SAE Aerospace
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AEROSPACE STANDARD

SAE AS6165

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Interface Standard, Airborne EO/IR Systems, Maintenance and Test

RATIONALE

This document was created to standardize the use of the electrical and data interfaces between aircraft and EO-IR sensors for the purposes of maintenance and test to reduce the overall cost of development of sensors and their associated support equipment as well as the associated life cycle support costs. This activity was initiated at the request of the U.S. Navy in 2009. While this standard was written with aircraft platforms as it primary intended application it is applicable to any platform that integrates EO/IR sensor systems.

FOREWORD

AS6165 is a standard that utilizes the electrical and data interfaces defined by AS6129 and AS6135. In particular, it defines the communication protocols and parameters and other data that would be required to support maintenance and test of an EO/IR system especially when installed on an aircraft or other platform.

This document was prepared by the AS-1C2, EO/IR Sensor System Maintenance and Test Interface Task Group, under the jurisdiction of the AS-1C Subcommittee, Avionic Subsystems, of the AS-1 Committee, Platform Systems and System Integration.

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http://www.sae.org/technical/standards/AS6165

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1. SCOPE

This standard defines the use of data interfaces between a host platform and an electro-optic/infrared (EO/IR) system for maintenance and test (M&T) purposes. In particular, this standard defines the use of the data interfaces in order to facilitate the:

a. confirmation of system performance and function;

b. external initiation of built-in-test (BIT) functions;

c. performance of other diagnostic tests of system health;

d. downloading M&T data;

e. uploading software changes.

This standard does not cover mechanical or electrical interfaces, nor does it define the basic platform-to-sensor communication protocols and formats. Furthermore, this standard does not address software changes that are made by the manufacturer and not accessible at the sensor interfaces. Data protocols and formats are covered by AS6135. Electrical interfaces are covered by AS6129. This standard covers the use of the interfaces defined by AS6129 and AS6135 for the purposes described herein.

1.1 Relationship Between Platform/Sensor Interfaces and SAE Standards

Figure 1 shows the relationship between the interfaces and the various SAE standards. Standard AS6129 (Electrical) covers Power, Connectors, and Communications (transport, the physical layer). Standard AS6135 (Data), covers both the Communications and the various data (e.g., imagery, meta-data, Command and Status). AS6135 overlaps AS6129 in the area of Communications, in particular protocols for data transport. AS6135 and AS6129 are closely bound together in that the data types, volumes, formats, and protocols defined in one standard force certain selections in the creation or update of the other. AS6165 (Maintenance and Test) overlaps both AS6129 and AS6135. A separate standard, AS6169, will cover the mechanical interface.

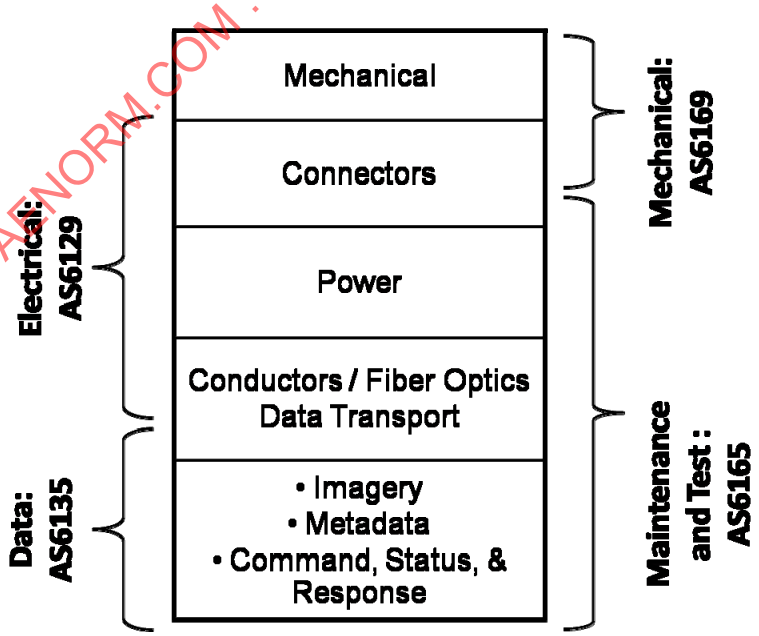

FIGURE 1 - RELATED SAE STANDARDS

1.2 Purpose

The intent of this standard is to enhance interchangeability and interoperability amongst equipment provided by various EO/IR system vendors and associated electronic systems with respect to M&T of the system during its development and employment. In so doing, this standard will reduce acquisition and life cycle costs associated with EO/IR system acquisition and integration and reduce the costs and proliferation of maintenance support equipment and associated software and training. Furthermore, it is envisioned that the ability to fully exercise the sensor system and download all relevant data while installed on the aircraft ("platform") will permit more robust assessment of system health without requiring deinstallation of the turret or associated electronics.

1.3 Application

This standard applies to platforms and EO/IR systems that interface with each other. Initial release of this document will address turreted EO/IR systems with future releases addressing other classes of EO/IR systems such as pods and warning sensors. This standard is applicable both to the development of new sensors and platforms as well as to upgrades to existing platforms or sensors.

2. REFERENCES

2.1 Applicable Documents

The documents listed in this section are cited in Sections 3 and 4 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in Sections 3 and 4 of this standard whether or not they are listed here. When specified herein, the specified revision level of a document shall be used. Otherwise, the latest revision level of the specified document is implied.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AS6129 Interface Standard, Airborne EO/IR Systems, Electrical

AS6135 Interface Standard, Airborne EO/IR Systems, Data

AS6169 Interface Standard, Airborne EO/IR Systems, Mechanical

2.1.2 NATO Publications

Available from NATO Standardization Agency, North Atlantic Treaty Organization HQ, Boulevard Leopold III B-1110 Brussels, Belgium, Tel: +32.2.707.5556; http://nsa.nato.int/nsa/.

STANAG 4586 UAV Control Systems (USCS) Architecture

STANAG 4609 NATO Digital Motion Imagery Standard

2.1.3 Industry Documents

2.1.3.1 IEEE Publications

Available from Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854-1331, Tel: 732-981-0060, www.ieee.org.

IEEE-802.3ab Physical Layer Parameters and Specifications for 1000 Mb/s Operation Over 4 Pair of Category 5 Balanced Copper Cabling, Type 1000BASE-T

IEEE-802.3ae Media Access Control (MAC) Parameters, Physical Layers, and Management Parameters for 10 Gb/s Operation

2.1.3.2 IETF Publications

Available at http://www.ietf.org/.

RFC 959 File Transfer Protocol (FTP)

2.2 Order of Precedence

In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption as been obtained.

2.3 Definitions

COMMAND, STATUS, AND RESPONSE INTERFACE: The data elements and message sets passed between the host platform and the sensor used to control the operation of the sensor. This interface may also be used to check sensor operation. The protocol for passing these messages is handled in coordination with the AS6129. AS6129 also covers the requirements for conductors/fiber optics. The following types of information are passed through the Command, Status, and Response Interface:

a. COMMANDS: The set of all digital instructions transmitted to the EO/IR system from the controller which directs its operation. These instructions come from an operator, from the platform, or from a pre-programmed set of instructions. These commands, for example, instruct the EO/IR system where to point and which features to utilize in gathering images, such as: slew left; turn on stabilization; lock onto a geo-location; change magnification to X; display black as hot vs. white hot; turn on image fusion; etc.

b. STATUS: Digital information returned from the EO/IR system back to the operator, platform, or recorder which provides feedback on sensor operation and other indications of its condition. Examples of this information include: magnification level, azimuth and elevation, stabilization setting, output scale setting for thermal sensors, heading, etc. Another example is the Built-In Test (BIT) information which might occur periodically, in response to a command, or only if a fault or warning is detected. Status information can overlap with metadata. Status can include non-embedded Imagery metadata, Geospatial Position and Time, Hand Controller, and/or Maintenance data.

c. RESPONSES: Digital information returned from the EO/IR system back to the operator, platform, in reply or reaction to a command. Responses are a sub-set of Status. For example, if the command is to turn on stabilization, the response could be “stabilization is on”.

COMMONALITY: A shared feature or attribute. Or a shared set of features or attributes.[1]

ELECTRONICS CONTROL UNIT (ECU): An electronic unit logically between the platform and the sensor, typically inside the platform, which is part of the sensor system, but external to the turret.

ELECTRO-OPTIC/INFRARED (EO/IR) SENSOR: A sensor which generates images based on a specific region of the electromagnetic spectrum (UV, Visible, Near-Infrared (NIR), Short Wave Infrared (SWIR), Mid-Wave Infrared (MWIR) and/or Long Wave Infrared (LWIR). It can be either the imager itself (e.g., a night vision camera) or a turret (gimbal) or pod which includes the imager. The turret or pod may also contain lasers operating in the EO/IR spectrum

EO/IR SENSOR POD: An aerodynamically shaped fixed housing containing EO/IR sensors external to the aircraft, typically mounted on a pylon.

EO/IR SENSOR TURRET: A motorized gimbaled mount for one or more EO/IR sensors permitting rotation about one or more axes. This rotation allows the sensors to be pointed relatively independent of the platform on which it is mounted.

FRAME: A single image from a sensor.

GEOSPATIAL POSITION DATA: Data in reference to translational and rotational position, velocity, and acceleration, etc., of the platform and current time. Characteristics of the data include: (1) Minimum rate data to be provided, (2) Data latency, (3) Maximum time stamp error (if data latency cannot be met), and (4) Data format to be reported in WGS 84 Height Above Ellipsoid.

IMAGE:

1. A visible impression obtained by a camera, telescope, microscope, or other device, or displayed on a computer or video screen.[2]

2. An optical counterpart or appearance of an object, as is produced by reflection from a mirror, refraction by a lens, or the passage of luminous rays through a small aperture and their reception on a surface.[3]

IMAGE COMPRESSION: Compression is the encoding of information while reducing the bandwidth or bits required. Image Compression is the compression of an image for storage or transmission.[4]

a. TRUE LOSSLESS IMAGE COMPRESSION: A form of image compression where the decompressed image is numerically identical to the source image.

b. VISUALLY LOSSLESS IMAGE COMPRESSION: A form of image compression where there is no subjective loss of image quality.

c. LOSSY IMAGE COMPRESSION: A form of image compression wherein there may be loss in subjective image fidelity.

IMAGE FORMAT: The horizontal and vertical pixel densities and the temporal update rate. It may also denote how an image or image sequence is packaged, stored and transported. This includes compression methods such as H.264, formats such as National Imagery Transmission Format (NITF), and interface standards such as SMPTE ST 292-1.

IMAGERY: Visual images collectively.

[1] Derived from definition in: the American Heritage® Dictionary of the English Language, Fourth Edition copyright ©2000 by Houghton Mifflin Company, updated in 2009. Published by Houghton Mifflin Company. All rights reserved.
[2] (http://oxforddictionaries.com/definition/image?q=image)visited 4/10/2012
[3] http://dictionary.reference.com/browse/image visited 4/1/2011
[4] http://www.thefreedictionary.com/image+compression

INTERCHANGEABILITY: A condition which exists when two or more items possess such functional and physical characteristics as to be equivalent in performance and durability, and are capable of being exchanged one for the other without alteration of the items themselves, or of adjoining items, except for adjustment, and without selection for fit and performance[5].

INTEROPERABILITY: The ability of two or more systems or components to exchange information and to use the information that has been exchanged.[6]

METADATA: Data about the Imagery. Examples include:

a. the time the image was generated;

b. the location of and information about the platform (e.g., latitude, longitude, altitude, pitch, roll, and heading of the platform);

c. information about the sensor (e.g., azimuth and elevation of the gimbal, the zoom level);

d. information about the target at the time the image(s) were taken (e.g., latitude and longitude).

Metadata can be incorporated into the image file and/or be sent in parallel.

MOTION IMAGERY: A sequential or continuous stream of images, utilizing Motion Imagery Standards Board (MISB) formats, that enable observation of the dynamic behavior of objects within the scene.

SOFTWARE: The programs, routines, and symbolic languages that control the functioning of the hardware and direct its operation.[7]

STILL IMAGERY: One or more individual images that use the NITF format.

TRANSPORT: A mechanism to move, carry, convey or transfer data and/or signals from one place to another.

VIDEO: A type of Motion Imagery, typically at frame rates used in television broadcasting. The word “video” has also been used to include non-television formats such as those found in the consumer internet community.

[5] Federal Standard 1037C, Telecommunications: Glossary of Telecommunication Terms. http://www.its.bldrdoc.gov/fs-1037/fs-1037c.htm Visited on March 22, 2011.
[6] IEEE Glossary
[7] The American Heritage® Dictionary of the English Language, Fourth Edition copyright ©2000 by Houghton Mifflin Company. Updated in 2009. Published by Houghton Mifflin Company. All rights reserved.

2.4 Acronyms

Table 1 shows the list of acronyms.

TABLE 1 - ACRONYMS

Acronym	Description
ASCII	American Standard Code for Information Interchange
BIT	Built-In-Test
COTS	Commercial Off The Shelf
CSR	Command, Status, and Response
CSRM	Command, Status and Response Message
ECU	Electronics Control Unit
EO/IR	Electro-Optic Infrared
FPA	Focal Plane Array
FTP	File Transfer Protocol
GPS	Global Positioning System
ICD	Interface Control Document
IMU	Inertial Measurement Unit
M&T	Maintenance and Test
MAC	Media Access Control
MISB	Motion Imagery Standards Board
MTBF	Mean Time Between Failure
NITF	National Imagery Transmission Format
PC	Personal Computer
SE	Support Equipment
UAS	Unmanned Aircraft System
UAV	Unmanned Air Vehicle
UCS	UAV Control Systems

3. GENERAL REQUIREMENTS

The details of the electrical and data interfaces required herein are provided in AS6129 and AS6135 respectively. Further discussion on the use of these interfaces for M&T purposes is provided in this section and in section 4. The M&T function may not require disconnecting any connectors from the sensor. In particular, it is expected that M&T Support Equipment (SE) will take the form of compact man-portable general purpose computers that will interface to the platform through a maintenance panel where access to an appropriate platform data bus is available. This is to minimize the frequency of disconnecting and reconnecting cables and thereby maximize Mean Time Between Failure (MTBF) of the cables.

As illustrated in Figure 2, the SE will be used to communicate with the turret to exercise all its functions, receive and view imagery and other sensor data, monitor the status of the system and its diagnostic parameters, modify parameters, and upload new software.

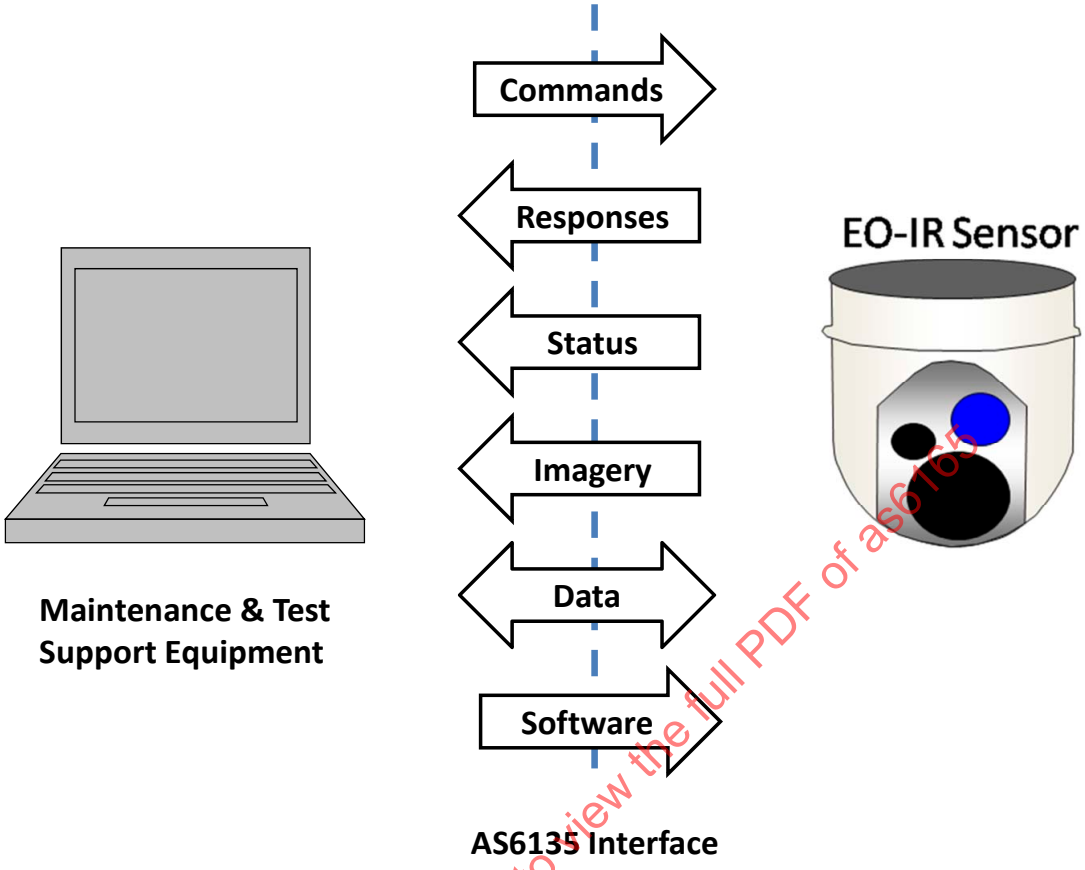

FIGURE 2 - M&T DATA FLOW

3.1 Power

Power to the sensor package is provided as defined in AS6129. No additional provision will be made to provide power for M&T purposes other than that provided for the operation of the sensor.

3.2 Command, Status, and Response

Command, Status, and Response Messages (CSRM) to and from the sensor as well as data and imagery shall be provided via the Ethernet per AS6135. CSRM for M&T purposes shall conform to AS6135. Video data may be accessed via the Ethernet or the dedicated video lines as defined in AS6129 and AS6135.

Figure 3 illustrates a notional concept where there is a maintenance access panel available in an aircraft that provides an Ethernet access connector and a connector for video. This approach minimizes the need to disconnect cables during M&T. This standard does not define this access panel or its connectors.

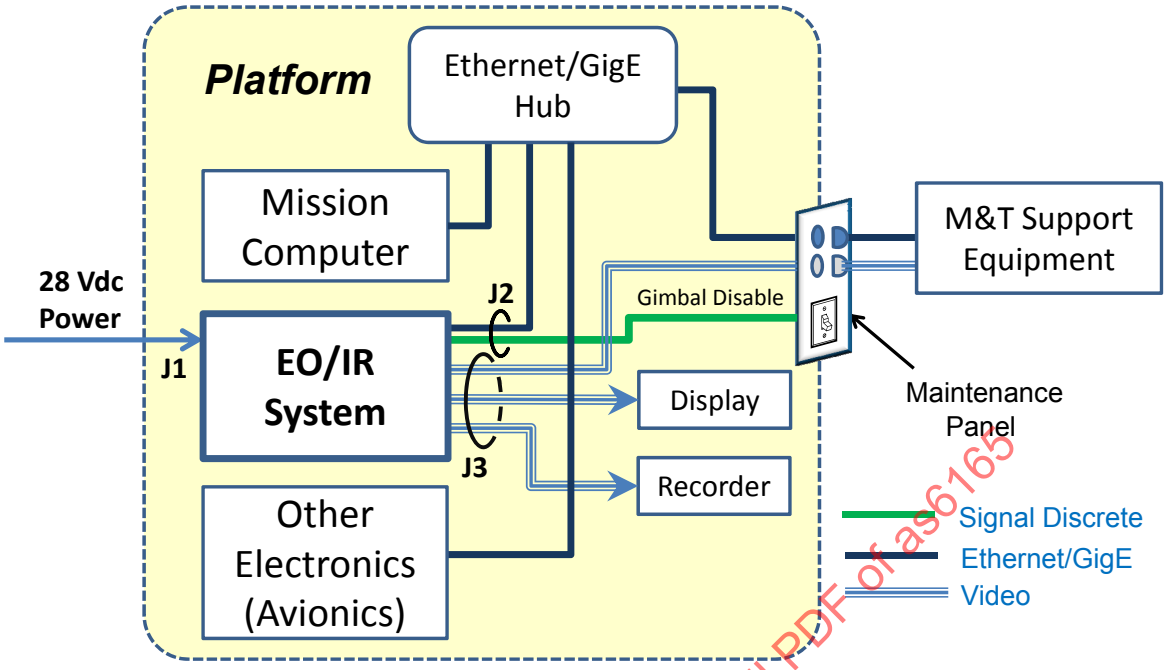

FIGURE 3 - MAINTENANCE AND TEST INTERFACES

If no access panel or other access point is available on the aircraft then M&T connection to the turret will have to be accomplished by removing the primary aircraft connectors to the turret and connecting separate M&T support equipment cables to the turret. This concept is illustrated in Figure 4. In this concept, specialized M&T support equipment, emulates all the necessary signals and discretes required to test the turret functions. It also provides power. Data from the turret is sent to a personal computer (PC) system for any required analysis.

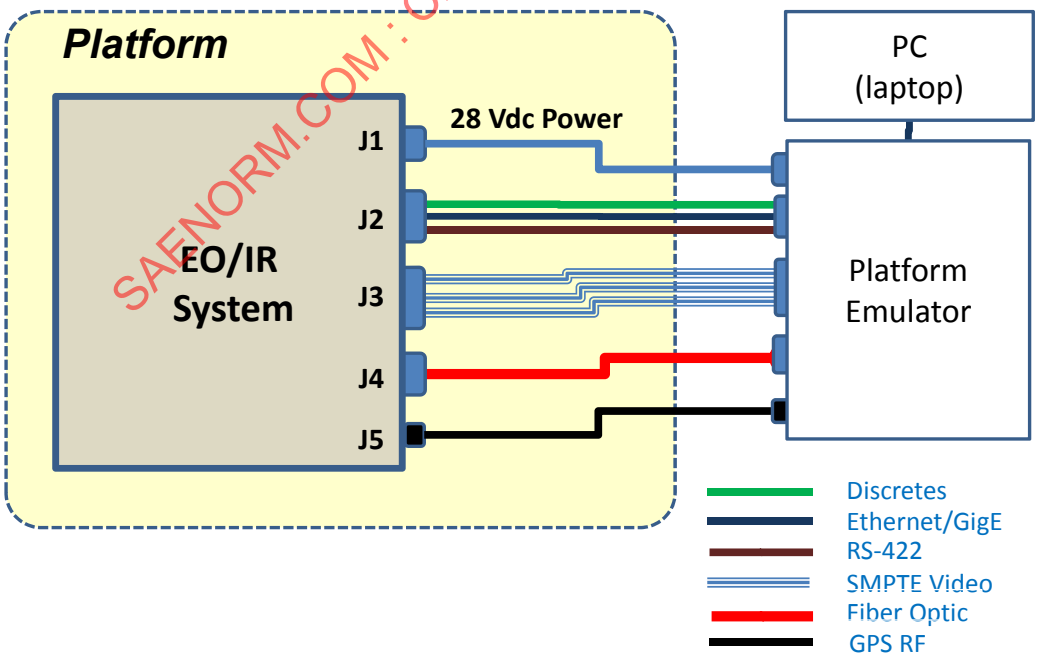

FIGURE 4 - ALTERNATIVE M&T CONNECTION TO EO/IR SYSTEM

3.2.1 Maintenance Mode Control

The normal operational state of an EO/IR system is herein termed the Operational Mode. In this mode all the normal functionality of the EO/IR system can be exercised through CSRM. The Maintenance Mode is that mode in which additional commands uniquely related to M&T are permitted in addition to the normal operational commands. It is envisioned that M&T commands will only be issued by special purpose M&T SE.

The command to enter Maintenance Mode shall conform to the requirements of AS6135. The command to return to Operational Mode shall also conform to AS6135.

Output imagery and other data from the EO/IR system shall be available on connectors J2, J3, and/or J4 during Maintenance Mode. During Operational Mode the M&T Support equipment may be permitted to monitor EO/IR system output data such as imagery and other status data from the Maintenance Panel as illustrated in Figure 3.

3.3 Safety Discretes

This refers to the discrete signal interface that is relevant to the selection, arming, and annunciation of non-eyesafe laser devices, as well as disabling automatic movement of gimbals during maintenance operations. Details of the provision for Safety Discretes in the system electrical connectors are provided in AS6129. In the case of laser arming these Safety Discretes are provided by the J2 Signal Connector pins contained in the Signal Group “Laser Arming and Cutouts”. In the case of disabling gimbal servos these discretes are provided by the pins in the “Enable Gimbal Movement” Signal Group. To mitigate the risk of an unintended unsafe state or event, the sensor shall reject any attempt to override these signals via CSRM.

3.4 Upload Software Updates and Sensor Configuration/Calibration Data

Software and other data files required for proper sensor operation shall be uploaded via Ethernet using File Transfer Protocol (FTP).

NOTE: It is expected that software and other data files required for M&T will be uploaded using standard commercial-off-the-shelf (COTS) laptop/notebook computers using a COTS operating system.

3.5 Diagnostics and Prognostics

The Ethernet shall be used to control the following functions associated with M&T:

a. downloading of logged anomaly data;

b. execution of external diagnostics;

c. facilitating automated in-air reporting;

d. calibration functions.

The commands required to execute these functions shall conform to the requirements of AS6135.

3.6 Imagery

EO/IR systems typically have multiple imagery/video output channels that can be routed to any number of platform subsystems such as monitors, recorders, microwave downlink, etc. The formats of these imagery data and their associated metadata are described in AS6135. As illustrated in Figure 3, if one or more of those channels are required for M&T purposes, and there is a desire to avoid disconnecting the J3 and/or J4 video interfaces, then the specific installation of the sensor system on the platform can route those channels to a test point or directly to a piece of test equipment on the platform.

Alternatively, on systems that are Ethernet and compressed video enabled, multiple channels of compressed video will be available via the Ethernet interface. Physically, this is a shared interface with CSRM.

4. DETAILED REQUIREMENTS

This section discusses the detailed requirements for Power, Command and Status, Safety Discretes, Uploading Software Updates and Mission Data, Diagnostics and Prognostics, and Imagery.

4.1 Power

The turret shall derive power from its operational power connector as defined in AS6129 during M&T operations.

NOTE: If the installation is such that the turret power connector is not accessible for M&T, then the sensor installation should route the power feed such that there is a point on the platform (e.g., test panel) where a test power supply can be connected. This implies that if switching is necessary to avoid paralleling power supplies, it will be accomplished outside of the EO/IR system.

4.2 Command, Status, and Response Messages (CSRM)

The M&T functions shall use CSRM per AS6135. The CSRM shall be transported over the Ethernet bus per AS6129 and AS6135. This will allow personnel to plug M&T ground support equipment, e.g., test computer, into the platform's Ethernet bus at any access point and communicate with the EO/IR system or any other electronics on the platform that have an Ethernet interface. Figure 3 illustrates the concept. Alternatively, if no Ethernet access is available on the platform, the sensor's cables can be disconnected from the platform and the M&T SE can be connected directly to the J2 connector on the sensor. This is illustrated in Figure 4.

4.2.1 Maintenance Mode

When the EO/IR system is installed on the platform and all cables are connected, power is provided to the EO/IR system from the platform either from its engines or an external power source. When the EO/IR system is turned on it automatically recognizes the "Primary Control System" function which may be a mission computer or other controller function on the platform. After the normal start up sequence, the EO/IR System will be in a Stand-By state or in Operational Mode. Control of the system shall then be permitted only via normal operational commands. When M&T SE is connected to the platform Ethernet bus it will issue a Request Control command to the sensor. The sensor shall acknowledge the Request Control command and transfer "proxy" control to the M&T SE only if permitted by the Primary Control System. When the EO/IR system receives a command from a control system which does not have exclusive control of the system, the EO/IR system shall reject the command. The return of control back to the Primary Control System shall require an explicit "agreement" response by the M&T SE.

To enter the Maintenance Mode the M&T support equipment shall issue the command "Enter Maintenance Mode". The EO/IR system shall respond with a confirmation when it has entered Maintenance Mode. The sensor shall then respond to all Operational Commands plus the unique commands that are M&T commands such as certain diagnostics or file transfers.

For safety reasons, when entering Maintenance Mode the gimbal servos shall be automatically disabled under software control. Gimbal servos may be subsequently operated with the required M&T command(s). Section 4.2.2.1 further describes the use of safety discretes for disabling gimbal servos.

While in Maintenance Mode, when the EO/IR system receives a command to Enter Operational Mode from the M&T SE in control, the EO/IR system shall return sole control to the Primary Control System, exit Maintenance Mode, and enter Operational Mode.

When the EO/IR system is disconnected from the platform and connected directly to M&T SE as illustrated in Figure 4 the sensor shall recognize the M&T SE as the Primary Control System.