The High Definition Earth Viewing (HDEV) Payload: Where have all the "Bad" Pixels Gone?

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Abstract

April 30, 2017 marks the third year of operation for the ISS High Definition Earth Viewing (HDEV) Payload. Less than 30 bad pixels have been detected in the video imagery from its four cameras. This paper discusses four possible areas which may be contributing to the lack of bad pixels.

1. Introduction/ Purpose

The HDEV Payload is an external Earth viewing, multiple camera payload using a set of four (4) Commercial-off-the-Shelf (COTS) video cameras. The HDEV integrated assembly is composed of the cameras, Command and Data Handling (C&DH) avionics (1533 Bus and/or Ethernet), and a power data distribution box for integration of the payload's components to the Columbus External Payload Facility (CEPF). The primary objective is to validate the space-based performance of the cameras in a variety of operation modes to exercise and demonstrate the features and longevity of the COTS equipment for future ISS Program usage.

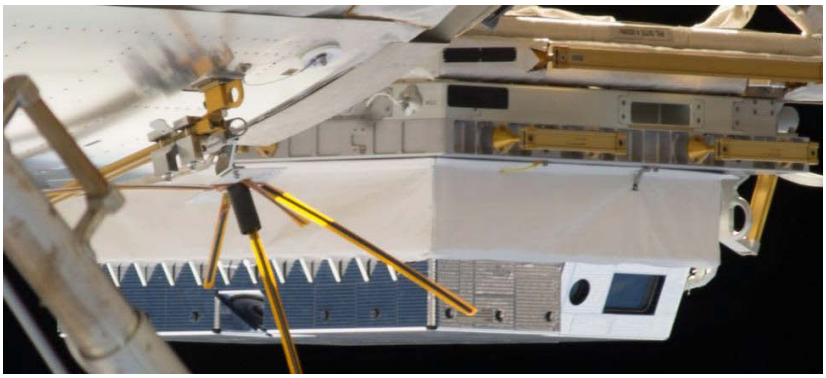

Figure 1. HDEV mounted on the nadir side of the ISS Columbus External Payload Facility. Visible are the windows for the two aft-viewing video cameras (rectangle and circle) and the one nadir-viewing camera (semicircle in center of dark gray panel)

The four cameras chosen were from Panasonic, Sony, Hitachi and Toshiba. The cameras sensors were either charge-coupled device (CCD) (one camera) or 1/3 inch complementary metal-oxide semiconductor (CMOS) (three cameras: 1.3, 2, & 2.1 megapixel).

HDEV was launched on SpaceX CRS-3 on April 18, 2014. Once delivered to the ISS, HDEV was installed by robotic ground controllers and activated just 12 days later on April 30, 2014. Currently HDEV is scheduled to stop operations around mid-2018 at which time the Atomic clock EnsEmblE in spAcE (ACES) payload will replace HDEV on the CEPF.

Results to Date

Prior to launch, one measure of HDEV camera hardware longevity was to monitor the number of bad pixels occurring over time reducing the quality of the video imagery. The cameras have fixed settings which allow them

to register video images while the ISS is in the daylight part of the ISS orbit. On the night side of the orbit the video appears black. Once a month, video is captured from each camera while the ISS passes through nighttime. This video is then run through a pixel corrector which firsts determines and reports the number of bad pixels that will be corrected. Between April 2014 and February 2017, there have been less than 30 bad pixels detected by the pixel corrector. Where have the bad pixels gone?

Several factors are being considered to help explain the lack of bad pixels: video compression, the HDEV housing, angles of the cameras, the location on ISS, and pixel technology.

Video Compression: Within HDEV, the integrated Command and Data Handling (C&DH) avionics (Ethernet) includes a Visionary Solutions' AVN443 Encoder which enables H.264 compression and an MPEG-2 Transport Stream to be moved, via Real-time Transport Protocol (RTP), then formatted by the Compact Reconfigurable Input/Output (CRIO) system, and delivered through the ISS Columbus module payloads communications system.

The AVN443 encoder is the same model that is used for ISS internal video. Given that HDEV video is encoded as an h.264 stream, 720p/60 frames per second output per NASA standard at 6Mbps, the compression, and data rate of the encoder also affects the resolution, which can mask bad pixels. [1]

Housing and/or angles of cameras in housing: HDEVs box is machined from aluminum with o-ring sealing at cover and viewing ports. The box is filled with Nitrogen gas (N_2) at 1 atm. There are also heater plates mounted in 6 places around the side walls of the box. Each camera has a heater plate on both sides of them. The structure has been successful in keeping the pressure and temperature within limits for the last three years.

Placement on ISS structure: Comparisons of the radiation environment and video quality between the Columbus module and the US. Lab module or other sites where crew video was often taken over the last three years, may provide insight into any differences in radiation influences.

Pixel Technology: Hot or bad pixels are not corrected by an image sensor's internal image correction functions [2] as demonstrated in a test which the same sample before and after irradiation to 5 krad (Si) with 50-MeV protons are compared. Have the HDEV camera sensor's internal image correction been able to compensate for any radiation which has occurred?

Conclusions and Next Steps

Are the lack of bad pixels real or is imagery data being masked? Determining the answer may assist future payloads or ISS program imagery planners in choosing camera hardware, equipment, communication mode or placement within a spacecraft depending on the purpose or level of quality required by the imagery user. The HDEV hardware will not be returned for examination so alternative ways to approach finding answers are being pursued.

References

[1] Muri, P., Runco, S., Fontanot, C., Getteau, C. (2017)/ The High Definition Earth Viewing (HDEV) Payload. IEEE Aerospace Conference – Big Sky, Montana, Mar 4-11, 2017, 5.0106

[2] Becker, H.N., Dolphin, M.D., Thorbourn, D.O., Alexander, J.W., Salomon, P.M., "Commercial Sensor Survey Radiation Testing Progress Report," JPL Publication 08-22 4/08, April, 2008.