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Space data and information transfer systems — Digital motion imagery

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National foreword

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ISO 21077 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 766.1-B-1, May 2015) and was adopted (without modifications except those stated in clause 2 of this International Standard) by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 13, *Space data and information transfer systems*.

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STATEMENT OF INTENT

The Consultative Committee for Space Data Systems (CCSDS) is an organization officially established by the management of its members. The Committee meets periodically to address data systems problems that are common to all participants, and to formulate sound technical solutions to these problems. Inasmuch as participation in the CCSDS is completely voluntary, the results of Committee actions are termed **Recommended Standards** and are not considered binding on any Agency.

This **Recommended Standard** is issued by, and represents the consensus of, the CCSDS members. Endorsement of this **Recommendation** is entirely voluntary. Endorsement, however, indicates the following understandings:

- Whenever a member establishes a CCSDS-related **standard**, this **standard** will be in accord with the relevant **Recommended Standard**. Establishing such a **standard** does not preclude other provisions which a member may develop.
- Whenever a member establishes a CCSDS-related **standard**, that member will provide other CCSDS members with the following information:
  - The **standard** itself.
  - The anticipated date of initial operational capability.
  - The anticipated duration of operational service.
- Specific service arrangements shall be made via memoranda of agreement. Neither this **Recommended Standard** nor any ensuing **standard** is a substitute for a memorandum of agreement.

No later than five years from its date of issuance, this **Recommended Standard** will be reviewed by the CCSDS to determine whether it should: (1) remain in effect without change; (2) be changed to reflect the impact of new technologies, new requirements, or new directions; or (3) be retired or canceled.

In those instances when a new version of a **Recommended Standard** is issued, existing CCSDS-related member standards and implementations are not negated or deemed to be non-CCSDS compatible. It is the responsibility of each member to determine when such standards or implementations are to be modified. Each member is, however, strongly encouraged to direct planning for its new standards and implementations towards the later version of the Recommended Standard.

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1 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this document is to provide a common reference and framework of standards for digital motion video and imagery, and to provide recommendations for utilization of international standards for sharing or distributing motion video and imagery between spacecraft elements and ground systems.

The scope of this document includes traditional real-time streaming video and television, including human and robotic spacecraft-to-spacecraft and spacecraft-to-ground systems, as well as video recorded and distributed later, either as a real-time stream or as a file transfer. In this context, real-time streaming includes all modes where video is sent from a spacecraft in a continuous stream and is intended for immediate use when received, regardless of the latency of the transmission path. Other specialized motion imagery applications, such as high-speed scientific motion imagery and multi-spectral motion imagery, are not addressed in this document. However, if a specialized imagery camera system has a requirement to interface to spacecraft systems in a video mode, it would be required to match these interfaces.

Ground-systems-to-ground-systems video distribution is obviously a key component of the entire video system. However, this is not the primary focus of this document. Currently, there are significant differences in the ways mission video products are exchanged between the various space agencies on the ground. This is the result of differences in network topologies between space agencies, and agreements for video sharing. Those differences preclude there being a standard methodology for delivering video imagery between agencies. Prior to the commencement of video transmission between space agencies, system design reviews and performance testing should be done between the ground systems in use to assure operability when video imagery comes from spacecraft.

1.2 APPLICABILITY

This document is a CCSDS Recommended Standard. It is intended for all missions that produce, consume, or transcode video imagery from low-bandwidth video such as web streaming through high-bandwidth video such as high-definition television imagery.

1.3 NOMENCLATURE

1.3.1 NORMATIVE TEXT

The following conventions apply for the normative specifications in this Recommended Standard:

a) the words ‘shall’ and ‘must’ imply a binding and verifiable specification;

b) the word ‘should’ implies an optional, but desirable, specification;

c) the word ‘may’ implies an optional specification;

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d) the words 'is', 'are', and 'will' imply statements of fact.

NOTE – These conventions do not imply constraints on diction in text that is clearly informative in nature.

1.3.2 INFORMATIVE TEXT

In the normative sections of this document, informative text is set off from the normative specifications either in notes or under one of the following subsection headings:

- Overview;
- Background;
- Rationale;
- Discussion.

1.4 REFERENCES

The following publications contain provisions which, through reference in this text, constitute provisions of this document. At the time of publication, the editions indicated were valid. All publications are subject to revision, and users of this document are encouraged to investigate the possibility of applying the most recent editions of the publications indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS publications.

[1] *Studio Encoding Parameters of Digital Television for Standard 4:3 and Wide Screen 16:9 Aspect Ratios*. ITU-R BT.601-7. Geneva: ITU, 2011.

[2] *Television—SDTV Digital Signal/Data—Serial Digital Interface*. SMPTE ST 259:2008. White Plains, New York: SMPTE, 2008.

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[21] *Dual Link 1.5 Gb/s Digital Interface for 1920 x 1080 and 2048 x 1080 Picture Frames*. SMPTE ST 372:2011. White Plains, New York: SMPTE, 2011.

[22] *Television—3 Gb/s Signal/Data Serial Interface*. SMPTE ST 424:2006. White Plains, New York: SMPTE, 2006.

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[23] *Ultra High Definition Television—Image Parameter Values for Program Production*. SMPTE ST 2036-1:2009. White Plains, New York: SMPTE, 2009.

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2 OVERVIEW

In the early days of human spaceflight, motion imagery was accomplished with motion picture film cameras, set at varying frame rates depending on lighting conditions. Upon safe return the film was processed and eventually shared with the world via documentaries or television. Inevitably live video became operationally desirable for situational awareness and to satisfy the public's interest in high-profile events such as the Moon landings or the Apollo-Soyuz test project. Compromises were made with those first video systems to fit within the constraints of bandwidth, avionics, and transmission systems. Even in the modern era, video systems on spacecraft are a hybrid of analog and digital systems, typically made to work within the existing spacecraft's avionics, telemetry, and command/control systems.

With the advent of digital cameras, encoding algorithms, and modulation techniques, it is desirable to treat video as data and to utilize commercially available technologies to capture and transmit live and recorded motion imagery, possibly in High Definition (HD) or even better. Thus the Recommended Standard addresses:

– Video Interfaces and Characteristics

– Video Formats and Characteristics

  Video data has a number of characteristics which need specification such as frame rate, aspect ratio, bandwidth and compression standards, color sampling, the inclusion of audio, etc.

– Encapsulation and Transmission Protocols

  Video data needs to be encapsulated, transported, and distributed. Although the choice of mechanisms and protocols may not be specific to video data, certain aspects need addressing because of the high bandwidth typically required for video. Thus this part will address encapsulation schemes (e.g., IP), transport protocols, and use of CCSDS Encapsulation Packets.

– Interoperability of Standards

  Future Human Spaceflight endeavors are expected to be collaborations between many agencies, with complex interactions between spacecraft and non-Earth surface systems, with intermediate locations (EVA crew, habitats, etc.) requiring the ability to view video generated by another agency's systems. Therefore interoperability between these systems will be essential to mission success and in some cases crew safety. Such interoperability will only be achieved by use of common references and joint agreement on international standards, either commercial or CCSDS or a combination of the two.

This Recommended Standard does not cover video quality. The intention of this document is to provide a framework of standards to ensure interoperability, not to define a level of quality. What is acceptable video quality varies widely with the application and requirements of users. A science experiment, for example, may have video quality requirements beyond what is available, or practical, within a spacecraft avionics system. The

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science team for that experiment might elect to record video on board at high quality and transfer that video as a digital file after the conclusion of the experiment run. They might elect to do that and have a real-time downlink of lesser quality as a confirmation the experiment is working properly. A requirement for real-time video to support a docking event might sacrifice spatial resolution to lower the latency of the real-time video feed. Within the parameters listed in this document and the capabilities of any given spacecraft, users and controllers can determine how equipment should be configured for the best match to requirements.

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3 SPECIFICATION

3.1 OVERVIEW

There are many system configurations that can be implemented in spacecraft video systems. Choices of interface standards, resolutions, and frame rates are based on the application, user requirements, available equipment, and spacecraft capability. There are multiple ways for signals to flow from the image source through to the spacecraft avionics system and on to the ground (see figures 3-1 and 3-2). Application of this Recommended Standard limits the overall number of options by limiting the interfaces to those that are in most common use. It should be noted that, while scientific imaging systems are excluded from this Recommended Standard, should a scientific imaging system need to interface to the spacecraft video system, the same interfaces would apply to them. It would be the responsibility of the user to provide a matching interface from the user's imaging system.

3.2 GENERAL

Users shall select from the following interfaces and standards when designing and implementing new video systems for spacecraft.

3.3 INTERFACE STANDARDS

3.3.1 NON-COMPRESSED STANDARD DEFINITION TELEVISION SIGNALS

The interface for non-compressed Standard Definition (SD) television signals shall be Serial Digital Interface (SDI), conforming to

- ITU-R BT.601-7 (reference [1]);
- SMPTE ST 259:2008 (reference [2]).

3.3.2 NON-COMPRESSED HIGH DEFINITION TELEVISION SIGNALS

The interface used for non-compressed high definition television signals shall be one of the following:

- High Definition-Serial Digital Interface (HD-SDI), conforming to
  - ITU-R BT.1120-8 (reference [3]);
  - SMPTE ST 292-1:2012 (reference [4]);
- High Definition Multimedia Interface (HDMI) 1.4 or higher, as defined by the HDMI Founders and licensed by HDMI Licensing, LLC (reference [5]);
- Camera Link Low Voltage Differential Signaling (LVDS) Interface Standard, as defined by the Camera Link Participating Companies (reference [6]).

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