AEROSPACE INFORMATION REPORT

AIR4911

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Requirements Document for Sensor/Video Interconnect Subsystems with Rationale

RATIONALE

AIR4911 has been reaffirmed to comply with the SAE five-year review policy.

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1. SCOPE:

The purpose of this document is to establish the requirements for sensor/video interconnect subsystems. These requirements have been driven predominantly, but not exclusively, by aerospace-type military platforms and commercial aircraft. These requirements are intended to be used as the criteria to establish a sensor/video interconnection standard that will foster the development of common hardware to simplify the total interconnectivity of future avionics platforms.

1.1 Background:

A wide spectrum of industry representation was tasked to define the requirements for a number of multinational, multiservice, standards for several next-generation interconnect subsystems. These include:

a. Sensor Interconnect
b. Video Interconnect
c. Inter-Module Interconnect
d. Test and Maintenance (T&M) Interconnect
e. Signal Processing Interconnect

The taskgroup has currently set its near-term goal to investigate sensor/video interconnect subsystems.

The requirements defined herein discuss technical aspects based upon the following considerations:

a. Functions
b. Performance
c. Test Requirements
d. Operational Properties
e. Validation Requirements

2. REFERENCES:

There are no referenced publications specified herein.

2.1 Definitions:

The following definitions relate specifically to the Sensor/Video Interconnect System Functional Model, which is described later.

PHYSICAL ENTITY: Physical equipment which produces or receives information.

INFORMATION TRANSFER: The physical transfer of information from one physical entity to another, which may be digital, analog, or control/status information.

DIGITAL INFORMATION: Information that is generated in digital form from a source.

2.1 (Continued):

ANALOG INFORMATION: Information that is generated in analog form from a source.

CONTROL/STATUS INFORMATION: Digital information that is generated in the form of standard, discrete digital messages.

SOURCE: The logical producer of an information transfer, whether data, control, or status.

SINK: The logical user of an information transfer.

USER INTERFACE: The logical interface between a source or sink and the sensor/video interconnect subsystem.

SENSOR/VIDEO INTERCONNECT SUBSYSTEM: The logical interconnect that provides the information transfer paths between sources and sinks.

LINK: A logical path between a source and one or more sinks (OSI Term: connection).

LINK TIME: The amount of time required to establish a link.

UNLINK TIME: The amount of time required to remove a link.

RELINK TIME: The amount of time required to reconfigure a link when adding or removing individual sources or sinks.

TRANSMISSION NETWORK: The physical interconnect that provides the information transfer paths between physical entities.

CONTROL/STATUS FUNCTION: The logical function provided by the sensor/video interconnect subsystem that establishes and maintains information transfer paths through the transmission network.

INTERCONNECT FUNCTION: The physical function that establishes and maintains information transfer paths through the transmission network.

TRANSMISSION NETWORK INTERFACE: The physical interface between a source or sink and the transmission network.

2.2 Acronyms and Abbreviations:

AIR	Aerospace Information Report
ASD	Avionics System Division
dB	decibel
Hz	Hertz
Mbps	million bits per second
MHz	megahertz
RF	radio frequency

2.2 (Continued):

SAE	Society of Automotive Engineers
SARS	Systems Applications and Requirements Subcommittee (AS-2A)
SVIRT	Sensor/Video Interconnect Requirements Taskgroup
T&M	Test and Maintenance

3. INTRODUCTION:

The sensor/video interconnect subsystems, set forth in this document, reflect the consensus of experts' views for satisfying the needs of applications encompassing the entire field of aerospace military platforms and commercial aircraft. These requirements are intended to represent a range of existing and emerging requirements, providing a means for standardization to reduce the proliferation of diverging interconnect specifications. Nonaerospace applications (e.g., shipboard, ground vehicle, fixed installations, etc.) are not precluded, and are encouraged to consider any proposed standard that emerges from these requirements.

3.1 Sensor/Video Characteristics:

The sensor/video signals to be addressed in this document are generally characterized as being continuous data flows, as opposed to discrete messages or packets. Discrete messages may be used, however, for remote control and status to or from a source or sink. The interconnect subsystem, therefore, should be capable of establishing continuous connections where both continuous and control/status information can flow from a source to one or more sinks. These connections may be established and dissolved from time to time as mission modes change, or to reconfigure around failures. The interconnect subsystem must be capable of providing multiple simultaneous information flows; addressing of sources and sinks; and establishing, maintaining and dissolving connections. The specific characteristics of the sensor/video signals are described later in this document. The signals outlined above may be either analog or digital in nature, and the interconnect subsystem is specified to support both.

3.2 Model:

A model for sensor and video interconnect subsystems has been developed to allow different subsystems to be described in similar terms to facilitate a common approach to the interconnection function. This model is not intended to imply a preference for any topology, architecture, etc., but is intended to allow the definition of functional terms which may be applied to the different candidate transmission networks.

The basic model of the Sensor/Video Interconnect Subsystem is shown in Figure 1. The Physical Entities are the physical equipment which produce or use the information being transferred over the sensor/video interconnect subsystem. Each of these may have a number of Sources and Sinks which are the logical processes producing and using the information. The connection of the physical entity to the sensor/video interconnect subsystem is through a User Interface to a specific source or sink. The sensor/video interconnect subsystem provides the Information Transfer path through a physical Transmission Network and physical interfaces between the transmission network and sources and sinks, as well as a Control/Status Function that

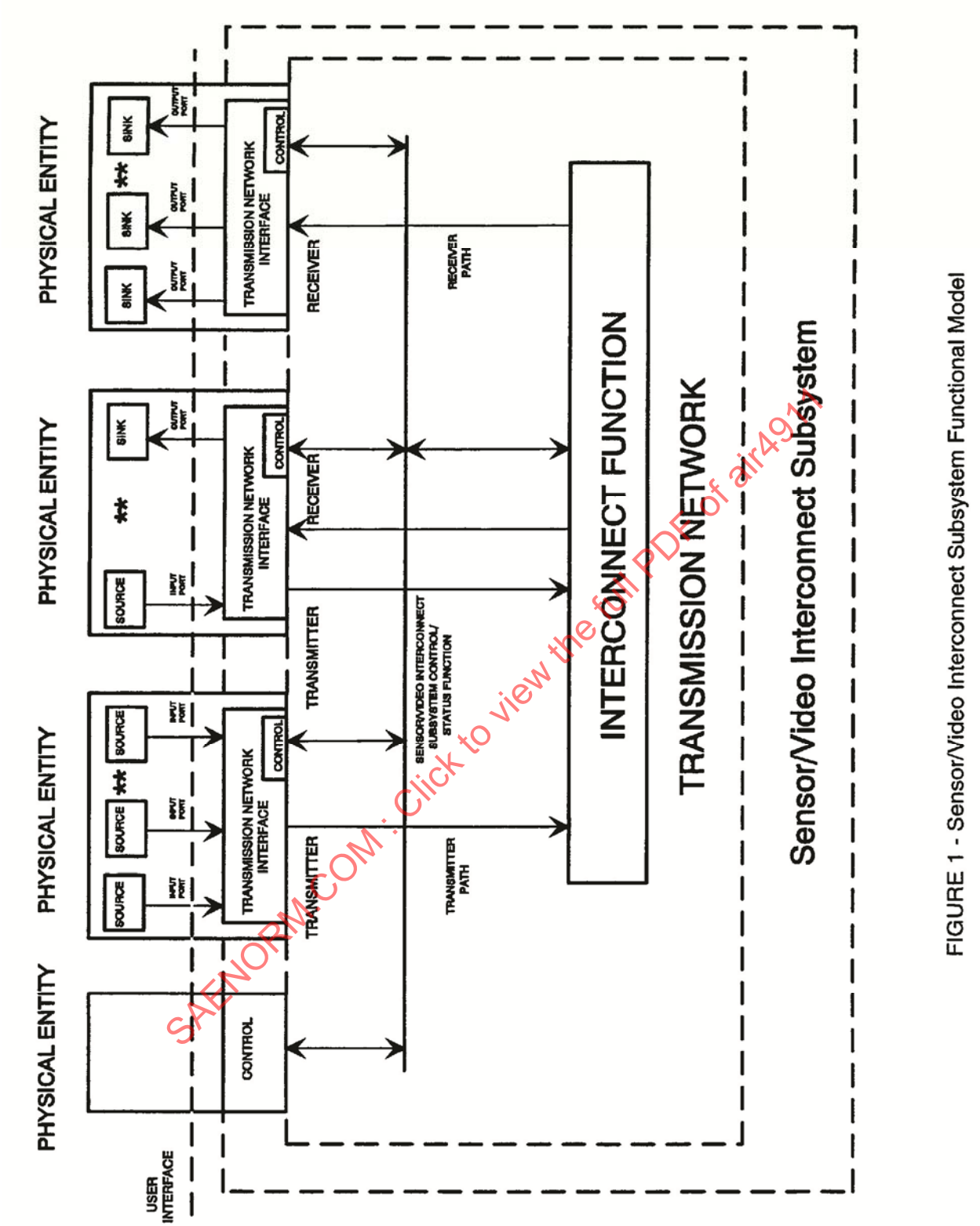

FIGURE 1 - Sensor/Video Interconnect Subsystem Functional Model

3.2 (Continued):

establishes and maintains the transmission network state. Physical access from a physical entity to the transmission network is through a Transmission Network Interface containing a transmitter for sources and/or a receiver for sinks. The modeling of the transmission network allows various parameters to be defined relating to the connectivity of the physical entities, transmission network bandwidth, etc.

The requirements for the sensor/video interconnect subsystem level and the transmission network level are discussed separately to allocate a reasonable set of transmission network requirements based on expected technology where sensor/video interconnect subsystem level requirements may be too broad or difficult to implement. In these cases, the transmission network level requirements should be considered the superseding requirements. Sensor/video interconnect subsystem level requirements are retained as stated in earlier sections to retain traceability.

3.3 Information Transfer Path Timing:

Basic timing of the information transfer path from a source to one or more sinks is shown in Figure 2. A source is initially not linked, meaning it is not connected to any sinks. When a connection is required between a source and one or more sinks, that connection is requested of the sensor/video interconnect subsystem. The sensor/video interconnect subsystem provides that connection within a maximum period of time referred to as Link Time. The connection may then be used for a period of time. When the connection is no longer required, or a sink must be added, deleted, or changed, a new connection (or disconnection) is requested of the sensor/video interconnect subsystem. If a connection between the source and at least one sink is still required, the sensor/video interconnect subsystem provides a new connection within a maximum period of time referred to as Relink Time. If the connection is no longer required, the sensor/video interconnect subsystem disconnects the sources and sinks within a maximum period of time referred to as Unlink Time.

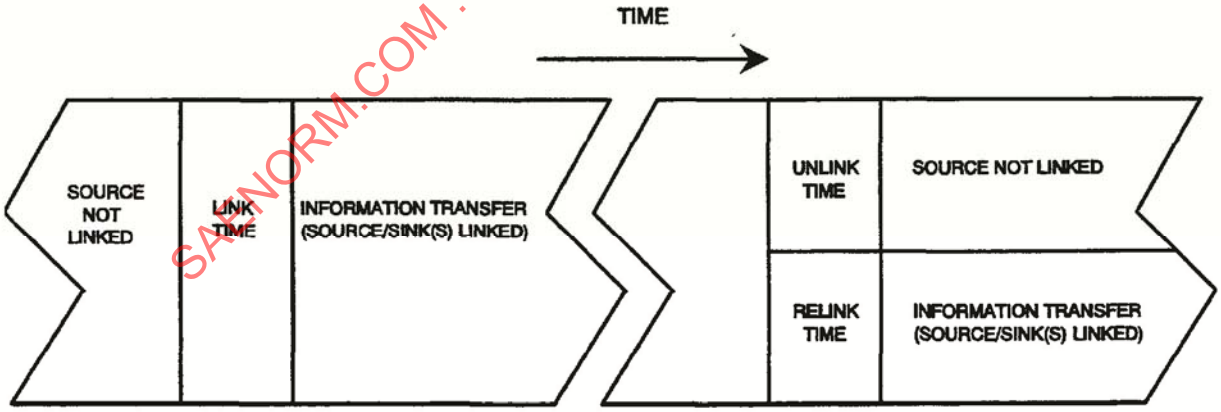

FIGURE 2 - Information Transfer Path Timing for Source

4. REQUIREMENTS:

4.1 General Requirements:

This section contains general requirements of the applications that must be supported by the sensor/video interconnect subsystem.

4.1.1 Topology: These requirements in no way specify a topology for the sensor/video interconnect subsystem.

RATIONALE: Network topology(ies) will be determined by the implementation.

4.1.2 Number of Physical Entities: The sensor/video interconnect subsystem shall support from 2 to 128 physical entities. Provision for more than 128 physical entities is desirable.

RATIONALE: Chosen to support the worst case number of physical entities (aircraft subsystems) indicated in the questionnaires.

4.1.3 Physical Entity Separation: The sensor/video interconnect subsystem shall support adjacent physical entity separation of up to 150 m. It is desired that separation of up to 300 m be supported.

RATIONALE: Selected to reflect worst-case path lengths foreseen for aircraft applications based on inputs from the questionnaire and the task group combined knowledge of aircraft installations. The desired length was selected to support further applications such as shipboard and laboratory integration if possible. There is no minimum separation requirement.

4.1.4 Change/Growth: The sensor/video interconnect subsystem shall have the capacity to be reconfigured, up to the limits stated in this requirements document.

RATIONALE: The subsystem topology and implementation must be adaptable to aircraft system modifications and growth requirements by allowing the simple addition or deletion of physical entities within the specified limits.

4.1.5 Physical Entity Insertion/Removal:

4.1.5.1 Insertion/Removal Interference: The insertion or removal of a physical entity shall not interfere with any transmission not involving that physical entity.

RATIONALE: When a physical entity is inserted or removed from an information transfer path, due to a planned or unplanned reconfiguration or failure, other paths that are not associated with that physical entity should remain unaffected. Only the affected path should require reconfiguration through the relinking process. This allows for distributed reconfiguration and tolerance to single-point failures.

4.1.5.2 Insertion/Removal Recovery: The sensor/video interconnect subsystem shall recover operation after the insertion or removal of any physical entity involved in a transmission.

RATIONALE: When a physical entity is inserted or removed, due to a planned or unplanned event or failure, the sensor/video interconnect subsystem shall recover or terminate, as applicable, the required information transfer paths.

4.1.6 System Tolerance to Failed Physical Entities: Any failed physical entity shall not impede the normal operation of the rest of the sensor/video interconnect subsystem.

RATIONALE: When a physical entity suffers an unplanned reconfiguration or failure, other paths that are not associated with that physical entity should remain unaffected. Only the affected path should require reconfiguration through the relinking process. This allows for distributed reconfiguration and tolerance to single-point failures.

4.1.7 Monitoring: The sensor/video interconnect subsystem shall permit the monitoring of its operation. It is desirable that the monitoring be accomplished from a single point.

RATIONALE: Monitoring is required in system development processes to track the flow of data through the system, and to isolate errors that are the fault of the sensor/video interconnect subsystem from all other errors. Monitoring is also useful to ensure correct operation of the sensor/video interconnect subsystem.

4.1.8 Fault Tolerant Operation: The sensor/video interconnect subsystem shall support fault tolerant operation. A single failure within the sensor/video interconnect subsystem shall not inhibit the reliable transfer of all information. It is desired that any single failure within the sensor/video interconnect subsystem not inhibit the reliable transfer of information between any two physical entities.

RATIONALE: Fault tolerance requirements are typical of mission critical avionics subsystems and are consistent with requirements placed on other avionics communication networks like MIL-STD-1553B, the SAE Linear Token Passing Multiplex Data Bus (LTPB), and the SAE High Speed Ring Bus (HSRB). A single-point failure may disable one path but must not disable the entire network, meaning all central resources (if required) must be fault tolerant. The desire that the sensor/video interconnect subsystem be able to reconfigure around a single failure is so that the subsystems and processes using that path are not lost or do not have to be moved to other resources.

4.1.9 Redundancy: The sensor/video interconnect subsystem shall permit, but not require, the utilization of redundant media to provide fault tolerant operation.

RATIONALE: This paragraph only states that the use of redundancy is allowed to achieve the fault tolerance required by the previous paragraph.

4.1.10 Security: It is desired that the sensor/video interconnect subsystem handle data with multiple levels of classification.

RATIONALE: It is recognized that secure data transfers must be supported, but network security is a higher level issue that cannot be resolved at the level of this document. Thus security is "desired" only.

4.2 Sensor/Video Interconnect Subsystem Requirements:

The primary function of the sensor/video interconnect subsystem is the passing of information from a source to one or more sinks. The transfer may be either digital or analog information for sinks, or control/status information for sources and sinks. The sensor/video interconnect subsystem also supplies a control function for establishing the information transfer paths. The following requirements apply to the sensor/video interconnect subsystem.

4.2.1 Source/Sink Types: Analog and digital source/sink types shall be accommodated by the sensor/video interconnect subsystem.

RATIONALE: This effort did not wish to limit, at the requirements level, transfers to be either analog or digital. Both analog and digital sources and sinks are expected to be connected to the sensor/video interconnect subsystem. Interfaces between the various source/sink formats and the sensor/video interconnect subsystem are implementation dependent.

4.2.2 Number of Sources Per Physical Entity: The sensor/video interconnect subsystem shall support from 1 to 64 sources per physical entity. Provision for more than 64 sources per physical entity is desirable.

RATIONALE: Chosen to support the worst-case number of sources per physical entity indicated in the questionnaire responses.

4.2.3 Number of Sinks Per Physical Entity: The sensor/video interconnect subsystem shall support from 1 to 64 sinks per physical entity. Provision for more than 64 sinks per physical entity is desirable.

RATIONALE: Chosen to support the worst case number of sinks per physical entity indicated in the questionnaire responses.

4.2.4 Digital Information Transfer: If the information to be transferred across an established link is digital, the following requirements apply.

4.2.4.1 Digital Information Transfer Rate: The sensor/video interconnect subsystem shall support information transfer rates both from a source and to a sink of up to 2000 Mbps.

RATIONALE: Chosen to support the majority of data rate requirements indicated by the questionnaire responses. Some responses indicated higher data rates, but they were few, and a higher data rate requirement for all applications was determined to be unreasonable given projected levels of technology. A separate requirement defines this data rate for the transmission network (4.3.4.1). Digital sources and sinks may operate at any rate up to this limit.

4.2.4.2 Digital Information Width: The word size of the information shall be determined by the source and/or sink, and not by the sensor/video interconnect subsystem.

RATIONALE: Responses to the questionnaire varied greatly-indicating that definition of this parameter is best left to the system. Since digital information transfers are expected to be continuous information flows, a specified word size is not important at the subsystem level.

4.2.4.3 Digital Information Length: The sensor/video interconnect subsystem shall not limit the length of an information transfer provided by a source.

RATIONALE: Responses to the questionnaire varied greatly-indicating that definition of this parameter is best left to the system. No limit should be imposed on the length of an information transfer, because continuous information flows are expected.

4.2.4.4 Digital Information Error Rate: Digital information passed from a source to a sink shall have a detected (uncorrected) bit-error rate better than $1.25 \bullet 10^{-7}$ and an undetected bit-error rate better than 10^{-14}.

RATIONALE: The nature of sensor and video information is that infrequent or transient errors are integrated out over time and extremely high data integrity is both unnecessary and expensive to the system. Frequent errors can degrade system performance, however, and they must be detected and reported to the system so that corrective action may be taken. The specified bit-error rates were chosen to support this rationale.

4.2.4.5 Digital Information Latency: Measured from a common point in the information transfer, the maximum latency of the digital information from the point it leaves the source to the point it enters the sink shall be less than 100 µs.

RATIONALE: Chosen to support worst-case from the questionnaire responses for this type of information. 100 µs is consistent with signal processing timelines that normally run on the order of a few milliseconds.

4.2.5 Analog Information Transfer: The sensor/video interconnect subsystem is not required to transfer analog information in analog form. If analog information is to be transferred and a digital implementation is selected, the analog information shall be converted to digital information prior to being submitted to the network. It is desired that the sensor/video interconnect subsystem be capable of transferring analog information in analog form. It is desired that the bandwidth capacity be as high as possible and the distortion be as low as possible, but a minimum of 20 Hz to 20 MHz (±0.1 dB) with less than 0.5% total harmonic and intermodulation distortion is provided as a guideline.

RATIONALE: It was decided that the specific implementation of analog-to-digital conversion needed to carry analog information on the network was beyond the scope of the network itself. Therefore, the network is only required to handle digital information.

However, because there are some potential implementations of this network that employ all-optical media, and are thus capable of handling analog information directly, and because there are system requirements for the transmission of analog information such as RF at extreme bandwidths, it was decided to include analog information transfer as a desire.

4.2.6 Control/Status Information Transfer: The sensor/video interconnect subsystem shall provide the capability of passing digital control and status information between sources and sinks across an established link. The content of the control/status information shall be determined by the source/sink, and not by the sensor/video interconnect subsystem.

RATIONALE: In addition to digital and analog information, the sensor/video interconnect subsystem may also be required to transfer control and/or status information in the form of digital messages between sources and sinks. Examples include health status from a subsystem or a control message to change the mode of a sensor.

4.2.6.1 Control/Status Information Priority: The priority of control/status information relative to digital or analog information shall not be determined by the sensor/video interconnect subsystem.

RATIONALE: If control/status information is multiplexed onto a link with sensor and video information by the implementation, the order of transfer must be determined by the source or sink and not set by the sensor/video interconnect subsystem. This order will depend on the latency requirements of the application.

4.2.6.2 Control/Status Information Transfer Rate: The sensor/video interconnect subsystem shall support information transfer rates for control/status information both from a source and to a sink of at least 1 Mbps.

RATIONALE: Chosen to support the worst-case data rate from the questionnaire for this type of information. Control and status messages are typically short and occur periodically at a fairly low rate.

4.2.6.3 Control/Status Information Width and Format: The control/status information shall be formatted into discrete messages. The preferred word size for control/status information is 16 bits.

RATIONALE: The preferred word size is consistent with the minimum word size of the typical avionics processor architecture. Although most applications are turning to 32-bit processors, 16-bit processors will still find use as simple controllers and will be present in retrofit applications.

4.2.6.4 Control/Status Information Length: The control/status message length shall not exceed 4096 bits.

RATIONALE: Typically, block sizes on the order of 256 16-bit words (4096 bits) can be very efficient. The nature of control/status messages is such that longer blocks are not expected to be needed except in a very few cases. These cases can use multiple 4096-bit blocks.

4.2.6.5 Control/Status Information Error Rate: Control/status information passed from a source to a sink shall have a detected (uncorrected) bit-error rate better than 10^{-10} and an undetected bit-error rate better than 10^{-14}.

RATIONALE: In a digital control/status message transfer, each individual bit contains information that is important to the system and corruption of a single bit can lead to erroneous or indeterminate system operation. Thus, high data integrity is required. The specified bit-error rates were chosen to support this rationale.

4.2.6.6 Control/Status Information Latency: Measured from a common point in the message, the maximum latency of a control/status message from the point it leaves the source to the point it enters the sink shall be less than 10 µs.

RATIONALE: This application must support frequent passing of processing threads between processors, and low-latency interrupts from sensors to processors. Latency must be minimized - 10 µs is consistent with the expected operating system overhead in those processors and is a justifiable minimum value. Smaller values than this probably cannot be justified when compared to other overheads in the processing chain.

4.2.6.7 Control/Status Information Transfer Path: It is desired that the control/status information be transferred over the same transmission network as other information transfers.

RATIONALE: It would be preferable if multiple transmission networks were not used due to the complexity of interconnecting physical entities that would result. A single path is expected to be more cost-effective than multiple network paths with potentially different protocols and architectures. The eventual configuration, however, must be determined by the implementation.

4.2.7 Sensor/Video Interconnect Subsystem Control: The sensor/video interconnect subsystem shall have a digital control mechanism (considered part of the transmission network) that controls the establishment and dissolution of information paths, and defines the operational modes of the transmission network to the transmission network interfaces. The source for the control of the transmission network (the controller) can be any of the following: 1) the physical entity that is the source of the information transfer, 2) the physical entity that is the destination of the information transfer, or 3) a physical entity that is not part of the information transfer. There may be multiple controllers. The recipient of the control information shall be either the interconnect function of the transmission network, or the control part of the transmission network interface. Requirements for the sensor/video interconnect subsystem control function are as follows.

RATIONALE: A digital control mechanism (distinguished from Control/Status information) is required for the sensor/video interconnect subsystem because of the complexity inherent in the connectivity options (large number of physical entities, large number of sources and sinks within each physical entity, one-to-one and one-to-many connectivity, etc.) and the performance requirements for rapid response. A single, central controller is not implied. More likely, a variety of processes will control a variety of physical entities, each operating in its own "domain". A system designer may elect to utilize a single process to control the entire sensor/video interconnect subsystem, or each source and destination physical entity may control their own access. The intent is to maximize flexibility while allowing the definition of the control mechanism.

Multiple controllers means that at any time, control may come from any of several places. This is not the same as distributed control where an arbitration process is used to determine the controller.

4.2.7.1 Linking: Linking refers to the method of establishing information transfer paths from a source to one or more sinks, as specified in the following paragraphs.

4.2.7.1.1 Connectivity: The connectivity provided between transmission network interfaces shall include the following:

a. One source to one sink
b. One source to any number of sinks from 2 to the maximum number of sinks defined by 4.2.3.

NOTE: Multiple sources to one sink shall be handled at the system level (e.g., multiple paths to one sink or by time multiplexing one path).

RATIONALE: The majority of questionnaire responses indicated 1-to-1 or 1-to-n connectivity is all that is required. The expected complexity of n-to-1 connectivity for this type of network does not appear justifiable for the few applications that may use it.

4.2.7.1.2 Concurrent Information Flows: The sensor/video interconnect subsystem shall simultaneously support transmissions between the maximum number of transmitter/receiver pairs available in the system.

RATIONALE: Transmissions between a source and sink(s) can be described as point-to-point, continuous information flows. Questionnaire responses indicate that all sources and sinks can be expected to be active concurrently, all requiring service simultaneously across the sensor/video interconnect subsystem.

4.2.7.1.3 Linking Capability: Two levels of linking are defined. The first level supports linking a source physical entity to a sink physical entity via the transmission network for the transfer of information. The second level, which resides within the physical entity, supports linking the transmission network interface to the sinks/sources within the physical entity. The sensor/video interconnect subsystem shall support both levels of linking.

RATIONALE: The process of linking a source to one or more sinks requires both a physical interconnect routing between physical entities across the transmission network, and a logical or physical routing to the various sources/sinks within the physical entity itself. The linking process supplied by the sensor/video interconnect subsystem shall support this end-to-end routing in both the logical and physical domains.

4.2.7.1.4 Linking Time: Linking time shall be defined as the interval between the initial entry of a linking command into the sensor/video interconnect subsystem and the establishment of the commanded information path between a source transmission network interface and a sink transmission network interface(s), in support of the first level of linking as defined in 4.2.7.1.3. The linking time shall be less than 50 ms. It is desired that the linking time be less than 10 µs.

RATIONALE: Most aircraft subsystems serviced by this network are not expected to require frequent rerouting-typically rerouting occurs only after failures or possibly on system mode changes. In this case linking time is not critical and the selected value should support most applications. It is recognized by the task group that some applications will require considerably faster linking times.

4.2.7.1.5 Unlinking Time: Unlinking time shall be defined as the interval between the initial entry of an unlinking command into the sensor/video interconnect subsystem and the dissolution of an established information path between a source transmission network interface and a sink transmission network interface(s), in support of the first level of linking as defined in 4.2.7.1.3. The unlinking time shall be less than 50 ms. It is desired that the unlinking time be less than 10 µs.

RATIONALE: Same as for linking time.