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MODULAR AVIONICS BACKPLANE FUNCTIONAL REQUIREMENTS AND CONSENSUS ITEMS (MABFRACI)

RATIONALE

This document has been reaffirmed to comply with the SAE 5-year Review policy.

FOREWORD

This document contains functional requirements for modular avionics backplanes as developed by the Backplane Interconnect Requirements Task (BIRST) group of the SAE AS-2, Interconnect Networks Committee. In addition to defining the requirements for modular avionic backplane interfaces, a suggested list of associated documents is included. Consensus items and rationale on all the areas are also presented. These requirements are an edited compilation of those voiced by numerous military and commercial organizations primarily concerning aircraft applications.

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1. SCOPE:

The original purpose of this document was to establish interface requirements for modular avionics backplanes to be prototyped up to 1995. The document was issued as ARD50011 in September 1992. It is being reissued as an SAE Aerospace Information Report (AIR) in order to:

a. Preserve the requirements for more than 2 years
b. Support design of retrofits and avionics systems to be fielded in the years 1995 to 2000
c. Provide a baseline for updating the requirements of future integrated systems

These requirements were and are intended to promote standardization of modular avionic backplane interfaces. These requirements have been driven predominantly, but not exclusively, by aerospace type military platforms.

1.1 Purpose:

Several studies (2.2.1, 2.2.2, and 2.2.3) have shown that a significant reduction in the life-cycle-cost (LCC) of complex systems can be obtained through the use of form, fit, and function (F^3) interface standards. Perhaps the most recent implementation and application of the F^3 concepts have been the development of common avionics modules for military aircraft programs. Significant effort has been expended to develop a family of line replaceable modules (LRM) which in many cases supplant the use of traditional line replaceable units (LRU). The applications for use of avionics LRMs include new platforms as well as product improvement, retrofit, and upgrade programs. Depending on particular programmatic requirements, the following benefits may be realized when using common avionics LRMs:

a. Reduction in the size of line replaceable items

b. Reduction in the number of types of line replaceable items

c. Reduced Avionics Intermediate Shop (AIS) complexity through a two-level maintenance structure with less AIS repair

d. Use of common building blocks to provide functions

e. Increased fault detection and tolerance with module level fault isolation

f. Support for reconfiguration.

The key to the application of the modular design approach for avionics lies in the standardization of backplane interfaces with integrated rack and packaging guidelines.

Currently, standards exist for some interfaces. Examples are the Pi (see AS4710) and TM (see AS4765) buses, but others may apply. There is a growing awareness that further definition of backplane interfaces is required. No overall view of backplane functions and requirements is available within the open literature. This document is intended to provide that overall view and avoid a fragmented approach to modular avionic backplane interface standardization.

1.1 (Continued):

The AS-2 Committee fosters the systematic approach of requirements definition before standard adoption or development. The baseline for this document was the Modular Avionics System Architecture (MASA) program document, “Requirements/Standards for a Modular Backplane” (2.2.4) which was developed by the MASA Interface Panel.

1.1.1 Document Objectives: This document was developed with two main objectives:

a. Define what modular avionics backplane services, interfaces, and physical attributes should be standardized or specified
b. List task group consensus attributes on which further backplane interface standardization and specification can be based.

The first objective is covered by Sections 3 and 6 while the second objective is covered by Sections 4 and 5. Thus, the only requirements included are those for which consensus could be realized within the group.

1.1.2 Document Structure: A definition of each identified backplane function is given in Section 3, listing the services which may be required by a modular avionics backplane. Requirements which may be applied generally to all backplane services are given in Section 4 while Section 5 describes requirements unique to a particular backplane service. Section 6 defines the types of documentation which are required to implement a backplane system which supports common avionics interoperability.

1.1.3 Scope of Detailed Service Requirements: This document brings together the definition of all the services required to be supported by the modular avionics backplane. Some requirements need to defined in greater detail before standards can be developed. However, these detailed requirements must be developed for use within the environment and constraints indicated within this document.

NOTE: The specific requirements defined by the group are considered important even though only an initial look at the problems. A more detailed investigation of the requirements could produce other results. The more detailed results should be adhered to, since the ones in this document are just an initial evaluation of the services.

It should be noted that these are functional requirements and more than one backplane service may be implemented by a single standard (e.g., Data Flow and Sensor/Video Networks). The BIRST group advocates consideration of requirements for similar networks during the development of a standard to minimize the number of standards generated.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this specification and references cited herein, the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

2.1.1.1 AS4074 Linear Token Passing Multiplex Data Bus

2.1.1.2 AS4075 High Speed Ring Bus

2.1.1.3 AIR4911 Sensor/Video Interconnect Subsystems with Rationale

2.1.1.4 ARD50012 Requirements Document for Sensor/Video Interconnect Subsystems with Rationale (to be replaced by AIR4911)

2.1.1.5 ARD50022 Local Memory Bus Requirements

2.1.1.6 ARD50023 Data Flow Network Requirements

2.1.1.7 AS4710 Pi-Bus Standard

2.1.1.8 AS4765 TM-Bus Interoperability Standard

2.2 Applicable References:

2.2.1 “Common Modules (Hardware/Software) Cost Effectiveness”, Final Report to Odgen Air Logistics Center (ALC/MMETM), Hill Air Force Base, Utah 84056-5609, Battelle, Report Number: F04606089-D-003425, May 1990.

2.2.2 “A Strategy for Reforming Avionics Acquisition and Support”, J. R. Gebman and H. L. Shulman with C. L. Batten, A Project AIR FORCE Report for the United States Air Force, Rand Report Nr. R-2098/2F.

2.2.3 “JSRC Avionics Commonality Management Study”, Prepared for the Joint Service Review Committee, ARINC Research Corporation and Westar Corporation, ARINC Publication Nr. 08671-01-91-SD-ANN-005.

2.2.4 “Requirements/Standards for a Modular Backplane”, Issue # 1 dated March 24, 1989, a Modular Avionics Systems Architecture (MASA) program document developed by the MASA Interface Panel.

2.2.5 IEEE Std P1149.5 - Standard for Module Test and Maintenance (MTM) Bus Protocol

2.2.6 IEEE-STD-1101.4-1993, "IEEE Standard for Military Modules, Format E Form Factor"

3. BACKPLANE DESCRIPTION:

This section describes the known backplane services, signal types, and media. An individual backplane may not be required to provide all of the services, signal types, or media. The intent is to support standard interfaces not standard backplanes. It is anticipated that some standard interfaces will provide and support one or more of the backplane services.

3.1 Backplane Services Description:

This section describes the known services to be supported by the backplane. These services include a tightly coupled bus; a message oriented bus; a data flow network; a test and maintenance bus; a global bus; a sensor/video network; configuration services; and utilities such as discretes, power, and ground. Figure 1 shows some examples of backplane services and the interconnection within and between module clusters.

3.1.1 Tightly Coupled Bus (Local Memory Bus): A tightly coupled bus is characterized by low latency and localized control. It is expected that a tightly coupled or local memory bus would be used by single and multiple processors. No matter how many processors are used, they will all be concerned with the same process. Examples of this service are executing sub-processes in a parallel processing system, the off-module extension of a processor memory or I/O bus, and the coupling of two or more processors to perform a single process.

3.1.2 Message Oriented Bus: A message oriented bus provides a multiplex communication system which transfers data and/or control in the form of messages. A message is an autonomous package containing both application specific data and network control.

3.1.3 Data Flow Network: A data flow network is the means by which two or more modules are interconnected to provide multiple, concurrent, nonblocking high bandwidth communication paths. Typically, this network is used to carry large amounts of data between memories and special purpose processors at very high rates, so that the data can be processed within specific time constraints. Arbitration is typically performed infrequently by a circuit switching type function.

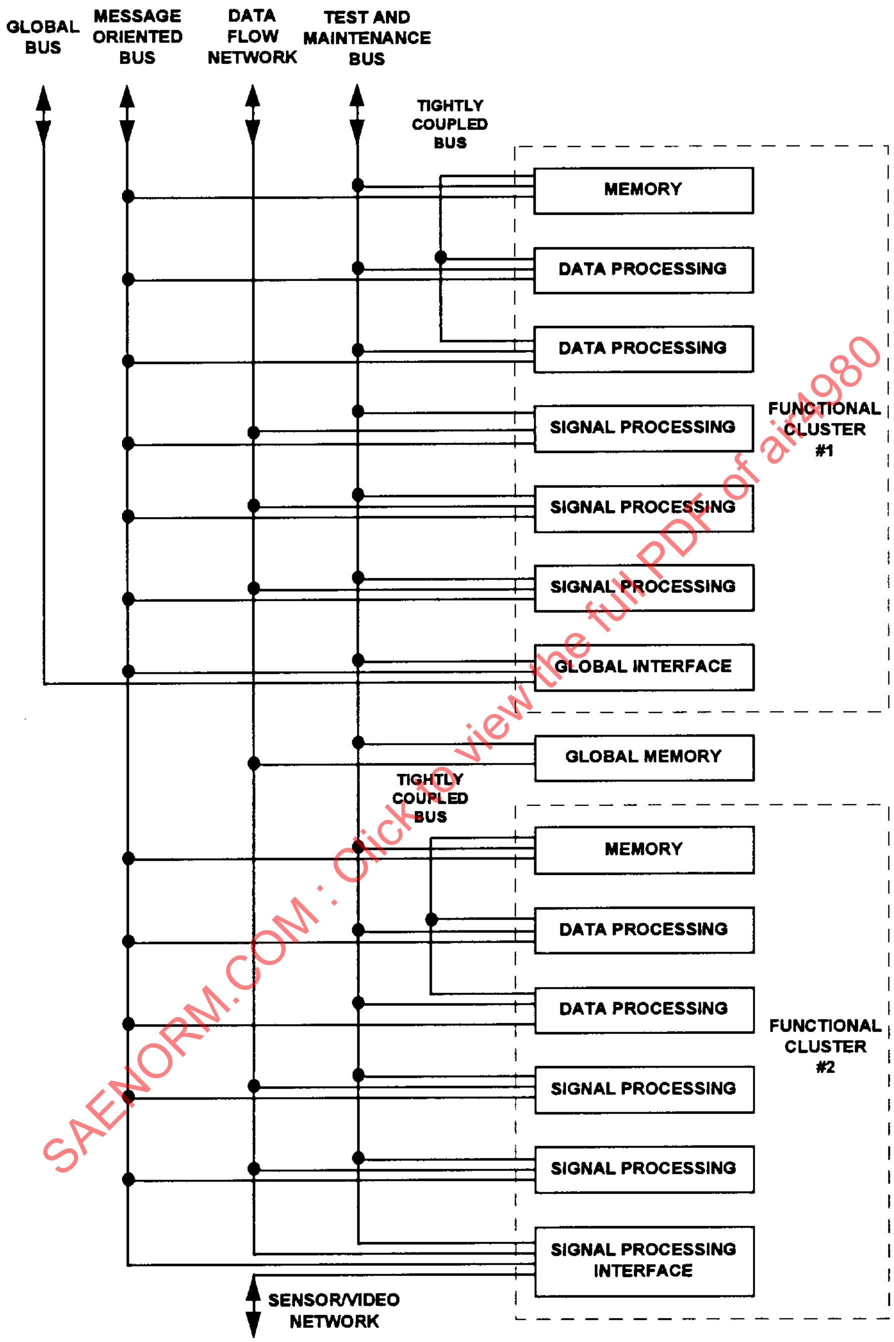

FIGURE 1 - Examples of Backplane Services

3.1.4 Test and Maintenance Bus: The test and maintenance bus provides a support service in the backplane. It provides for the transfer of diagnostic, test status, and test control information. Maintenance functions such as the recording of fault information is also supported. Test and maintenance buses provide the capability to communicate information about the status and health of module resources. The test and maintenance bus interfaces to, and has the ability to command, embedded module test resources and diagnostic functions.

3.1.5 Global Bus: Global buses are those multiplex communication systems which extend beyond the backplane.

3.1.6 Sensor/Video Network: A sensor/video network provides high bandwidth communication paths which may extend beyond the backplane. Typically, each path is considered dedicated to a single data flow at one time and connections are reformed infrequently.

3.1.7 Support and Integration: Support and integration services are provided by the backplane for system level hardware and software test and evaluation. These services connect modules on the backplane to a user console providing test and integration support. This capability is typically present, but not used, in an operational system.

3.1.8 Configuration: Configuration services are provided by the backplane to allow a capability for configuring modules (e.g., provision of address straps/module slot IDs).

3.1.9 Discretes: Discrete signal lines are provided for signals which cannot be integrated into other backplane functions either because their information content/source is singular in nature or because the latency requirement for the signal prohibits encoding with other signals.

3.1.10 Power: The power lines are the means by which a voltage source is supplied to each module to provide power for active circuitry.

3.1.11 Ground Planes: The ground planes are provided for screening (shielding) modules, components, and signals.

3.2 Signal Types Description:

The services described above may utilize different signal types. Each signal type will present particular requirements and characteristics which must be considered.

3.2.1 Digital: A signal where information is transferred by a finite range of logic states, typically “0” and “1”.

3.2.2 Analog: A signal where information is transferred by a variable level, the exact level representing the information transferred.

3.2.3 RF: An analog signal of high bandwidth (usually over 20 MHz) where information of much lower bandwidth is often modulated on a carrier frequency.

3.2.4 Video: An unmodulated analog signal of low to moderate bandwidth (usually less than 20 MHz).

3.3 Media Description:

The signals defined above may be transferred upon a variety of media. Each media will present particular requirements and characteristics which must be considered.

3.3.1 Electrical: Electrical media of different types are commonly used for various interconnects either entirely within the backplane (local) or extending beyond the backplane (global). All of these types are susceptible to a greater or lesser extent to noise induced within the conductors by electromagnetic radiation. The use of these different types of electrical media becomes increasingly difficult with increasing frequency, requiring more and more complex construction techniques.

3.3.2 Fiber Optic: Fiber optic media will be used for various interconnects either entirely within the backplane (local) or external to the backplane (global). Fiber optics is considered relatively invulnerable to external electromagnetic radiation. The use of fiber optics is considered to provide improved performance in terms of signal bandwidths.

4. GENERAL REQUIREMENTS:

This section addresses the general requirements for the backplane, regardless of the service provided. It covers the general areas of security, packaging, mechanical and electrical interfaces, testability, and system level constraints.

4.1 Security:

Backplanes shall support the necessary partitioning to implement a trusted computing base in accordance with the target platform security requirements.

RATIONALE: Security requirements will vary from system to system and will be handled differently in each case. This is a right dodgy area we don't want to get into.

4.2 Module Size:

It is believed the SEM-E size (2.1.2.1) will become the dominant module size. The pitch shall be standardized. Thicknesses greater than that of the standard thickness shall be allowed with either a single connector or multiple connectors. No consensus was reached on whether a greater thickness would be allowed in standard thickness steps or continuously variable. See Figure 2 for an illustration of module pitch, width, thickness, and height.

RATIONALE: SEM-E characteristics have been used in the majority of module developmental programs. Since there are many modular design issues to be resolved, freezing of some characteristics such as module size for a period of time is not only reasonable but necessary. Module height is considered to have a minimal effect on backplane design but should be studied. Module width significantly affects the backplane design requiring a trade-off between width and signal density and should be studied. Module thickness and pitch also significantly affect backplane design. All four size characteristics are interrelated.

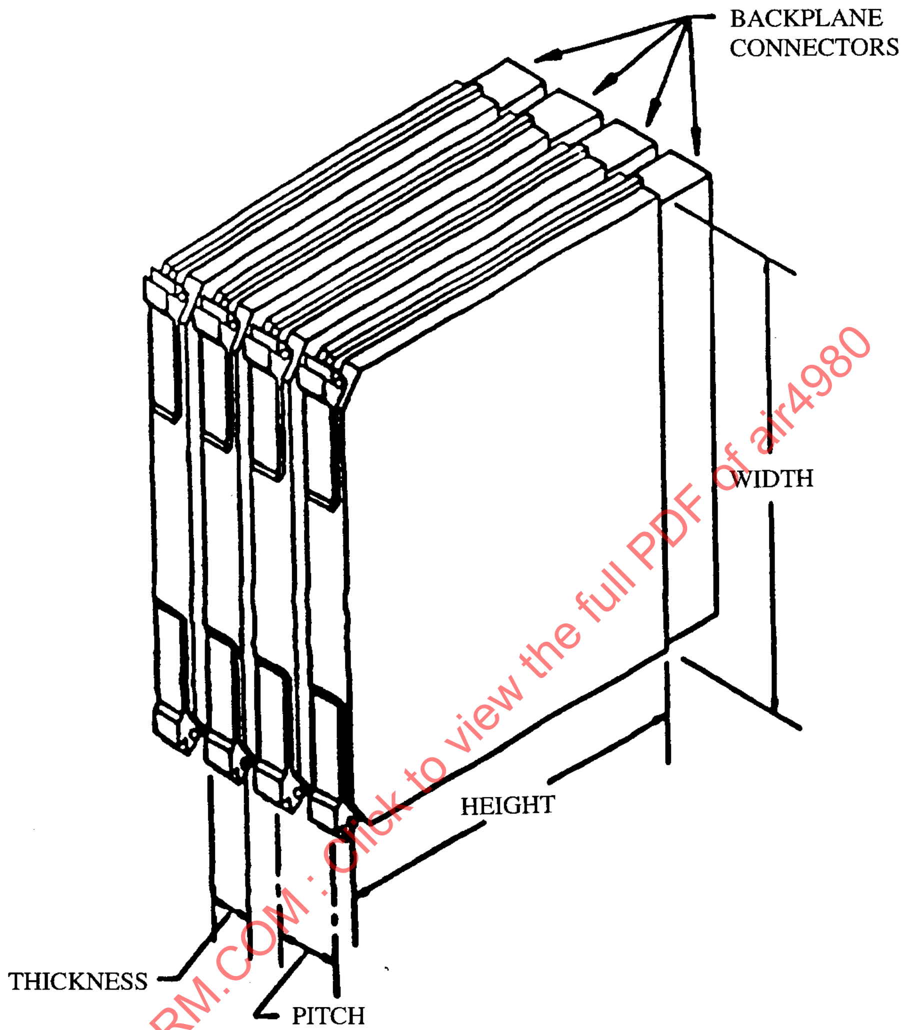

FIGURE 2 - Dimension Nomenclature

4.3 Insertion/Removal:

The transfer services of the backplane shall not be degraded by the removal of modules. Power may be removed from the backplane for module insertion and removal. The module and its related connector shall allow a minimum of 500 mate/demate cycles, desirably 1000 mate/demate cycles. Insertion and removal forces are to be defined in the applicable packaging documents.

RATIONALE: While modules are assumed to have high reliability (10 000 hours MTBF or more), it will be necessary to remove modules in order to check out connectors, backplanes, and failures not isolated by fault detection circuits. Assuming 400 hours of operation per year over a 20 year life, a mate/demate requirement of 500 allows removal and reinsertion every 16 hours of operation. The desired goal of 1000 allows this procedure every 8 hours of operation. Note that the mate/demate requirement affects both module and backplane connector design. Also note that high frequency buses may need to be terminated when modules are removed.

4.4 Rack Interface:

The rack is defined as the physical framework which provides support, protection, and heat transfer for the modules and backplane assemblies. The effect of connecting the backplane services to the rack interface shall be taken into account. For example the global buses are both backplane interfaces and part of the rack interface.

RATIONALE: Many of the backplane services described in 4.1 are limited to within a single rack and so require only mechanical support interfaces within the rack. However, some backplane services extend between racks and, as such, must also interface with the rack to pass signals out of the rack. This may affect both the backplane service and the physical backplane. Since the backplane is removable, additional connectors, other than at the module and the rack, may be required. This may not be acceptable such that a connection physically separate from the rest of the backplane may be required to minimize losses. Similarly, space must be allowed for the separate connection to be made to the module through the backplane. The above rack interface requirement simply states: Include backplane services in the overall system design.

4.5 Mechanical:

The backplane shall provide the infrastructure required to support the module connectors and backplane signals (e.g., power, ground, buses, returns, discretes). The backplane shall also be designed to withstand the specified number of mate/demate cycles, related insertion and removal forces, and environmental stresses without structural damage or impact on the line trace impedance. The backplane shall not be required to provide structural rigidity for the modules. The media for all modular avionic backplane services shall be removable from the rack while the rack is in place. It is desirable that the media for all modular avionic backplane services be removable as a single item.

4.5 (Continued):

RATIONALE: The backplane contains the signal routing line traces which carry signals between the modules. The backplane typically mounts half of the connector through which these signals are passed between the backplane and the inserted modules. The backplane should be capable of supporting the connector halves during the high insertion/removal forces related to the mate/demate cycle of a module, without affecting the performance of the signals in the backplane. Sufficient rigidity should be provided by the module supporting rails such that, if the backplane were removed, the modules would still be adequately clamped. This is needed to prevent excess forces being placed on the connector shell attached to the backplane which could distort the signal pin connections and routing line traces. Since the rack is considered to be a semi-permanent part of the aircraft, the backplane service media must be replaceable from the installed rack for maintenance and repair. To ease this removal, it would be best if all service media could be replaced as a single item. However, it is reasonable that for some services, which connect to the rack interface, separate media may be required.

4.6 Isolation:

All electrical connectors on the backplane shall have appropriate electromagnetic shielding. RF or video backplanes may have different requirements than the digital backplane.

RATIONALE: The definition of isolation requirements for backplane interfaces is best left to individual standards since these services may be discrete, serial, or parallel and have any of the signal types describe in 3.2.

4.7 Maximum Number of Modules:

The maximum number of modules shall be consistent with the addressability limits and the specific electrical/optical properties of the applicable bus types employed in the configuration.

RATIONALE: No consensus can be reached for a general requirement to be placed on the number of modules to be provided for by all services defined because the number of modules will be different for each service. For example, the global bus will extend beyond one rack to many racks and thus cannot be limited by the number of modules in a rack.

4.8 Testability:

It is required that the method employed to interconnect two or more modules in a backplane support testing of the backplane.

RATIONALE: This requirement allows determination of the ability of these modules to fulfill the communication part of their overall tasks. This requirement may not apply to all services because it is not possible, e.g., power and ground.

4.9 Module Keying:

The backplane connector associated with each module type shall have a unique key.

RATIONALE: The unique key meets the need for correct module location and orientation.

4.10 Custom Backplane:

The backplane will have defined pins for certain services and optional pins for other services. Customization of the backplane is allowed but a specified service must adhere to its allocated pin locations.

RATIONALE: Some applications will not require all the services described in section 4.1. It is not reasonable to burden all applications with the requirements of all the backplane services. The group recognized that there are some issues with respect to pin definition and layout that are beyond the scope of this document; these issues should be addressed in a future document.

4.11 Multiple Connector Modules:

Modules with multiple backplane connectors shall be allowed within the limits of insertion force constraints, thermal constraints, etc. One of the connectors shall utilize the defined pins for the backplane services. The other connector(s) are defined by the needs of the system design.

RATIONALE: System design may require more input/output than is provided by the defined pins for the backplane services. Additional connectors must be allowed to provide for the required input/output.

4.12 Blind Mating of Fiber Optic Connectors:

The backplane shall provide for blind mating of fiber optic connectors into or through the backplane.

RATIONALE: Unless fiber optic connectors can be blind mated as part of the module connector, maintenance activities will be increased and additional access for mating and demating may be required.

4.13 Software:

The consensus of the task group was that software is not a backplane requirements driver once the architecture is defined.

RATIONALE: Software does not appear to place that many requirements onto the backplane. A particular application is probably a much larger driver. The requirements that software imposes on a modular avionics backplane are, in part, architecture dependent. For an application whose processing requirements can be met with one processor module, the requirements are relatively simple. The backplane

4.13 (Continued):

must support the following: (1) The ability to input data to the software residing on the processor module; (2) The ability to take output data from the software residing on processor modules; (3) The ability to inform the software residing on the module of external events (e.g., interrupts); and (4) If the software does not reside in nonvolatile memory, the ability to load and verify (i.e., read) software into memory on the processor module. This could be considered a special case of (1) and (2).

For an application requiring two or more processor modules, two other requirements are added. In addition to items 1 through 4, stated previously, the backplane must also support the following: (5) The ability to allow inter processor communication (e.g., data) and (6) The ability to allow interprocessor coordination (i.e., events, semaphores). A backplane that meets requirements 1 through 4 should also be able to meet requirements 5 and 6.

4.14 Active/Passive Backplanes:

The use of active devices on the backplane is not precluded.

RATIONALE: It was the consensus of the group that active backplanes should not be excluded, but their use is not likely. Active backplanes will present the system designer with many challenges, i.e., maintenance, power, and built-in-test.

4.15 Pin Count:

A primary objective shall be to minimize the pin count of the backplane connector. In addition, standard connector(s) shall allow sufficient pins to implement a minimal set of standard data path widths (e.g., 16, 32).

RATIONALE: The number of pins in the backplane connector relates directly to force required to mate the connector, and therefore to the complexity of the design required to prevent damage to the backplane pins or connector over the life of the system. The number of pins also relates inversely to reliability, the more contacts the lower the reliability. Other factors including impedance and noise considerations require minimizing the pin count. Interface constraints may require different variations in bus width which will require different slash sheets to the developed interface standards.

A trade-off point must be established between parallel and serial data path connections. Serial data path connections minimize pin count, but add considerably to the complexity needed to maintain the same data transfer capabilities, as compared to parallel paths.

5. BACKPLANE SPECIFIC REQUIREMENTS:

5.1 Backplane Services:

This section addresses requirements that are unique to the type of service being provided. These requirements consist of both amplifications of general requirements for a particular service as well as requirements that are unique to the specific service. Unique requirements to be considered include length, isolation, complexity, mechanical constraints, number of modules, and clocking.

5.1.1 Tightly Coupled Bus (Local Memory Bus): Detailed requirements for a tightly coupled bus were defined by the Local Memory/Data Network Interconnect Requirements Task Group of AS-2. These requirements are documented in ARD50022 (2.1.1.5). High Level requirements for a tightly coupled bus are listed in the following paragraphs.

5.1.1.1 Number of Modules: The bus shall be capable of supporting up to 5 modules. It is desirable that it support up to 10 modules.

RATIONALE: The number 5 arises from a typical requirement for 1 or 2 processors, global memory, and I/O. It is felt that a substantial number of applications could be covered by 5 modules. If, however, it were possible to have up to 10 modules without impairing performance, that capability would be an advantage. A typical performance consideration, here, is the unacceptability of wait states in the single processor case or once a processor has been granted access to this bus in the multiple processor case.

5.1.1.2 Bus Width: It is not a requirement that a specific bus width be implemented. However, the bus shall be capable of supporting data and control requirements for 8, 16, 32, and 64 bit processors for a variety of processor architecture types. Mixed data width transfers on tightly coupled buses shall not be precluded.

RATIONALE: If it were possible to implement a serial bus, this approach should not be precluded. In the near and medium time frame, the majority of tightly coupled buses will be parallel. The desire not to burden smaller data path width processors with the requirements of larger data path width processors means that the backplane will be modular and custom. A tightly coupled bus must be applicable to different processor architecture types. These include a single processor accessing resources on associated modules and multiple processors exchanging data and sharing resources.

5.1.1.3 Clock Rate/Delay: It is highly desirable that the timing performance of a tightly coupled bus not preclude the full performance of a processor to be realized.

RATIONALE: It is considered that this goal could probably be achieved for a smaller number of modules.

5.1.1.4 Reliability: The bus shall not significantly contribute to the failure rate of the system compromising the bus and the connecting modules.

RATIONALE: The processor backplane will be dedicated to a single process. Hence, for a well balanced design from a reliability point of view, no one element should be significantly less reliable than any other. The minimum reliability of the backplane should therefore be no less than that of a module.

5.1.1.5 Data Integrity: It is desirable that the error rate for a transaction across this backplane interface should be no worse than if the whole of the circuitry were incorporated in a single module. Error detection/correction may be needed.

RATIONALE: As above, a tightly coupled bus will be dedicated to a single process which has been split across a number of modules. Thus, it is desirable that the integrity of the data be the same as if a single module were used to implement the process. Due to the more severe environment of the backplane compared to on a module, additional errors can be expected such that error detection/correction will be required. The choice between these two will depend on the type of data; i.e., whether all data is important (error correction) or some can be missed provided erroneous data is not included (error detection).

5.1.1.6 Physical Separation: There is no consensus requirement for this item. The maximum physical separation of modules connected to this bus should be determined by system and implementation requirements.

RATIONALE: Maximum physical separation impacts performance. Performance requirements are determined by the types of modules connected to a tightly coupled bus. Thus, no requirement may be specified in this document.

5.1.1.7 Addressing: A tightly coupled bus is required to support a 32-bit address space.

RATIONALE: The consensus of the task group was that a 32 bit address space is sufficient.

5.1.2 Message Oriented Bus:

5.1.2.1 Number of Modules: The bus shall be capable of supporting up to 32 modules. It is desirable that it support up to 128 modules. One Interface per module is assumed.

RATIONALE: 32 modules should be more than adequate for most process communications within single clusters. 128 may be required for process communications that apply to rack to rack process communications and some intra-rack communications where the rack has more than one cluster. It is recognized that the evolution of modular avionics may result in smaller, rather than larger maximum module counts.

5.1.2.2 Message Latency: The message latency for this bus shall support the required process iteration rates and interprocess timing margins. Any trade-off between message latency and other parameters, such as number of modules, shall be determinable. The consensus reached is that iteration rates may exceed 1 kHz. Guaranteed maximum message latencies in the order of less than 1 us may be required.

RATIONALE: Being asked to support appropriate process iteration rates and to provide inter process timing margins are the most important factors. It is likely that a trade-off between timing, number of modules, and message size will be necessary for a particular design. This trade-off will be configurable as opposed to a fixed requirement.

5.1.2.3 Throughput: Any trade-off between throughput and other parameters such as message latency shall be determinable.

RATIONALE: Same as the rationale for 5.1.2.2.

5.1.2.4 Reliability: The probability of a catastrophic failure of the bus (i.e., a failure resulting in the complete inability of all modules connected to the bus to communicate with each other) shall be less than the probability of coincident failures of all modules connected to the bus, within a time period determined by the logistic/mission requirements. The probability of a “soft” failure of the bus (i.e., a failure resulting in a somewhat degraded ability, relative to the performance parameters defined herein, of any modules connected to the bus) shall be less than the probability of coincident failure of any two modules connected to the bus, within the same time period defined above. In addition, no single component failure will result in a catastrophic failure of the bus. Redundancy may be implemented as a technique to achieve these requirements.

RATIONALE: Since a system incorporating a message oriented backplane is likely to be supporting a number of processes which can contribute to the operation of the system individually as well as in co-operation, the probability of failure of the backplane should not be higher than that of all the modules over a mission. This is a significantly greater reliability than that required for a tightly coupled bus and redundancy is almost certainly needed.

5.1.2.5 Physical Separation of Modules: The bus shall be capable of operating over a distance of 20 in (51 cm). It is desirable that it be capable of operating over substantially longer distances.

RATIONALE: Assuming a straight line configuration, 32 adjacent modules with a 0.6 in (1.5 cm) pitch will be 20 in (51 cm) long. Longer buses are desirable to accommodate other configurations.

5.1.3 Data Flow Network: Detailed requirements for a data flow network were defined by the Local Memory/Data Network Interconnect Requirements Task Group of AS-2. These requirements are documented in ARD50023 (2.1.1.6). High Level requirements for a data flow network are listed in the following paragraphs.

5.1.3.1 Number of Ports: The network shall be scalable, supporting up to 16 ports. It is desirable that it support up to 32 ports.

RATIONALE: The task group consensus is that a substantial number of applications could be covered by 16 ports. If, however, it were possible to have up to 32 ports without impairing performance, that capability would be an advantage.

5.1.3.2 Data Word Size: It is not a requirement that a specific data word size be implemented. A 32-bit data word size or greater is desired.

RATIONALE: Since this network is optimized for large data block transfers and since most emerging processors operate on 32-bit data, a minimum of a 32-bit data word size is desired.

5.1.3.3 Clock Rate: It is not a requirement that a specific clock rate be implemented.

RATIONALE: Maximizing data rates is usually the driving concern in system design. This requires maximizing clock rates, which are usually technology limited.

5.1.3.4 Reliability: The network shall not significantly contribute to the failure rate of the system compromising the network and the connected modules.

RATIONALE: The reliability of the network is determined by the components on the modules that implement the bus protocol and electrical characteristics. The reliability of these components should be of the same order as the reliability of the other components on the module.

5.1.3.5 Data Integrity: It is desirable that the error rate for transactions on the network should be no worse than if the whole of the circuitry were incorporated in a single module. Error detection/correction may be needed.

RATIONALE: Due to the more severe environment of the backplane compared to on a module, additional errors can be expected such that error detection/correction will be required. The choice between these two will depend on the type of data; i.e., whether all data is important (error correction) or some can be missed provided erroneous data is not included (error detection).

5.1.3.6 Physical Separation: There is no consensus requirement for this item. The maximum physical separation of modules connected to this bus should be determined by system and implementation requirements.

RATIONALE: Maximum physical separation impacts performance. Performance requirements are determined by the types of modules connected to the data flow network. Thus, no data flow network physical separation requirement may be specified in this document.

5.1.4 Test and Maintenance Bus: The test and maintenance bus provides support for built-in-test and maintenance services. This bus shall not be used for flight or mission critical functions. The redundant message oriented bus (5.1.2) shall be used when critical communication is required.

5.1.4.1 Test Services: The test and maintenance bus shall provide support for initiating a module's built-in-test sequences. The sequence results shall be reported in a manner which allows the initiating module to determine if the tested module is capable of performing its intended function.

The test and maintenance bus shall provide support for conducting fine grain or low level test vector diagnostics on the module. This shall include support for large data packages so that vendor specific testing may be conducted.

RATIONALE: Modules must be tested using Built-In-Test during system initialization or reconfiguration in order to prevent system failure or degradation due to a malfunctioning module. Capability for fine grain or detailed test vector diagnostics is required to conduct maintenance on a malfunctioning module.

5.1.4.2 Maintenance Services: The test and maintenance bus shall provide mechanisms for maintaining diagnostic and test status information about each module. Such information shall be kept in nonvolatile read/write memory. A mechanism for maintaining a sequential log of fault/diagnostics or status data shall be provided.

The test and maintenance bus shall have features which allow modules to indicate that maintenance or test actions are required. The bus shall also provide the capability to control maintenance actions which may be required on the module, as well as read the result of status change information resulting from such maintenance actions.

RATIONALE: Diagnostics and test information contained in a module fault log is required to identify intermittent module failures. The data in this log must be retrievable via the test and maintenance bus.

5.1.5 Global Bus: Global buses provide support for message passing communication services beyond the backplane. The backplane shall support the use of existing standard global bus protocols. System designers must consider that some fiber optic global buses require separate receive and transmit lines for each module supported.

RATIONALE: These global buses must interface to modules in the rack and, hence, must form part of the backplane. It seems reasonable and cost effective to use existing global bus protocols. More detailed requirements for the global bus were defined by the HSDB Application Requirements Task Group of AS-2. These were subsequently used for the development of two standards; AS4074 (2.1.1.1) and AS4075 (2.1.1.2).

5.1.6 Sensor/Video Network: Detailed requirements for the sensor/video network were defined by the Sensor/Video Interconnect Requirement Task Group of AS-2. These requirements are now documented in AIR4911 (2.1.1.3).

The backplane shall provide for blind mating of video signal connectors into or through the digital backplane. Attributes of particular importance are the number of modules, reliability, physical separation of modules, number of simultaneous channels, throughput per channel and data latency on a channel. The first three attributes will have similar requirements to those of the global bus. The last two attributes will have requirements similar to those of the data flow network.

RATIONALE: The first three attributes will have similar requirements to the global bus because the sensor/video network will cover the same sort of processor cluster interconnections, although providing dedicated data transfer channels rather than a message passing capability. The number of simultaneous channels is thus important as all are considered to be in operation at the same time. Data transferred on each channel will be of high bandwidth (hundreds of megabits/sec) and require low latency due to the time sensitivity of the data.

5.1.7 Support and Integration: The support and integration services are a class of interfaces which provide system control, system state monitoring, and system performance monitoring. These functions are required during development and may (or may not) be used in operational service.

5.1.7.1 System Control: The backplane shall support control of the modular avionic system for support and integration.

RATIONALE: To support the development of modular avionics systems, control of the system operation (e.g., halt, run, single step) from outside the rack will be necessary. Modification of application software (e.g., set break point) or loading of specific support and integration software may also be necessary. This service may require a connector on the module that may or may not be required for normal operation.

5.1.7.2 System State Monitoring: The backplane shall support the ability to monitor, nonreal-time, module operation for support and integration.

RATIONALE: During integration, the system may be halted or single-stepped in order that the state of the system be obtained. Since the system is not operated at full speed, devices on the modules can be interrogated without affecting subsequent operation. This service may require a connector on the module that may or may not be required for normal operation.

5.1.7.3 System Performance Monitoring: Consensus was reached that no specific requirement could be defined at this time for real-time performance monitoring of module operation for support and integration.

RATIONALE: The avionics system integration problem is rapidly becoming so complex that it is adversely affecting the ability to produce next generation avionics systems. A major factor in this situation is the evolution of highly distributed processing architectures with several processors of varying types interconnected with several types of data buses. A key ingredient missing for integration, test, and support of these complicated systems is an integrated set of system support tools which allow the test manager to instrument, control, debug, and passively monitor the system under test.

Integrated support tools are starting to emerge that will permit nonintrusive monitoring of distributed processing systems. However, a major hindrance has been the difficulty in gaining access to the required signals of multiple processors and buses. One thought for a requirement would be for the backplane to provide a “conduit” for these signals from each processor module to be routed to a common point where the support tools would gain access to the signals. In the days of the single processor LRU, this access point was commonly referred to as an Automated Ground Equipment (AGE) port or connector. Depending on the processor, the AGE port had upwards of 75 to 80 signals. Section 5.1.2 specifies that the message oriented bus support up to 32 modules. Section 5.1.1 specifies that a tightly coupled bus support up to 5 modules, based on 1 or 2 processors in each tightly coupled configuration. This would mean that the backplane we are specifying could reasonably support approximately 12 processors. Bringing out 12 “conduits” of 80 signals each would require that the backplane support at least 960 lines, and that doesn't include any of the operational buses! Therefore, it appears that some connection directly to each processor module is a more reasonable approach, and consequently, there is no requirement placed on the backplane.

5.1.8 Configuration: Configuration information shall be provided to the module connector by the backplane through the use of hardwired logic level signals. This configuration information uniquely identifies certain parameters for the module such as its position. It is desirable that the configuration signals contain fault detection and that the number of pins required for configuration information be minimized.

RATIONALE: A number of backplane services, defined elsewhere in this document, require each module to be uniquely identified in order for the function to operate correctly. e.g., data bus address. To prevent any possibility of duplicated addresses, etc., it is thought necessary to provide this configuration information by hard wired pins, preferably with a parity to ensure the correct information.

5.1.9 Discretes:

5.1.9.1 Connections: The backplane shall support the use of discretes common to all modules and discretes specific to particular module types.

RATIONALE: Discretes may be used to control or provide status about the operation of the system and may be connected to every module; e.g., power on initialization, power off early warning. Discretes may also be used specifically for control of a particular module type; e.g., processor breakpoint.

5.1.9.2 Sources: Single source and multiple source discretes shall be supported. All discretes may have single or multiple sinks.

RATIONALE: Some control functions within the rack are sourced by a single module (e.g., power supply fail) while other functions, predominantly status, may be indicated by any one of a number of modules (e.g., module fault). Single source and multiple source discretes will require different source characteristics. Single sink and multiple sink discretes will require different source characteristics.

5.1.9.3 Signal Levels: Discretes for which all sources and sinks are within the same backplane shall be logic level compatible. Discretes for which sources and sinks may lie outside the backplane shall be differential.

RATIONALE: For simplicity, single logic level signals can be used within a backplane to transfer the discrete signal. Discrete signals which are sourced or sunk outside the backplane must be differential for noise immunity and possible ground differential.

5.1.10 Power:

5.1.10.1 Aircraft Power: Consideration shall be made for routing aircraft power along the backplane and its effects on other backplane services.

RATIONALE: Although aircraft power will not be required by most modules, it will need to be routed along the backplane to the power supplies. Care must be taken that high current transients on the aircraft power lines do not interfere with other backplane services or modules.

5.1.10.2 Power Redundancy: The support of power supply redundancy is desirable.

RATIONALE: A single power supply to a set of modules constitutes a single point of failure. Thus it is desirable that the backplane support redundant supplies of power to the modules. How this is accomplished is to be determined by the system designer.