



Digital Video over Space Systems & Networks



Full Motion Video Conference

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Rodney Grubbs

NASA MSFC

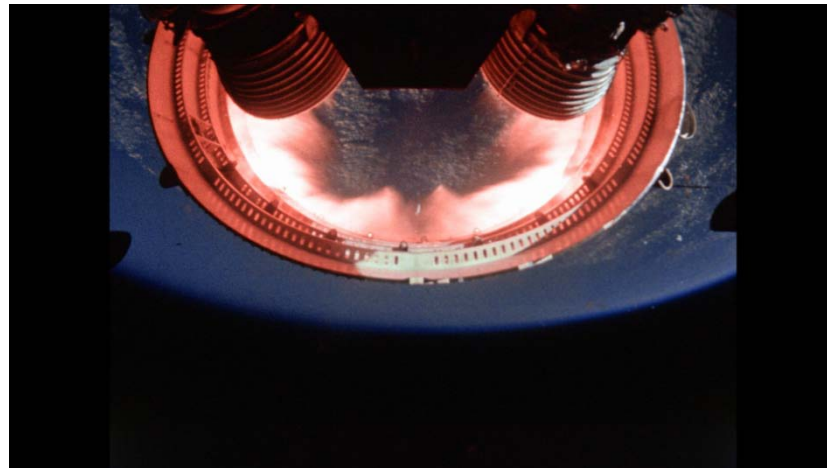
256-544-4582

Rodney.Grubbs@nasa.gov



Introduction

- ◆ Space imagery started with film
 - ◆ Public saw the footage after the mission
 - ◆ Black & White and Color motion picture film
 - ◆ Slow frame rates
 - ◆ Had to get the film back!
- ◆ Live TV from space!
 - ◆ Black & White
 - ◆ Color via Black & White “color wheel” system
 - ◆ Long term ground recording via film kinescopes
 - ◆ Lots of unique video
 - ✦ Field sequential
 - ✦ ISS VBSP



Digital Video Parameters



- ◆ Analog video pretty simple
 - ◆ PAL, SECAM and NTSC
 - ◆ Interlace, frame rates and resolution differences
- ◆ Digital Video a bit more complicated
 - ◆ Horizontal/Vertical resolution options
 - ✦ 480, 720 and 1080
 - ◆ Scanning
 - ✦ Interlace
 - ✦ Progressive
 - ◆ Frame Rates
 - ✦ You name it
 - ◆ Aspect Ratios
 - ✦ 4:3
 - ✦ 16:9
 - ✦ 14:9
 - ◆ Color Sampling
 - ✦ 4:2:0
 - ✦ 4:2:2
 - ✦ And a bunch of other schemes

Video over IP



- ◆ Digital Video requires a lot of compression
 - ◆ SDTV is 270 Mbps uncompressed
 - ◆ HDTV is 1.485 Gbps uncompressed
 - ◆ MPEG-2
 - ✦ Groups of pictures
 - ✧ I, B and P frames
 - ✦ Frames divided into 8 x 8 pixel blocks
 - ◆ MPEG-4
 - ✦ MPEG-4 Part 10 = h.264
 - ✦ Compression between blocks and frames
 - ◆ Motion JPEG2000
 - ✦ Intraframe compression

Video over IP



◆ Transport Stream

- ◆ Combines video, audio and other elements together
- ◆ Typically used for real-time video applications such as terrestrial broadcasting or digital video satellite systems
- ◆ Advantages
 - ✦ Video & audio in sync
 - ✦ Common hardware solutions for encoding and decoding
 - ✦ Easy IP routing or video routing (using Asynchronous Serial Interface)
- ◆ Dis-Advantages
 - ✦ Added bandwidth overhead
 - ✧ Packetization stacks are common
 - ✦ Susceptible to packet-loss and jitter

Video over IP



- ◆ Program Element Stream
 - ◆ Video and audio are separate
 - ◆ Typically used for file-based playback, such as with DVD, or from computers
 - ◆ Advantages
 - ✦ Computer to computer friendly
 - ✦ Flexibility with audio and video
 - ✦ Less bandwidth overhead
 - ◆ Dis-Advantages
 - ✦ Re-synchronization of audio and video
 - ✦ Hard to take out of the IP world and into the video world (ASI)



Video over IP



- ◆ Real-time Transport Protocol
 - ◆ Typically used for end-to-end multimedia applications like voice-over-IP or video teleconferencing
 - ◆ More tolerant of packet drops and jitter, but...
 - ◆that requires end-to-end bi-directional links, or “handshakes”
 - ◆ ...which makes use of RTP for space links challenging
 - ◆ Also, most commercial decoders cannot recognize RTP streams
 - ◆ Best when used entirely within the computer domain, not a good candidate for use between computers and conventional video equipment



Link Integrity

- ◆ Encoded video creates a high bandwidth synchronous data stream, susceptible to packet loss and network jitter
- ◆ Video is typically the largest data requirement for a spacecraft avionics system compared to telemetry, voice and other data streams
- ◆ Therefore, video drives the link integrity requirements
- ◆ MPEG-4 more susceptible to bit errors, packet loss and jitter problems than MPEG-2
- ◆ Motion JPEG-2000 less susceptible because there is no interframe encoding

Latency

- ◆ Compression creates latency
- ◆ Packetization of the data stream adds to that latency since the stream has to be de-packetized on the ground to get back to a signal that can be decoded
- ◆ Typically, the better the video quality, the longer the latency, since the encoder takes more time to analyze the incoming video for quality enhancement
- ◆ Real-time monitoring on spacecraft and the ground need to consider the latency vs. quality trade-off
 - ◆ Rendezvous
 - ◆ Interactive conversations
 - ◆ Time, voice and metadata synchronization with video



NASA Plans for advanced space-based motion imagery

- ◆ Evolvable High-Definition Imagery Testbed—External platform on International Space Station
 - ◆ Testing radiation damage mitigation efforts
 - ◆ Testing optical communications
 - ◆ Testing encoding and communications protocols
 - ◆ Flight to ISS NET early 2012
- ◆ Motion Imagery & Applications Working Group—Part of the Space Internetworking Services area of the Consultative Committee for Space Data Standards
 - ◆ Working on a recommended practices document outlining basic standards for the interchange of video between space craft, space craft to ground, and ground to ground communications

Conclusion

- ◆ Digital video provides many improvements but comes with new challenges
- ◆ Video as data allows for improved workflows and reusing data systems and avionics for routing of video
- ◆ Designers and System Engineers must consider impacts of compression, Video-over-IP options & trades, link integrity and latency on their video system
- ◆ End-to-end System Engineering is key!
 - ◆ Can't treat digital video piece-meal and expect good results
 - ◆ The payoff can be some incredible imagery, useful for science, engineering, control center monitoring, and engaging the public