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Produced by the NASA Center for Aerospace Information (CASI)
High Speed Digital Camera Technology Review
(aka HSD Review; HSD Bake-off; HSD-palooza)

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*NASA Sponsor*: Robert Page (NASA MK-SIO)

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*ASRC Aerospace Imaging Development Lab*

27 October 2009
Kennedy Space Center, FL
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HSD Review

Goal:
Evaluate the state-of-the-shelf of high speed digital camera technologies
HSD Review

Previous HSD Reviews:
2003* – Aberdeen Test Center; >10 HSD cameras
2005 – WSMR; 3 cameras (Film Elimination Plan)
2007* – NASA KSC; 6 HSD cameras, STS-118

Current HSD Reviews:
2009* – NASA KSC; 6 HSD cameras, STS-128

*NASA KSC Participation
HSD Reviews

2009 HSD Camera Technology Review

*Phase 1:* Market Survey $\rightarrow$ camera selection

*Phase 2:* Field Test during STS-128

*Phase 3:* Bench Testing
HSD Review

Phase 1 – Market Survey

• Questionnaires sent to camera manufacturers
• Asked to identify camera(s) that meet NASA / KSC engineering imagery requirements
• Asked to provide camera performance specs for those requirements
• Four manufacturers replied with information on six cameras
HSD Review

Cameras invited for Phases 2 and 3:

- Cooke Corporation pco.dimax
- IDT / Redlake MotionPro Y5
- IDT / Redlake MotionPro Y6 (withdrawn)
- Photron SA-2
- Vision Research Phantom HD
- Vision Research v640
HSD Review

Phase 2 – Field Test

- Familiarization Tour (July 28)
- Check-out Operations (August 17 – 20)
- Final Set-up (August 24)
- Field Test – STS-128 (28 August 2009, 11:59pm EDT)
HSD Review

Phase 2 – Field Test Evaluation Criteria

• Setup and Operations
  – Setup procedure
  – Camera operation
  – Imagery acquisition process
  – Imagery conversion process

• Imagery Assessment
  – Image quality
  – Timing metadata
HSD Review

Phase 2 – Field Test Assessment

• Setup and Operations Judges drawn from:
  – ASRC Imaging Development Lab
  – IMCS Photo and Media Services (Imaging Operations)
  – NASA KSC
  – OSG (Aberdeen Test Center)

• Imagery Assessment Judges drawn from:
  – ASRC Imaging Development Lab
  – IMCS Photo and Media Services (Imaging Operations)
  – NASA KSC Image Analysis Team
HSD Review

Setting up for the Field Test
HSD Review

Setting up for the Field Test
HSD Review

Field crew
HSD Review

The Field Tested Cameras

Photron SA-2  Vision Research v640  IDT MotionPro Y5

Phantom HD  Rocket Launch  Cooke pco.dimax
HSD Review

Setting up for the Field Test in the remote control room
HSD Review

Check-out & Operations Judges at work
HSD Review

Field Test Camera Settings and Operation

- Resolution = 2K x 2K
- Frame rate = 400fps
- Bit-depth = 14-bit
- Remote camera control
- Remote trigger at T-6s
- Remote data offload
- Vertical FOV = 16°
- Live video feed (HD preferred)
- Record IRIG time in metadata
HSD Review

Imagery comparison during set-up operations

Vision Research v640  VR Phantom HD  Photron SA-2

Top and bottom images were recorded on different days

Cooke pco.dimax  IDT / Redlake MotionPro Y5
HSD Review

Phase 2 – Field Test

• Camera representatives were responsible for setting exposure
• All were provided information on how the exposure of the film cameras would be set
• Some representatives have more experience with launches and thus had an advantage when setting exposure
HSD Review

Bit depth and display settings

12-bit camera, default display settings

12-bit camera, adjusted display settings
HSD Review

Field Test – Imagery comparison (T-5.9s)

Vision Research v640  VR Phantom HD  Photron SA-2

Default display settings used

Cooke pco.dimax  IDT / Redlake MotionPro Y5

Triggered later, image NA
HSD Review

Field Test – Imagery comparison (T-5.9s)

Vision Research v640  VR Phantom HD  Photron SA-2

Cooke pco.dimax  IDT / Redlake Y5

Triggered later,
Image NA
HSD Review

Field Test – Imagery comparison (T-3.1s)

Vision Research v640  VR Phantom HD  Photron SA-2
Cooke pco.dimax  IDT / Redlake MotionPro Y5

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HSD Review

Field Test – Imagery comparison (T+1.3s)

Vision Research v640  VR Phantom HD  Photron SA-2

Cooke pco.dimax  IDT / Redlake MotionPro Y5
HSD Review

Field Test – Imagery comparison (T+2.1s)

Vision Research v640  VR Phantom HD  Photron SA-2

Cooke pco.dimax  IDT / Redlake MotionPro Y5
HSD Review

Field Test – Imagery comparison (T+4.1s)

Vision Research v640  VR Phantom HD  Photron SA-2

Cooke pco.dimax  IDT / Redlake MotionPro Y5
HSD Review

Phase 2 – Field Test

- Imagery Assessment Judges will evaluate the Field Test imagery in the KSC Image Analysis Facility in the coming weeks
HSD Review

Phase 3 – Bench Testing
- Attributes evaluated
  - Timing accuracy
  - Image quality
    - Sensitivity
    - Resolution
    - Color rendition
    - Dynamic range
    - Sensor uniformity
  - Download time
  - File conversion time
  - Thermal performance
  - Ease of Use

References:
Telles, D. & Husman, E. (2005)
WSMR Film Elimination Plan

RCC Secretariat (2008)
Standard Testing Protocols for High-Speed Digital Imagers
(Document 463-08)
HSD Review

Bench Testing – Timing tests with the LabDITCS
HSD Review

Bench Testing - Sensitivity & Uniformity tests

Max = 0.892 (relative to 1 for pixel 65535) [32x32 pixels areas]
Corners: worst = 0.63 (70.7%); mean = 0.657 (73.7%)
Sides: 0.734 (92.3%); 0.786 (88.1%); mean = 85.2%

Picture Window Pro Light Falloff settings:
Lens Focal Length (mm) = 29; Film Size (mm) = 36

0 hot, 0 dead pixels of 4194304 total
Threshold: hw = 64507; d = 1026; Any chan
Crop (LRTB) 0 0 0 0
3.5.1 Master 21-Oct-2009 17:02:15
HSD Review

Bench Testing – Step chart: sensitivity & dynamic range

Stepchart analysis Bayer RAWR2C1

First order

(Gamma = 0.962 = 1/1.04)

Second order

Density step = 0.1

Stepchart results

- Y
- R
- G
- B

SNR = 40

SNR = 10

log (Exposure)
HSD Review

Bench Testing – Thermal properties

Camera Body Temperature

Camera Powered On at 22:26

Time (EDT)

27 October 2009

ASRC Aerospace Imaging Development Lab
NASA / KSC
HSD Review

Phase 3 – Bench Testing

• Data / Imagery Acquisition complete!!
• Analysis underway
HSD Review

Phase 3 – Bench Testing Lessons Learned
• Cameras were tested serially
  – Probably, cameras should be tested in parallel
• One camera was tested per week
  – One week per camera is not long enough!
• Tests conducted by people splitting their time between multiple tasks
  – In general, one person conducted a test on all the cameras. However, in some instances, different people conducted a particular test on different cameras.
  – Ideally, one person would be dedicated to each test for better consistency.
HSD Review

NASA KSC High Speed Digital Camera Specification

- Prepared based on experience during field tests and HSD Reviews including the 2009 HSD Review
- Updated annually to the current state-of-the-shelf (sometimes pushed a bit)
- Geared toward NASA's Shuttle engineering imagery requirements
HSD Review

OSG Task: OS-33

- Create a specification for a High Speed Digital Video (HSDV) camera
- Specify camera functionality and features desirable in a variety of user environments
- Use the NASA KSC *HSD Camera Specification* as a first draft for *OS-33: HSDV Camera Specification*
- Due date: October 2010
**Title and Subtitle:** High Speed Digital Camera Technology Review

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**Abstract:**
A High Speed Digital Camera Technology Review (HSD Review) is being conducted to evaluate the state-of-the-shelf in this rapidly progressing industry. Five HSD cameras supplied by four camera manufacturers participated in a Field Test during the Space Shuttle Discovery STS-128 launch. Each camera was also subjected to Bench Tests in the ASRC Imaging Development Laboratory. Evaluation of the data from the Field and Bench Tests is underway. Representatives from the imaging communities at NASA / KSC and the Optical Systems Group are participating as reviewers.

A High Speed Digital Video Camera Draft Specification was updated to address Shuttle engineering imagery requirements based on findings from this HSD Review. This draft specification will serve as the template for a High Speed Digital Video Camera Specification to be developed for the wider OSG imaging community under OSG Task OS-33.

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