

# **International Avionics System Interoperability Standards (IASIS)**

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**Baseline – March 2019**

**Baseline**

**REVISION AND HISTORY**

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**PREFACE**

**INTERNATIONAL AVIONICS SYSTEM INTEROPERABILITY STANDARDS (IASIS)**

This International Avionics System Interoperability Standards (IASIS) establishes a standard interface to enable collaborative endeavors utilizing different spacecraft in deep space.

Configuration control of this document is the responsibility of the Multilateral Coordination Board (MCB). The National Aeronautics and Space Administration (NASA) will maintain the IASIS under Human Exploration and Operations Mission Directorate (HEOMD) Configuration Management. Any revisions to this document will be approved by the MCB.

**Baseline**

**INTERNATIONAL AVIONICS SYSTEM INTEROPERABILITY STANDARDS (IASIS)**

**CONCURRENCE**

**MARCH 2019**

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## **Baseline**

### **1.0 INTRODUCTION**

This International Avionics System Interoperability Standards (IASIS) is the result of a collaboration by the International Space Station (ISS) membership to establish interoperable interfaces and terminology to facilitate collaborative endeavors of space exploration in cislunar and deep space environments. These standards are available for international and commercial partnerships.

Standards that are established and internationally recognized have been selected where possible to enable a variety of providers. Increasing commonality among providers while decreasing unique configurations has the potential to reduce the traditional barriers in space exploration: overall mass and volume required to execute a mission. Standardizing interfaces reduces the scope of the development effort.

The information within this document represents a set of parameters, which if accommodated in the system architecture support greater efficiencies, promote cost savings, and increase the probability of mission success. These standards are not intended to specify system details needed for implementation nor do they dictate design features behind the interface. Specific requirements will be defined in unique documents.

#### **1.1 PURPOSE AND SCOPE**

The purpose of the IASIS is to provide a starting framework that allows developers to independently design compatible Avionics systems for human exploration and associated interfaces in cislunar and deep space environments.

This document specifies data link protocols and physical layer standards options to be used to architect the interfaces between spacecraft elements, including docking adapters connecting the elements as well as element services in support of items that are expected to be common among elements, such as Low Profile Grapple Fixtures for Robotics.

Although these standards focus on interoperability between elements as well as common item data interfaces among elements, the standards are not exclusive to any element's network selection or other network standards. It is understood that other data network protocols will be needed and utilized within an element.

#### **1.2 RESPONSIBILITY AND CHANGE AUTHORITY**

Any proposed changes to this standard by the participating partners of this agreement shall be brought forward to the IASIS working group for review.

Configuration control of this document is the responsibility of the Multilateral Coordination Board (MCB). The National Aeronautics and Space Administration (NASA) will maintain the IASIS under Human Exploration and Operations Mission Directorate (HEOMD) Configuration Management. Any revisions to this document will be approved by the MCB.

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### **2.0 DOCUMENTS**

#### **2.1 APPLICABLE DOCUMENTS**

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. The documents listed in this paragraph are applicable to the extent specified herein.

ARINC 664-part 7	Avionics Full-Duplex Switched Ethernet
IDSS IDD	International Docking System Standard (IDSS) Interface Definition Document (IDD)
IEEE 802.3-2008	1000BASE-T Gbit/s Ethernet over twisted pair at 1 Gbit/s
SAE AS6802	Time-triggered Ethernet

#### **2.2 REFERENCE DOCUMENTS**

The following documents contain supplemental information to guide the user in the application of this document. These reference documents may or may not be specifically cited within the text of this document.

None

## **Baseline**

### **3.0 INTERNATIONAL AVIONICS SYSTEM INTEROPERABILITY STANDARDS**

#### **3.1 GENERAL**

The goal of establishing standards is to maximize the success of future human spaceflight missions conducted as international partnerships. The ability of components, systems, or vehicles delivered from multiple sources to work together as an effective system is important to the success of missions. Good collaboration can make technology development and system maturation more efficient, by sharing the lessons learned and failures that drive requirements. Using standard assumptions can also make development more efficient by making tests conducted by one partner relevant and valid to multiple partners.

This document is focused on issues that drive system performance and on issues that most directly affect interoperability between systems. Care will need to be taken in designing and balancing bandwidth in support of time triggered, rate constrained, and best effort traffic on the network. This document is focused on how an Inter-Element Network allows communications between potential elements or spacecraft providers to assist in an integrated avionics architecture that allows for the incorporation of desirable attributes associated with a more open architecture.

##### **3.1.1 DESCRIPTION**

The following subsections describe the system interfaces for the IASIS. The document cites only existing data link standards (protocols), from which an interoperable spacecraft onboard communications system should be developed. Details such as tailoring and associated design specifics will be captured in unique specification documentation.

##### **3.1.2 ENGINEERING UNITS OF MEASURE**

All dimensions are in International System of Units (SI units) (metric).

#### **3.2 INTERFACES**

The focus of this standard is to allow communication between the various elements and spacecraft. Two aspects will be largely considered as a consequence; hardlined communications between elements via the docking systems and communications to the common element interfaces requiring data connectivity such as robotic grapple fixtures. If a robotic arm is to move between elements, robotic grapple fixtures will want to be common between the elements, utilizing common data protocols among those fixtures. Payload data accommodations, such as the Small Orbital Replacement Unit (ORU) Platform Interface (SORI), would likewise be expected to be common.

There are other datalink protocols and conversions that are expected to take place within a given element or spacecraft that this standard does not address. These will be determined in future studies that will assess trade-offs among requirements, design, schedule, and cost.



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### 3.2.1 INTERFACE STANDARDS

#### 3.2.1.1 TIME-TRIGGERED ETHERNET SYSTEM INTERFACE CHARACTERISTICS

##### 3.2.1.1.1 INTERNATIONAL DOCKING SYSTEM STANDARD (IDSS) DATA UMBILICAL COMPLIANCE

**AV-1:** The Inter-Element Network shall be compliant with the International Docking System Standard (IDSS).

*Rationale: The IDSS will be updated to reflect 1000BaseT as part of deep space docking mechanisms development. <TBR 3-1>*

### 3.3 PERFORMANCE

The following standards address expected performance needs between elements, providing the ability to move both critical and/or non-critical data at a high rate and/or with high time dependencies.

#### 3.3.1 PERFORMANCE STANDARDS

##### 3.3.1.1 TIME-TRIGGERED ETHERNET SYSTEM PERFORMANCE CHARACTERISTICS

###### 3.3.1.1.1 BEST EFFORT ETHERNET SERVICES

**AV-2:** The Inter-Element Network shall support a tailorable 802.3-2008 1000BaseT standard (Gigabit Ethernet).

*Rationale: The 1000BaseT network provides the backbone network in which data and services are provided among the elements or spacecraft.*

###### 3.3.1.1.2 DETERMINISTIC-RATE CONSTRAINED DATA SERVICES

**AV-3:** The Inter-Element Network shall support a tailorable ARINC 664-p7 standard (Deterministic rate constrained capability over Ethernet)

*Rationale: Data services requiring deterministic guaranteed delivery will need to be available to support critical needs. This service is available over the same physical network as that being utilized for best effort Ethernet.*

###### 3.3.1.1.3 TIME CRITICAL DATA SERVICES

**AV-4:** The Inter-Element Network shall support a tailorable SAE AS6802 standard (Time-triggered Ethernet).

*Rationale: Data services requiring tight timing requirements, such as time critical closed loop control and time synchronization will need to be available to support those needs. This service is available over the same physical network as that being utilized for best effort Ethernet.*

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### 3.4 ADDITIONAL CONSIDERATIONS FOR STANDARDS INCORPORATION

Historically, crewed spacecraft have addressed the functional areas of vehicle command and control, crew interfaces and science, and specialty interfaces. The following sections will discuss consideration of those areas. It is not the intent of this document to address all the decisions and tradeoffs associated with the implementation within spacecraft. The intent is to show considerations that the elements may want to address as part of implementing the Inter-Element Network. An example of how the various functional areas could interact and consider different element needs is provided below in Figure 3.4-1, Notional Time Triggered Ethernet Based Integrated Architecture.

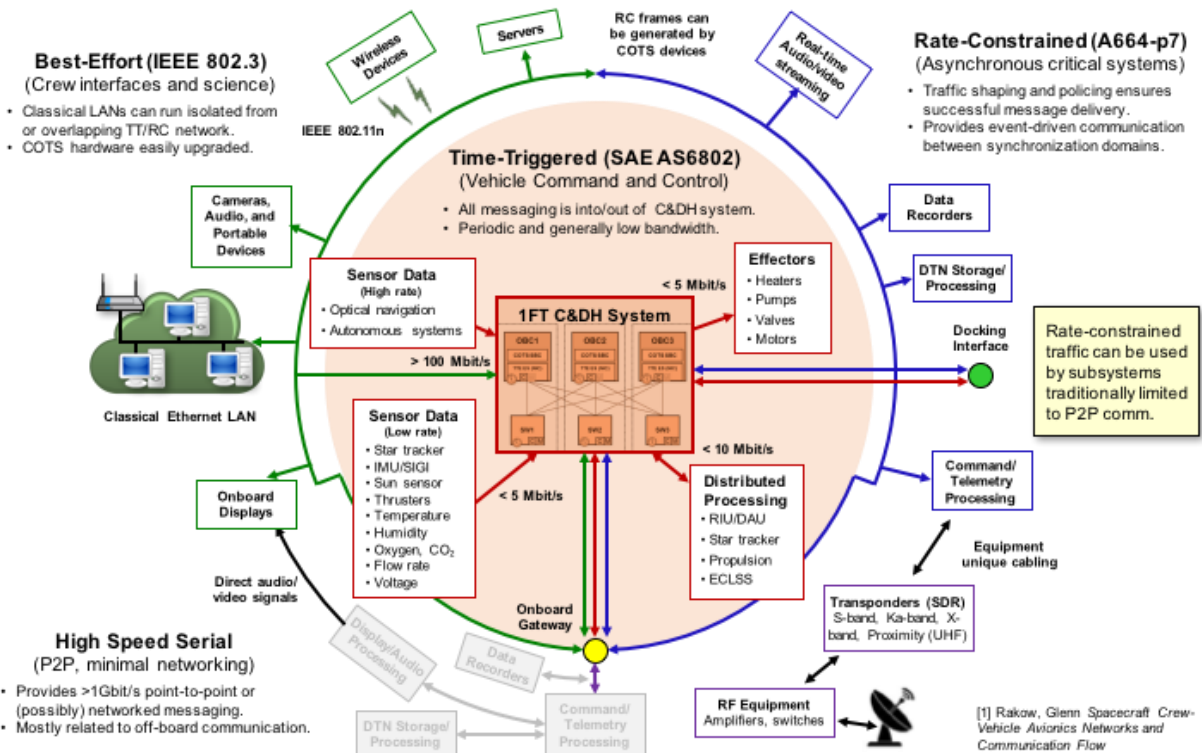


FIGURE 3.4-1 NOTIONAL TIME TRIGGERED ETHERNET BASED INTEGRATED ARCHITECTURE

#### 3.4.1 VEHICLE COMMAND AND CONTROL

The network needs for vehicle command and control have historically been low bandwidth (at least by today's standards) and periodic. The networks typically support a failure tolerant Command and Data Handling (C&DH) system that addresses critical functions. Fault tolerant systems are usually designed to handle more than just fail-stop faults, so inevitably some form of voting must be employed. Networks in support of vehicle command and control functions need to support various voting schemes such as exact match, fault-tolerant averaging, and mechanical.

Options currently exist where rather than having a dedicated vehicle command and control network, mixed types of data and criticality can occur over the same network.

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An example currently employed by some aircraft manufacturers and the Orion spacecraft would be the utilization of strong space-time partitioning to accommodate these mixed criticality and data types.

### **3.4.2 CREW INTERFACES AND SCIENCE**

Exploration networks will be expected to support crew interfaces and science as well. This can often be accommodated via classical Ethernet Local Area Network (LAN)s utilizing best effort protocols such as IEEE 802.3 that can run isolated or overlapping with a Time-triggered/Rate Constrained type of network. Typically, Commercial-Off-The-Shelf (COTS) hardware in terrestrial applications, may be replaced with newer, faster elements so long as they conform to the network protocol. This approach would allow a vehicle, assembled over years to take advantage of advances in systems without disrupting the performance of hardware delivered earlier.

Examples of devices that would be supported would be onboard displays, cameras, audio, portable devices, wireless devices such as those utilizing IEEE 802.11 based protocols, and servers.

### **3.4.3 SPECIALTY INTERFACES**

Cislunar and deep space networks often have a need for off-board communications that require a high speed serial link. This is often accommodated with a Point-to-Point (P2P) network.

Examples of equipment that would be supported would be Radio Frequency (RF) equipment such as amplifiers and switches, transponders that support protocols such as S-band, Ka-band, X-band and Proximity (Ultra High Frequency (UHF)).

## **3.5 VERIFICATION AND TESTING**

It is the responsibility of the spacecraft developer to perform verification and validation. The majority of the standards will be verified using a combination of interface/compatibility testing, integrated end-to-end testing and analysis at the subsystem and system level.

## **Baseline**

### **4.0 FUTURE TOPICS FOR POSSIBLE STANDARDIZATION**

Future deep space development efforts such as lunar surface missions will be assessed for impacts of applicability to these standards as it relates to current avionics state of the art. Necessary updates to this standard will be addressed at that time.

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### APPENDIX A – ACRONYMS AND ABBREVIATIONS

C&DH	Command and Data Handling
COTS	Commercial-Off-The-Shelf
HEOMD	Human Exploration and Operations Mission Directorate
IASIS	International Avionics System Interoperability Standards
IDD	Interface Definition Document
IDSS	International Docking System Standard
IEEE	Institute of Electrical and Electronics Engineers
ISS	International Space Station
LAN	Local Area Network
MCB	Multilateral Coordination Board
NASA	National Aeronautics and Space Administration
ORU	Orbital Replacement Unit
P2P	Point-to-Point
RF	Radio Frequency
SI	International System of Units
SORI	Small Orbital Replacement Unit Platform Interface
TBD	To Be Determined
UHF	Ultra High Frequency

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**APPENDIX B – <RESERVED>**

## Baseline

### APPENDIX C – OPEN WORK

Table C-1 lists the specific To Be Determined (TBD) items in the document that are not yet known. The TBD is inserted as a placeholder wherever the required data is needed and is formatted in bold type within brackets. The TBD item is numbered based on the section where the first occurrence of the item is located as the first digit and a consecutive number as the second digit (i.e., <TBD 4-1> is the first undetermined item assigned in Section 4 of the document). As each TBD is solved, the updated text is inserted in each place that the TBD appears in the document and the item is removed from this table. As new TBD items are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBDs will not be renumbered.

**TABLE C-1 TO BE DETERMINED ITEMS**

<b>TBD</b>	<b>Section</b>	<b>Description</b>

Table C-2 lists the specific To Be Resolved (TBR) issues in the document that are not yet known. The TBR is inserted as a placeholder wherever the required data is needed and is formatted in bold type within brackets. The TBR issue is numbered based on the section where the first occurrence of the issue is located as the first digit and a consecutive number as the second digit (i.e., <TBR 4-1> is the first unresolved issue assigned in Section 4 of the document). As each TBR is resolved, the updated text is inserted in each place that the TBR appears in the document and the issue is removed from this table. As new TBR issues are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBRs will not be renumbered.

**TABLE C-2 TO BE RESOLVED ISSUES**

<b>TBR</b>	<b>Section</b>	<b>Description</b>
3-1	3.2.1.1.1	Update rationale once IDSS has been updated to include 1000BaseT.