

Abstracts Template for SpaceOps 2018

Enabling Technologies for Deep Space Motion Imagery

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From the beginning of the Space Age, imagery, particularly motion imagery, has been a part of crewed and un-crewed missions. As technologies have evolved the imagery gets better, more compelling, and more useful for operations and monitoring of systems, crew, and spacecraft. Film, video and live television have engaged the public and sparked the imaginations of engineers, scientists, and artists alike. As we look forward now to crewed missions beyond low-Earth orbit, such as the Deep Space Gateway being considered as a pre-cursor to future crewed Mars missions, there are both opportunities and challenges in implementing a multi-faceted imaging system that advances mission capabilities and technology.

This paper will present a vision for an imaging system that is relevant for operations of the ISS and future crewed missions in deep space, with a detailed look at some of the key innovative technologies required to enable such a system. In addition, impacts to Space Operations, video distribution to the public and to science investigators, and video system interoperability will be presented. Opportunities where Standardization can enable interoperability are also identified for those imagery and communications functions planned for inclusion in the Consultative Committee for Space Data Systems (CCSDS) Blue Book.

Specific enabling technologies included are: Innovative camera systems capable of providing a 360° field-of-view without moving parts; Ultra-high Definition (or higher) resolution; High Efficiency Video Coding compression; Compatibility with Delay Tolerant Network protocols; and Intelligent systems capable of monitoring the field-of-view for un-crewed missions

Each of these technologies will be discussed in detail, including current state-of-the art tests or usage of these technologies on the International Space Station or deep space probes.

Camera systems with a 360° field-of-view have the advantage of providing pan and tilt functionality without the weight and mass of mechanical pointing systems. In addition, multiple users can view or monitor a different field-of-view simultaneously from the same camera system. These camera systems do require considerably more image processing within close proximity of the hardware.

Ultra-high Definition resolution cameras can provide much more detail for operations analyses and allow a wider field-of-view for situational awareness. The advanced technology challenge is this higher resolution can dramatically increase the file sizes, bandwidth and compression processing required.

High Efficiency Video Coding (HEVC), also known in the industry as h.265 compression, is the video industry's successor to MPEG-4 (or h.264) compression algorithm popular with digital cable, satellite, and internet streaming applications. HEVC scales well to Ultra-High Definition resolution video, and provides up to 4 times the reduction in bandwidth without sacrificing quality vs. MPEG-4. It also requires considerably more processing power.

Communication links from spacecraft beyond the Earth-Moon system will experience delay and interruptions. Terrestrial internet protocols assume a consistent link, or at least a network that provides real-time alternative paths for servers to communicate with each other. A spacecraft in deep space, trying to send "live" video back to Earth, will likely encounter disruptions and will certainly not be able to maintain the kinds of network protocol "hand-shake" that terrestrial internet protocols rely on for full functionality. Video data streams, therefore, must be compatible with delay tolerant network topologies such as bundle streaming services. The paper will identify existing and future standards that enable this operational capability.

Missions in CisLunar Space or on Mars will have periods of time where spacecraft and hardware are un-crewed. Video monitoring for situational awareness will be critical to space operations, especially if crew are in transit. During these un-crewed phases, it may not be practical to have humans monitoring the video feeds that are available. Therefore, future camera systems need to have built-in intelligence to monitor movement, changes in structure, and other important system functions, alerting operators on the ground or astronauts on in-bound spacecraft and providing recorded video for further analysis.

Future deep space missions are likely to feature participation from multiple space agencies and operations centers. The concepts for Lunar-based precursor missions envision components from multiple agencies, and possibly commercially provided components as well. This will likely result in an imaging system that needs to be standardized and compatible with a variety of operations centers around the world. Any future imaging system will need to be compatible with internet protocols to allow easy simultaneous distribution to multiple locations in real-time. These key interfaces, standards and protocols will be discussed in detail.

Looking beyond missions in CisLunar space, the concept of "live" monitoring and display of motion imagery changes as the communication delay increases. The paper will conclude with concepts for dealing with this and monitoring crewed and un-crewed missions to Mars or other destinations beyond the Earth-Moon system.

Note—If the venue's technical presentation capability allows, my presentation will feature Ultra-high definition video shot from the ISS