity for data message or entity

T_T = store system clock value at time of transmit of time tagged data message or entity

L_M = maximum latency allowed by the application system specification or interface control document

$$T_{S1} = S_S + (T_A - S_A)$$

$$T_{S2} = S_S + (T_A - S_A + T_R)$$

If $T_T - T_{S1} < L_M$, then,

$$T_S = T_{S1}$$

else, if $T_T - T_{S2} < L_M$, then,

$$T_S = T_{S2}$$

otherwise T_S is unknown

17.3.6 Definition of 2's complement, Table B-XXVII.

The definition of the MSB for 2's Complement entities was changed between MIL-STD-1760B and MIL-STD-1760C, but was changed back in MIL-STD-1760C Notice 1. The issue is whether the first bit is a "sign bit" or is a MSB with a value of minus twice the value of the next to highest order bit.

The 1760C version of Table B-XXVII agrees with Paragraph 80.2.2.2 of MIL-HDBK-1553 and is in use on existing programs. However, it is not mathematically correct to call the first bit a sign bit, since it is not the same as the sign bit on a "signed" format. The sign bit on a signed number format indicates that there is a minus sign and the rest of the bits represent a magnitude, i.e., the sign bit indicates only a negative sign. In a 2's complement, the first bit has a value of minus twice the magnitude of the next highest order bit, and if the first bit is a one, it indicates that the 2's complement of the rest of the bits must be taken to determine the magnitude of the negative number.

The interpretation of 2's complement defined in notice 1 (and in 1760B) is in use on some programs (particularly European). The interpretation that calls the first bit a sign bit results in the same bit pattern and is therefore functionally equivalent. This confusion may have been caused by the fact that the table in Revision B was not clear, i.e., it showed the MSB value as a negative number and the LSB as a positive number and did not explain how the sign changes in between. Note 2 was added on table B-XXVII to clarify this.

17.3.7 Invalidity, Table B-XXXI.

This table defines the invalidity word, which is part of some messages. The bits in the invalidity word are used to identify a word or entity that is not valid for use.

Table B-XXXI, and the notes on the table, were revised in Notice 1 to Revision C in an attempt to clarify it.

It would be logical to use the exact same invalidity bit assignment conventions for all messages that use invalidity, including user defined messages, but existing interfaces have strayed from this pattern. For example, some systems use one invalidity bit for a complete entity (may be more than one word) rather than one bit per word, as the table requires.

It seems strange to set reserved bits to zero ("valid") as required by note 2, but this is the intended mode of operation. It is not clear why this convention was adopted. It may simply be an extension of the general rule that unused bits are zero filled, and zero is defined as valid in this word. The system ICD should clearly define which words in a message contain data and which are reserved, so an aircraft that violates this rule can be functionally compatible with a store that follows the rule.

17.3.8 ASCII blank versus space.

The standard (up to Revision C Notice 1) requires unused characters to be "blank filled" in Table B-XXVI and Table B-XVI. The ASCII character set does not include a character called "blank", so this is interpreted to mean the ASCII "space" character (20H) should be inserted in unused character locations.

18. COMPATIBILITY BETWEEN VERSIONS OF MIL-STD-1760

The following is a very brief summary, and is not complete.

The fundamentals of MIL-STD-1760 have not changed since the standard was originally published, with the signal set defined in 1981 and the physical (connector) defined in 1982. All versions use the same Type I connector, signal set, and data bus. The Type II connector was added at Notice 2 to Revision B.

The first edition and revision A did not have a Logical requirement, so aircraft software must be changed to go from program-unique implementations under these versions to a standardized approach under revisions B and C. Some software change is normally required with each new store integration anyway to accommodate different targeting method, different aerodynamics, etc.

Requirements on the High Bandwidth interfaces were re-written in Revision C. They are tougher in some areas, less restrictive in others. Do not expect any Revision A or Revision B aircraft to be compliant with Revision C high bandwidth requirements--Most were not even compliant with requirements in Revisions A or B.

Other details changed between Revisions B and C and are discussed in Appendix C of Revision C. While they may prevent a system from being strictly compliant, most can be worked around in interface control documents without significant change to hardware.
A Revision B store will generally be compliant with Revision A of the standard, but significant new airplane software would still be required to put it on a Revision A airplane, unless the airplane software has already been modified to accept the standard data words in Revision B.

The current (1999) generation of air-to-ground GPS-guided stores are basically Revision B compliant. They will generally be compatible with a Revision C airplane, although there will be constraints required in the ICD to account for minor differences in the standard data words. Installing any of these stores on any aircraft will still require development of an ICD and development of software, to provide the user-defined data words and accommodate the unique identity and performance of each store.

Any new aircraft or store should be built to Revision C latest notice to capture the refinements and corrections that were incorporated in this revision. In addition, it will need to meet the requirements of an ICD which documents the peculiarities of the systems it interfaces with, regardless of which Revision the interfacing system was built to.

19. CHANGES BETWEEN MIL-STD-1760 AND MIL-STD-1760A

19.1 MIL-STD-1760 FIRST ISSUE.

MIL-STD-1760 was issued 1 Jul 81 and primarily covered the Electrical element of the interface, i.e., the signal set definition.

19.2 MIL-STD-1760 NOTICE 1.

NOTICE 1 (USAF version) was published 15 Dec 82 and added the Physical element of the interface, i.e., definition of the standard connector.

19.3 MIL-STD-1760 NOTICE 2.

NOTICE 2 was published 30 Jan 83. It was published as a Tri-service standard, with the same contents as notice 1.

19.4 MIL-STD-1760A.

MIL-STD-1760A was published 3 Sep 85. It incorporated Notice 2 into the body of the document, added MSI definition, and defined Classes.

20. CHANGES BETWEEN MIL-STD-1760A AND MIL-STD-1760B

20.1 MIL-STD-1760A NOTICE 1.

MIL-STD-1760A Notice 1 (Navy) was published 30 May 86. It added the initialization portion of the Logical Element.

20.2 MIL-STD-1760A NOTICE 2.

Notice 2 was published 24 Oct 86. It was published as a Tri-service standard with the same contents as notice 1.

20.3 MIL-STD-1760A NOTICE 3.

Notice 3 was published 30 Jan 87 and added the rest of the logical requirements.

20.4 MIL-STD-1760B.

In December of 1987 the SAE transmitted to the Air Force OPR a proposed Notice 4 to MIL-STD-1760A, which was used by the Air Force to produce MIL-STD-1760B. MIL-STD-1760B was published 15 Apr 91. It incorporated Notices 2, 3, and proposed Notice 4 into the body of the document.

20.4.1 General.

This version of the standard contains the above mentioned proposed Notice 4, plus many errors and omissions. It does not, however, contain further changes to the technical requirements. The major change that it did introduce was the deletion of all "WILL" statements (or any word of a similar intent) and the substitution of "SHALL". The reader is therefore warned that where a "SHALL" statement appears to be nonsensical in Revision B, then it can be assumed to be only an expression of intent, i.e., should be a “WILL” statement.

20.4.2 Revision B changes.

The following items detail the changes proposed to MIL-STD-1760A by Notice 4 that were introduced into MIL-STD-1760B. Some of the changes were not introduced correctly, but these are not identified here. No attempt has been made in this Handbook to identify the errors and omissions mentioned in Paragraph 20.4.1

a. <u>Table III</u>.

Addition of MIL-C-39029 /102 and /103 co-axial contacts.

b. <u>Paragraph 5.2.1.2, line 5</u>.

Typographical error correction. "ot" deleted, "not" inserted.

c. <u>Paragraph 5.2.1.2.2.1</u>.

Deletion of last two sentences. Requirement now covered by MIL-STD-1553B, Notice 2.

d. <u>Paragraph 5.2.1.4.2.1.a, line 1</u>.

Typographical error correction. "stae" deleted, "state" inserted.

e. <u>Paragraph 5.2.1.4.2.1.a, line 2</u>.

Typographical error correction. "voltae" deleted, "voltage" inserted.

f. Paragraph 5.2.1.6.3.2.a, line 1.

Current flow correction. "into" deleted, "out of" inserted.

g. Paragraph 5.2.1.9.2.1, line 1.

Typographical error correction. "shal" deleted, "shall" inserted.

h. Paragraph B.40.1.2.2, sentence 3.

Grammar correction. "thus" added.

k. Paragraph B.40.1.2.2.

Sentence 4 deleted to avoid clash with MIL-STD-1553B, Notice 2.

l. Paragraph B.40.1.2.3, sentence 1.

Requirement made less specific and therefore more encompassing. Words "store mode or the data valid bits seen in" deleted.

m. Paragraph B.40.1.5.3, line 7.

Clarification of requirement (4). "result" deleted, "consequence" added and words "resulting in the inability of the RT to move data to or from the subsystem" added.

n. Paragraph B.40.1.5.4.

Deletion of the Busy Bit setting.

p. Paragraph B.40.1.5.6.

Re-write of paragraph to include the requirements needed to avoid premature destruction of the vector word content. Also reflected in figure B-1.

q. Paragraph B.40.1.5.10.

Inclusion of "Data Consistency" requirement. This was deleted from MIL-STD-1760A, Notice 3 whilst a review was carried out to ensure that it was needed.

r. Paragraph B.40.2.2.3.

Re-word of first sentence to make it singular. There were originally (before Notice 3) multiple store description messages.

s. Paragraph B.40.2.3.

Changes in paragraph numbering to reflect changes in sub-tier paragraphs.

t. Paragraph B.40.2.3.1.

Up-front statement of the "File Structure". NO additional requirements.

u. Paragraph B.40.2.3.2.

i) Change of paragraph number.

ii) Change of title to reflect content of succeeding paragraphs.

v. Paragraph B.40.2.3.2.1.

Change of paragraph number.

w. Paragraph B.40.2.3.2.2.

i) Change of paragraph number.

ii) Deletion of the word "command" in two places as it was not applicable.

x. Paragraph B.40.2.3.2.3.

Change of paragraph number.

y. Paragraph B.40.2.3.3 and sub tier.

Change of paragraph numbers.

z. Paragraph B.40.3, sentence 2.

Introduction of authorisation requirement for non-standard data entity usage.

aa. Paragraph B.40.3.1.2.

Clarification of the inverted validity protocol. "validity" deleted, "invalidity" added.

bb. Paragraph B.40.3.1.13.

Fuze Function Distance requirements made more specific to allow introduction of Fuze Function Height (see B.40.3.1.25). The two requirements could not be met with one data entity.

cc. Paragraph B.40.3.1.25.

Cross refer to Item bb.

dd. Paragraph B.40.3.3.1, B.40.3.3.2, B.40.3.3.3 and B.40.3.3.4.

It had been found necessary to introduce extensions to both Time and Time Tag by using LLSP. It was obviously not good practice to split up these entities so all six were introduced as B.40.3.3.82 through B.40.3.3.87 and the above four paragraph numbers should have been annotated with a cross reference only.

The old paragraph text was, however, not removed although all six new paragraphs were introduced.

ee. Paragraphs B.40.3.3.77 thru B.40.3.3.80.

Correction in requirements. "integer" deleted, "number" added.

ff. B.40.3.3.82 thru B.40.3.3.87.

Cross refer to Item dd.

gg. Paragraphs B.40.3.3.88 thru B.40.3.3.90.

Introduction of Aircraft Time. This was deleted from MIL-STD-1760A, Notice 3 as "System Time", whilst a review was carried out to ascertain what was actually needed.

hh. Paragraph B.40.3.4.10.

Clarification of the inverted validity protocol. "validity" deleted, "invalidity" added.

jj. Paragraph B.40.3.4.52.

Correction of the "decreasing distance" parameter. "positive" deleted, "negative" added.

kk. Paragraph B.40.3.5.3.

Correction in requirement. Deletion of sentence 2 which discussed waypoints prior to and on "Store Release".

ll. Paragraph B.40.3.5.5, line 3.

Clarification of requirement. "air" deleted, "reference" added.

mm. Figure B1.

Cross refer to Item p.

nn. Figure B10, Note 3.

Introduction of system specification/ICD to specify pattern position etc, rather than use target Lat/Long for the centre of the pattern.

pp. Figure B-1.

Introduction of "Data Wraparound" to SA 30 and "Note 4". This to reflect MIL-STD-1553B, Notice 2.

qq. Tables B-II and B-III, Note 2.

Clarification of requirement.

rr. Table B-X.

Change of paragraph references for Headers 0422 and 0423.

ss. Tables B-XI and B-XII.

Introduction of "Fuze Function Height" into the MSC and MSM messages.

tt. Table B-XVI, Note 1.

Clarification of requirement for characters to be "upper case".

uu. Table B-XVII.

Clarification of requirements by amending Notes 4 and 5, plus introduction of Note 6.

vv. Table B-XVIII.

Clarification of requirements by adding Notes 1, 6, 7 and 11.

ww. Table B-XIX.

Clarification of requirement by introduction of Note 1.

xx. Table B-XXI, last sentence.

Clarification of requirement by the addition of "or to the applicable pre-assigned sub-address".

yy. Table B-XXIII.

Clarification of requirements by amending Notes 1, 2, 3, 5, 6 and 7.

zz. Table B-XXIV.

Clarification of requirements by amending Notes 2, 4, 6, 7 and 8.

A. Table B-XXV.

Clarification of requirements by adding Note 1 and amending Notes 2 and 3.

B. Table B-XXVI.

Various amendments to reflect the above applicable changes, eg Fuze Function Height and Invalidity.

C. Table B-XXXI.

Cross refer to Item aa.

D. Tables B-XXXII and B-XXXIII.

Applicability of Note 2 indicated by adding "(Note 2)" under the "Store Control" Heading.

E. Table B-XL, Note 2.

Clarification of requirements when table is used for 7 bit ASCII, by actually allocating bit 01 and bit 09 to HOB usage.

F. Table B-XLI.

Applicability of Note 1 indicated by adding "(Note 1)" under the "Discriminator Enables" heading.

G. Acronyms and Abbreviations.

To avoid the necessity of going to REV B, the SAE had provided this new section as Appendix C. MIL-STD-1760B actually incorporated this as paragraph 3.2 on Pages 4 and 5.

21. CHANGES BETWEEN MIL-STD-1760B AND MIL-STD-1760C Notice 1

21.1 Changes between MIL-STD-1760B and MIL-STD-1760B NOTICE 1.

Notice 1 was published 17 Mar 92. It changed the distribution notice on the front of the document from “Distribution D” (DoD and DoD contractors only) to “Distribution A” (public). There were no technical changes in this version.

21.2 Changes between MIL-STD-1760B NOTICE 1 and MIL-STD-1760B NOTICE 2.

Notice 2 was published 25 Jun 93. It added definition of the Type II connector (to be used on blind-mate and rail-launch applications).

21.3 Changes between MIL-STD-1760B NOTICE 2 and MIL-STD-1760B NOTICE 3.

Notice 3 was published 5 Feb 96 - NOT TO BE CONFUSED WITH THE SAE PROPOSED NOTICE 3 DRAFT. Notice 3 changed the name of the document to “Interface” standard. While this change appeared to be trivial, it was significant in that it designated MIL-STD-1760 as an Interface standard that is to be retained and used under acquisition reform, while most mil specifications and standards were being canceled.

21.4 Changes between MIL-STD-1760B NOTICE 3 and MIL-STD-1760C.

The following significant changes were made between MIL-STD-1760B Notice 3 and Revision C. These changes incorporate most of the technical content of the proposed NOTICE 3 DRAFT, dated Jan 94, which was provided to the Air Force by the SAE. Note that this is only a summary and is not complete. The final published version of rev C, dated 20 Mar 97, is defined by the files “1760C1.PDF” and “1760C2.PDF”, both dated 3/27/97.

a. Replaced High Bandwidth (HB) and Low Bandwidth (LB)) sections: Sections 4.3.1, 5.1.1, 5.2.1, 5.3.1 are heavily revised. This change reduces allowed signal level, reduces allowed Voltage Standing Wave Ratio, changes the grounding scheme for HB 1 and 2, defines a reference point at the aircraft end of the HB and LB networks and adds requirements on the network back to this point, reduces allowed propagation delay, etc. LB nominal impedance is changed to 600 ohms.

b. Changed connector requirements to compatibility only: As part of government standards reform, the connector requirements were changed to only state the interface requirement, i.e., be compatible/ interchangeable with the standard connectors. The decision to use or not use a specific MIL-qualified part is now left to individual programs and contractors.

c. Added reference to SAE 15531: Allows this commercial version of the data bus standard to be used in lieu of MIL-STD-1553.

d. Reduced tolerance on 1553 zero crossing deviation from 150 to 120 ns (5.1.2.2.1): Concern was that 150 nanoseconds is not good enough at the ASI because 150 is what can be tolerated at a 1553 receiver, and the ASI may be several feet and several connectors away, so the tolerance must be less at the ASI.

e. Added carriage store requirements (new Section 5.3): A new section establishes requirements on carriage stores in order to reduce proliferation of non standard carriage stores. Numerous references to “mission stores” were changed to clarify where requirements apply to mission stores, carriage stores, or both.

f. Clarified allowable voltage drops on power interfaces: Actual voltage required at the ASI CSI, CSSI, and MSI is now stated (para. 5.1.8.2, 5.1.9.2, 5.2.8.2, 5.2.9.2, 5.3.8.2, 5.3.9.2) rather than stating voltages relative to MIL-STD-704.

g. Deleted the Electromagnetic Compatibility requirements and the associated Appendix A.: EMC requirements inappropriate in an interface standard were deleted.

h. Added umbilical cable requirements (new Section 5.4): New section defines characteristics of the umbilical cable between the aircraft and the store in order to reduce proliferation of non standard umbilicals.

i. Modified maximum power load current on figures 17 & 18: Limits for load currents of less than 0.1 second duration (in-rush current) are now defined, making the requirements more compatible with solid state power controllers.

j. Revised requirements on Mass data transfer messages (B.4.2.3): This section was re-written to more clearly define mass data transfer, using the approach adopted by current weapons as the baseline.

k. Rearranged and consolidated electrical power interrupt requirements (new section 5.5): Minor change in requirements, major change to the document, to clarify and reduce duplication between sections.

l. Rearranged and consolidated connector requirements (new Section 5.6): Minor change in requirements, major change to the document, to clarify and reduce duplication between sections.

m. Replaced table B-XXVI, standard data entities: Table B-XXVI and the 236 paragraphs that it referenced were replaced with a new table. This new table is 15 pages long and includes the technical requirements that were formerly in the paragraphs. Also, additional standard data entities were added and some existing ones were modified to correct duplications, ambiguities, or inadequate bit values.

n. Clarified restrictions on broadcast on the MIL-STD-1553 bus (B.40.1.5.11): Restrictions on broadcast messages to some subaddresses were added.

o. Added wander axis definition and other details to figure B-3: Makes the coordinate definition consistent with that used on current weapon programs.

p. Deleted MIL-SPEC references: Eliminated as many references to military specifications and standards as possible. Most of the remaining references only require interchangeability with the MIL document, not actual use of the MIL hardware. Note that MIL-STD-1760 and MIL-STD-1553 have been identified as necessary Interface Standards and are available for continued use.

q. Moved guidance and lessons learned data to this Handbook: The technical guidance from the notes section (6.0) was moved to this document, MIL-HDBK-1760.

r. Added “annotations” in the text: These comments about what changed and why show up in brackets, numbered like “[NOTE 1]”. The notes are at the end of the document in appendix C.

WARNING: While the notes identify all the major changes, they are not necessarily complete or accurate. Do not assume that something has changed, or not changed, unless you see it in the body of the actual standard.

s. Refinements, corrections, paragraph numbering simplified: Several typos, misplaced subscripts, and ambiguous phrases are corrected. Several paragraphs that added no technical information were deleted, resulting in a ".1" being deleted from nearly every paragraph number. A summary cross reference of the old paragraph numbers to the new, and to the sections of this Handbook, is provided in section 22

21.5 Changes between MIL-STD-1760C and MIL-STD-1760C NOTICE 1.

Notice 1 was published 2 March 1999. The following is a summary of the significant changes:

a. Clarified the status of devices such as rocket pods, flare dispensers and small smart bomb dispensers. Basic options considered were: a) Call them “mission stores”, which is confusing since they drop weapons, like a carriage store, or, b) Call them “carriage stores”, so they can claim the higher input power voltages allocated to carriage stores, but this ignores the fact that they will be carried on other carriage stores in some applications and their lack of CSSIs violates the carriage store section of 1760C, or, c) define another class of store called a “dispenser” which has a 1760 interface on the top and some smaller, lower cost interface (or no electrical interface at all) to the devices they carry. Option C was chosen and is included in the notice.

b. Clarified that 270 V DC is not required in the Class IIA interface.

c. Put address bit A_0 back on figure 2 to correct a typo.

d. Corrected the references to Appendix B in paragraph 5.5.4.

e. Added the lines that were missing on figure 25.

f. Deleted the Synchronize with data word Format flag and associated figures, since they are no longer needed.

g. Corrected references in the checksum paragraph (B.4.1.5.2.).

h. Added time tagging in para. B.4.1.5.12 and B.4.2.4 to reduce the proliferation of functionally equivalent but technically different ways to pass time tags. Note, this version is only the aircraft-to-store part.

i. Added an Aircraft Description message in para. B.4.2.2.6, to be used by stores which need information about the aircraft they are being launched from

j. Corrected a bit number error in para. B.4.2.3.2.3.3.

k. Corrected a bit number error in note 2 of table B-XI.

l. Corrected the wording/meaning of two fuzing data entities, in line 16 and line 17 of table B-XXVI.

m. Deleted time (M) from line 76 of table B-XXVI in conjunction with the time tagging change.

n. Added Store station number and pylon/bay identity data entities to table B-XXVI.

o. Changed Table B-XXVII by inserting a minus sign in front, and doubling the value, of the MSB of each of the 2’s complement word formats. Numbered the note that was there, and added notes to this table and table B-XXVIII to clarify.

p. Corrected a typo on line ten of the second page of Table B-XXVII by superscripting the exponents.

q. Deleted the minus sign from the “Angular Rate “M” LSB on Table B-XXVII. This minus sign was there in rev. B and in the SAE draft notice 4, but is mathematically inconsistent with the rest of the table and is a mistake.

r. Changed Table B-XXXI in the following areas:

"VALIDITY OF ENTITY" is changed to "VALIDITY OF WORD" in the table. Rev B and C referred to "an entity", but this table is now being used primarily for the words in subaddress 11, rather than generic user-defined entities, so "word" is more appropriate in the table and in note 1.

Note 2 was changed to only apply to subaddress 11, which is the only place the standard requires use of validity bits.

Note 3 was modified to account for use of words 31 and 32 for routing through a carriage store, as allowed in Revision C.

Note 4 is a new note which basically abandons efforts to standardize how user defined messages use invalidity, since we have found that existing programs have adopted a variety of different conventions.

s. Added a continuation list on the end of Appendix C, to explain the changes made in Notice 1.

22. Cross reference of sections between Revision B, Revision C and Handbook.

TABLE XXXV. Revision B, C and Handbook Cross Reference.

1760C paragraph	**1760B paragraph**	**SUBJECT**	**MIL-HDBK-1760 Reference**
Section 1	Section 1	Scope	Section 1
2	2	Referenced documents	2
3	3	Definition of terms	3
4	4	General	4
		System Design	5
4.3.1 5.1.1 5.2.1 5.3.1	4.3.1.1 5.1.1.1 5.2.1.1	High Bandwidth Interface	8
4.3.2 5.1.2 5.2.2 5.3.2	4.3.1.2 5.1.1.2 5.2.1.2	Digital Data Bus Interface	6
4.3.3 5.1.3 5.2.3 5.3.3	4.3.1.3 5.1.1.3 5.2.1.3	Low Bandwidth Interface	9
		Discrete signals	7
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4.3.5 5.1.5 5.2.5 5.3.5	4.3.1.6 5.1.1.5 5.2.1.5	Interlock Interface	7.2

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23. NOTES

23.1 Intended use.

MIL-HDBK-1760 is intended to provide guidance for airborne military applications and applies to all aircraft and stores that electrically interface with each other.

23.2 International standardization agreements.

Certain provisions of MIL-STD-1760 are subject to international standardization agreements: NATO STANAG and ASCC Air Standard. It is intended that MIL-STD-1760 will be compatible with the following documents:

a. STANAG 3350AVS, Analogue Video Standard for Aircraft System Applications;

b. STANAG 3837AA, Standard Aircraft/Store Electrical Interface; and

c. STANAG 3838AVS, Digital Time Division Command/Response Data Bus.

23.3 Keyword listing.

aircraft
aircraft station
audio signals
avionics
bus controller
data word
discrete signals
electrical connector
electrical interface
electrical power
high bandwidth signals
low bandwidth signals
remote terminal
serial data bus
store
stores management system
suspension and release equipment
video signals

Some of the people who worked on this handbook.

CONCLUDING MATERIAL

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3. DOCUMENT TITLE
AIRCRAFT/STORE ELECTRICAL INTERCONNECTION SYSTEM

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

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