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

Acknowledgements

Thanks to the HSD camera representatives for their participation.

Mark Corbin & Bill Shipman (Vision Research)

Doug Squires & Mark Reinhardt (Cooke Corp.)

Rick Sutherland & David Hofer (IDT / Redlake)

Rick Burmeister (Motion Capture Technologies)

Karl Weincek (Photron)

Acknowledgements

Thanks to the many groups and individuals who supported this effort.

ASRC Aerospace - C. Kuehner, M. Baldwin, K. Bivona, M. Fox, F. Gryn, S. Sherry, C. J. Rumbaugh

IMCS – M. Olszewski, R. Stratton, A. Nehr, T. Terry, J. Blair, R. Robinson

USA – B. Lawrence

NASA KSC– B. Page, R. Stute, C. Abell, D. England, T. Ford, S. Lockwood

ATC (OSG) – Ariel Sherman and Steven Lowther

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 → 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- IDT / Redlake MotionPro Y6 (withdrawn)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

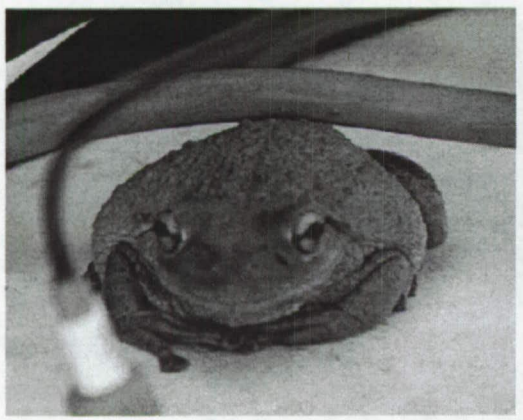
Phase 2 – Field Test Assessment

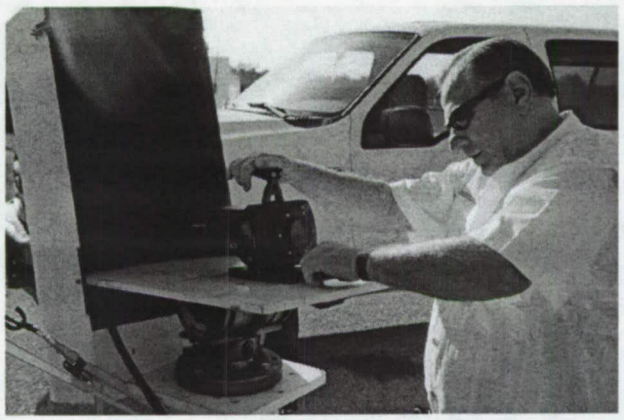
- Setup and Operations Judges drawn from:
  - ASRC Imaging Development Lab
  - IMCS Photo and Media Services (Imaging Operations)
  - NASA KSC
  - OSG (Aberdeen Test Center)

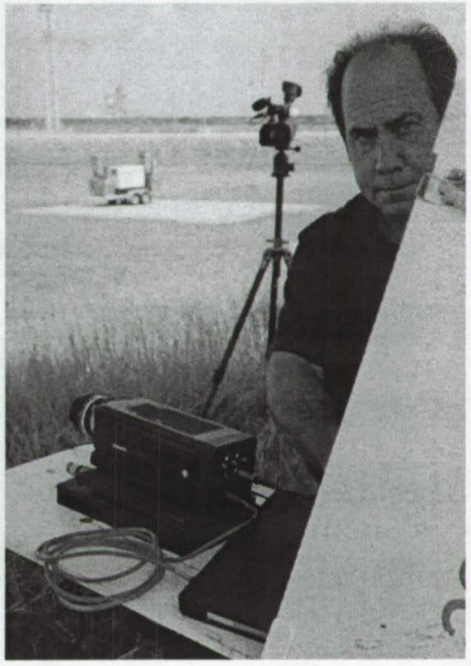
- Imagery Assessment Judges drawn from:
  - ASRC Imaging Development Lab
  - IMCS Photo and Media Services (Imaging Operations)
  - NASA KSC Image Analysis Team

HSD Review

Setting up for the Field Test

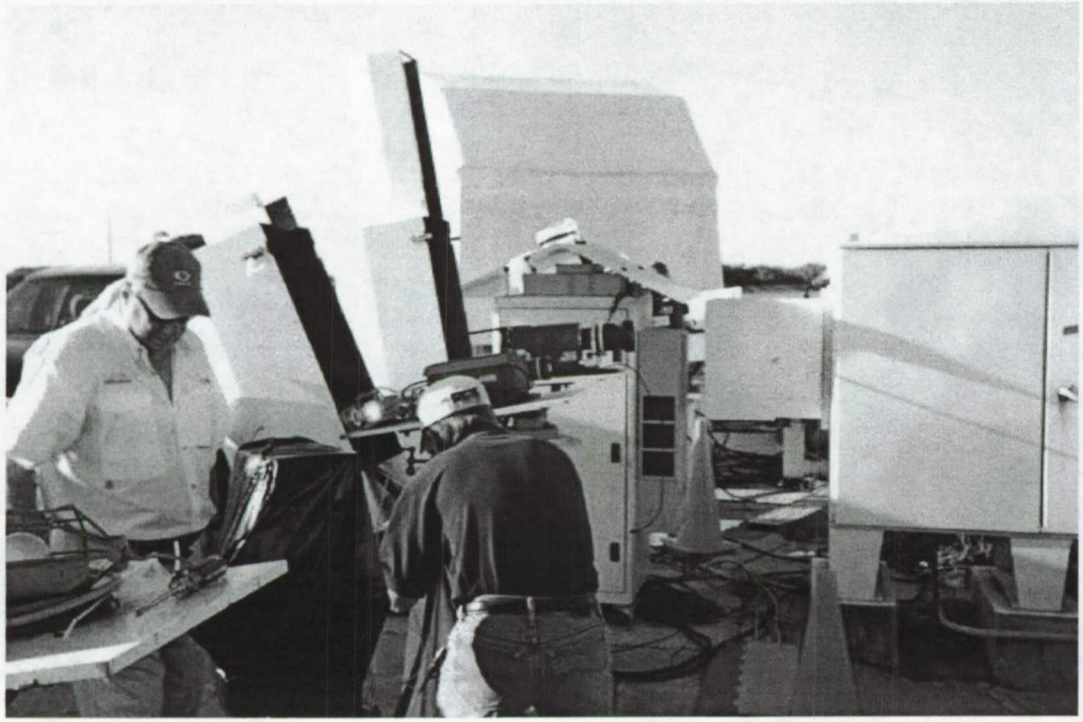






HSD Review

Setting up for the Field Test



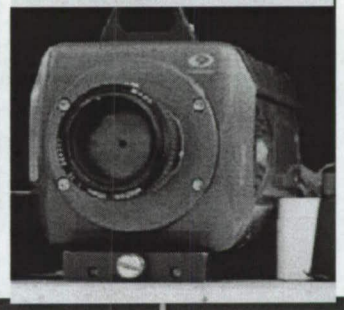
HSD Review

Field crew

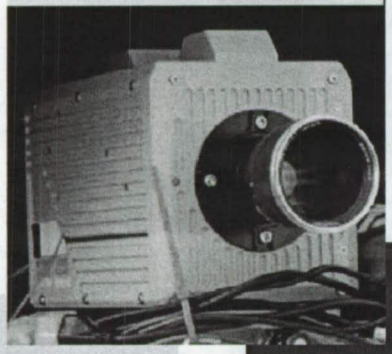
HSD Review

The Field Tested Cameras

Vision Research v640

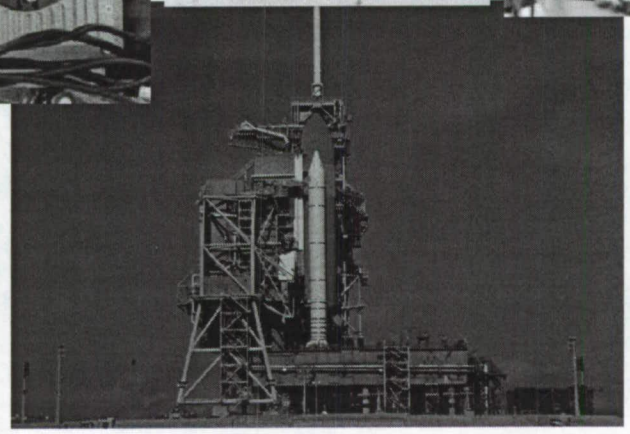


Photron SA-2

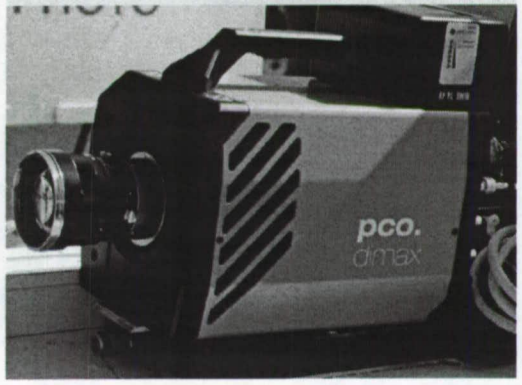


IDT MotionPro Y5

Phantom HD



Cooke pco.dimax

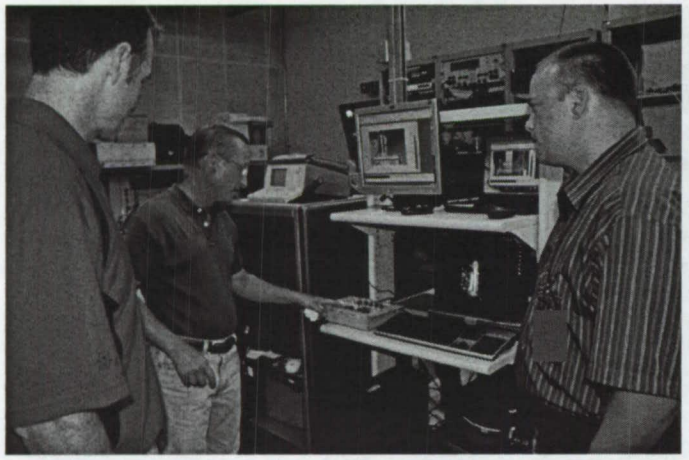


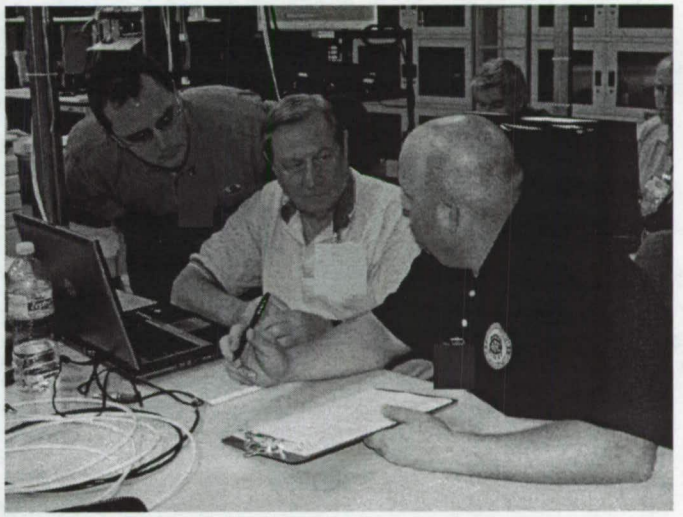
HSD Review

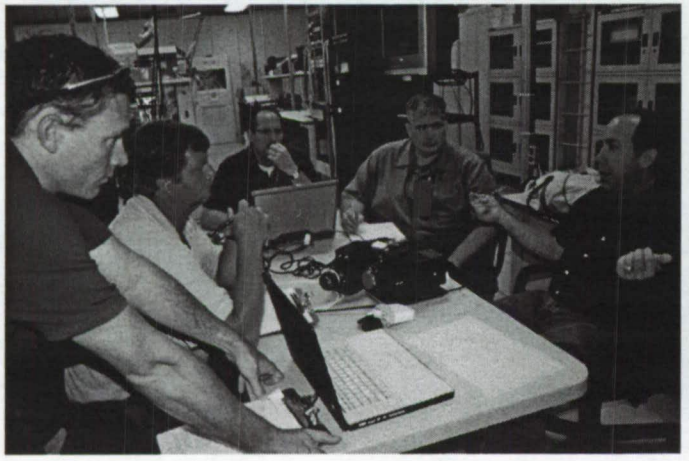
Setting up for the Field Test in the remote control room

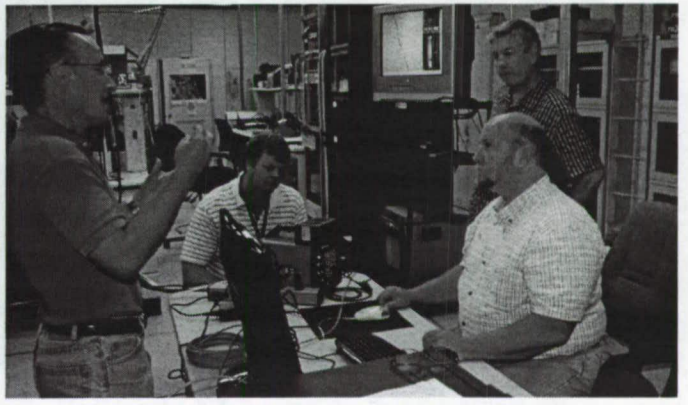
HSD Review

Check-out & Operations Judges at work





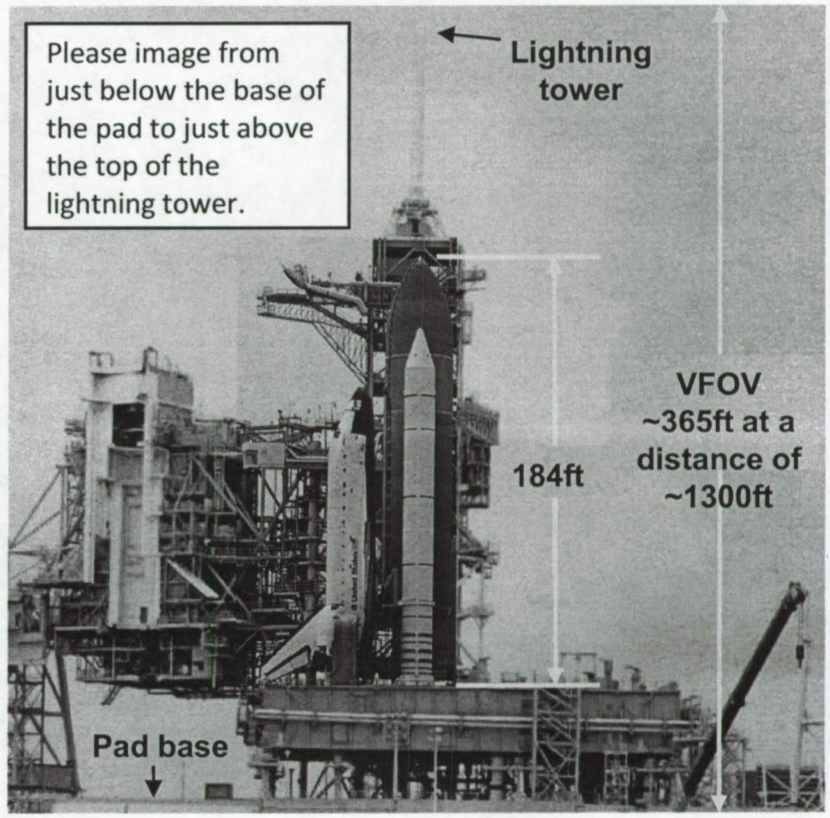




HSD Review

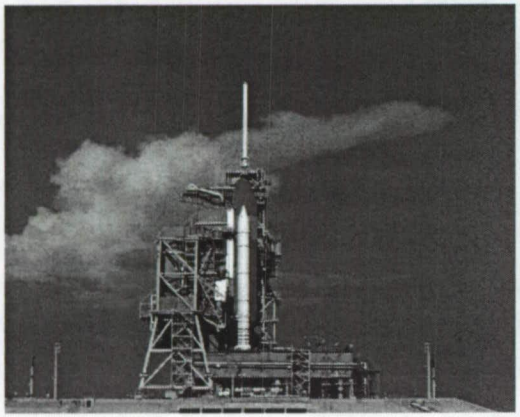
Field Test Camera Settings and Operation

- Resolution = 2K × 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

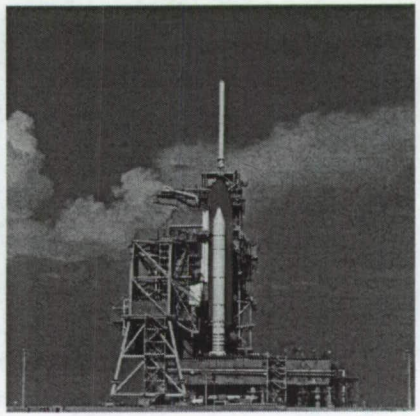


HSD Review

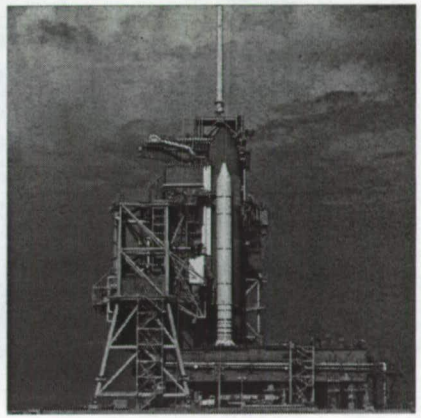
Imagery comparison during set-up operations



Vision Research v640

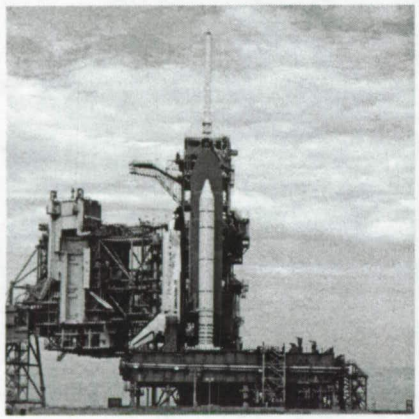


VR Phantom HD

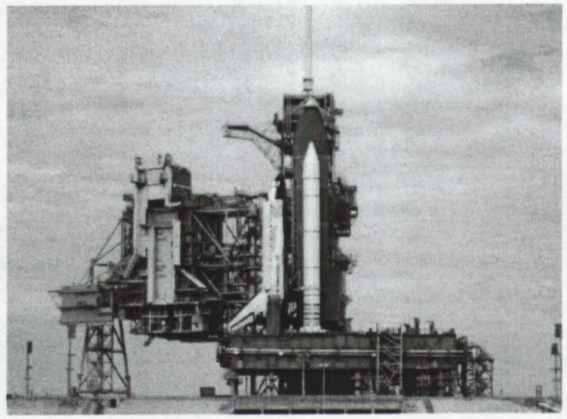


Photron SA-2

Top and bottom images were recorded on different days



Cooke pco.dimax



IDT / Redlake MotionPro Y5

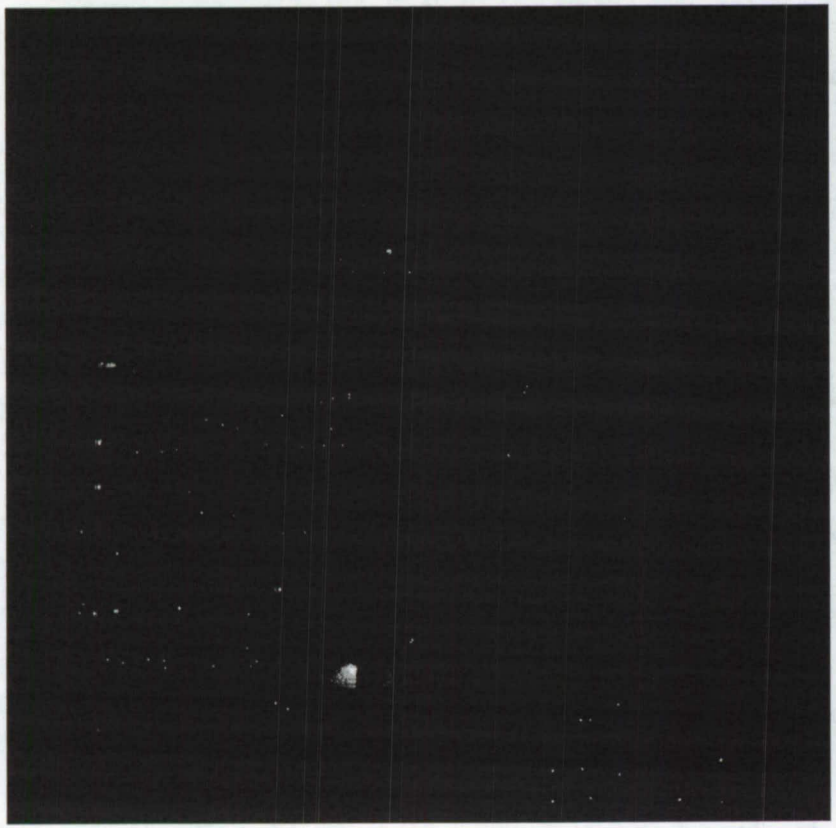
HSD Review

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

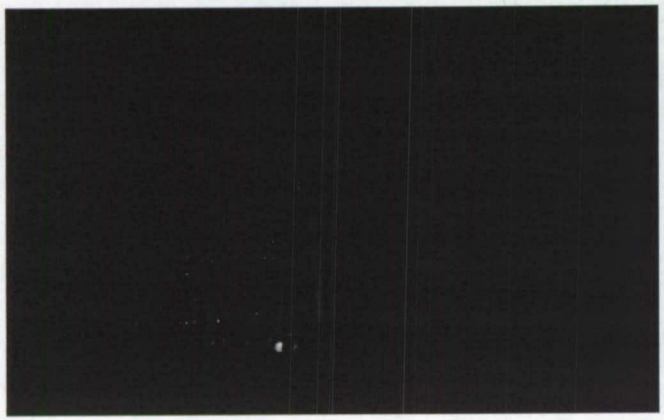


12-bit camera, default display settings

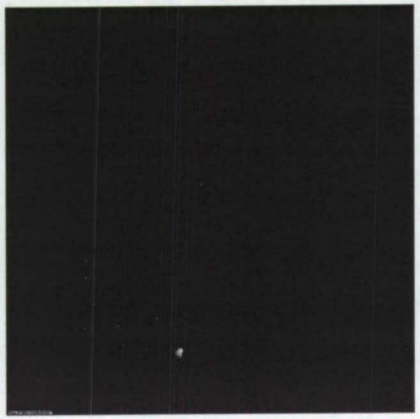
12-bit camera, adjusted display settings

HSD Review

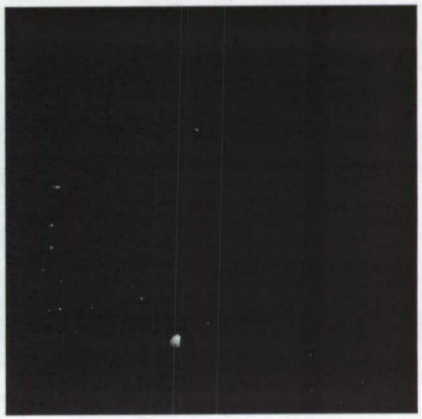
Field Test – Imagery comparison (T-5.9s)



Vision Research v640

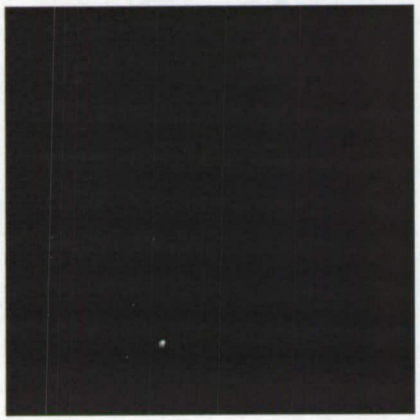


VR Phantom HD



Photron SA-2

Default display settings used



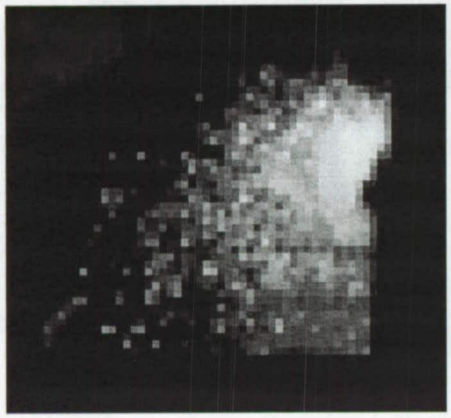
Cooke pco.dimax

Triggered later, image NA

IDT / Redlake MotionPro Y5

HSD Review

Field Test – Imagery comparison (T-5.9s)



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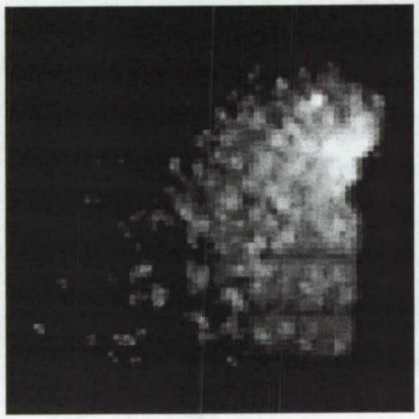
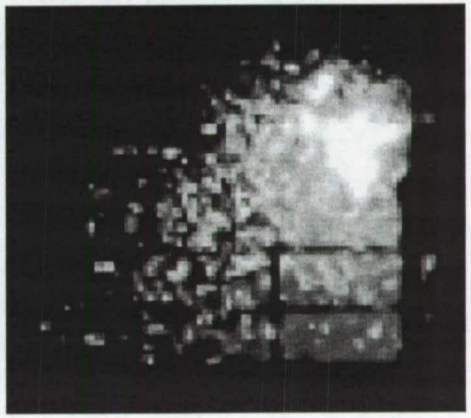
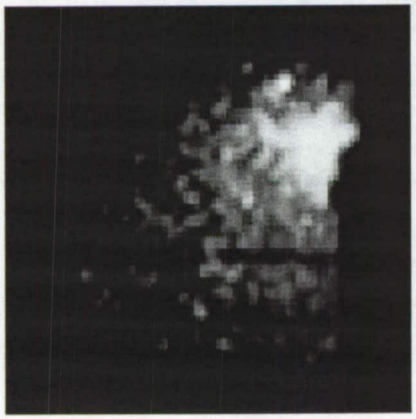


VR Phantom HD



Photron SA-2



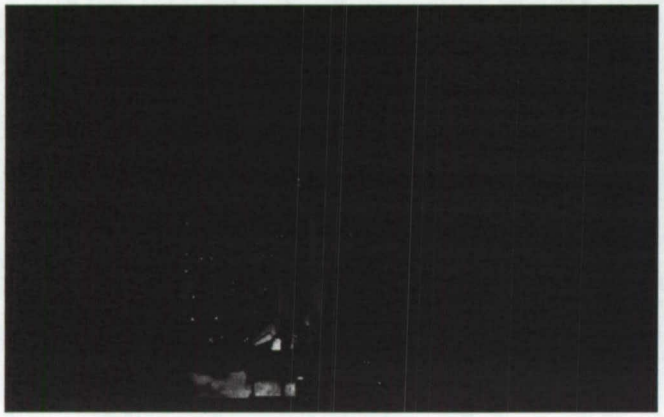
Cooke pco.dimax

Triggered later,
Image NA

IDT / Redlake Y5

HSD Review

Field Test – Imagery comparison (T-3.1s)



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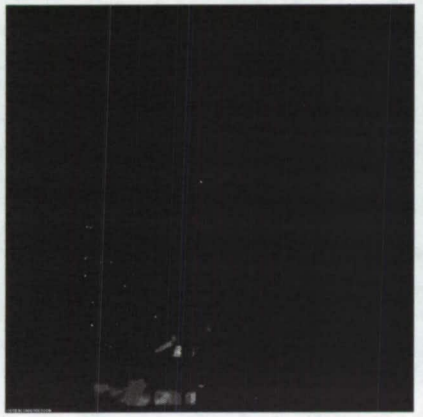
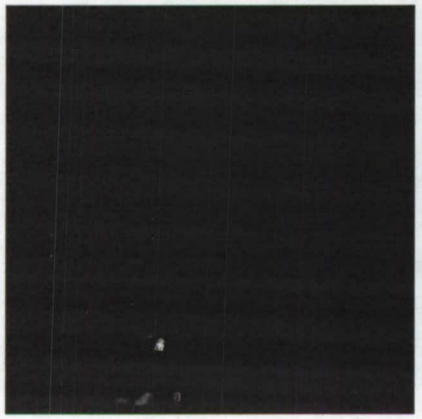


VR Phantom HD

Photron SA-2

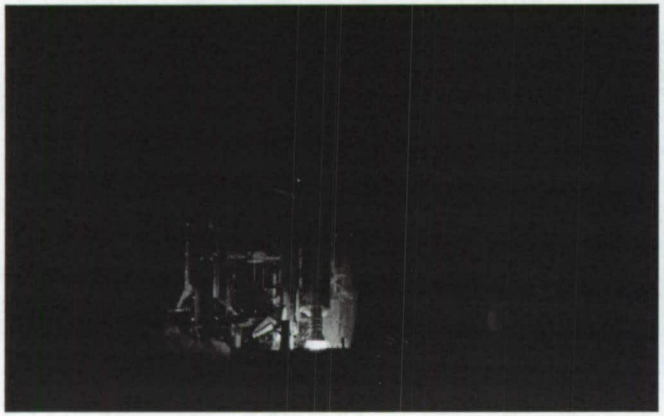


Cooke pco.dimax

IDT / Redlake MotionPro Y5

HSD Review

Field Test – Imagery comparison (T+1.3s)

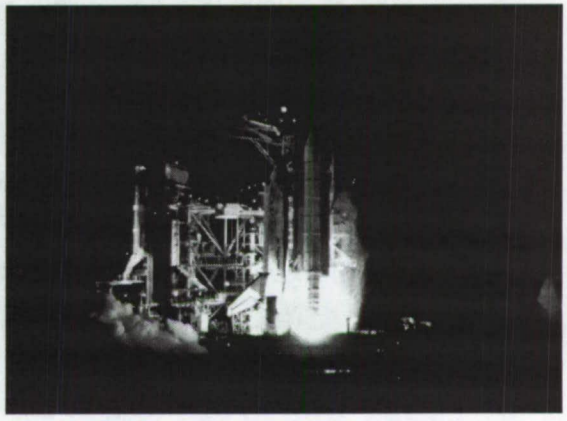


Vision Research v640

VR Phantom HD

Photron SA-2

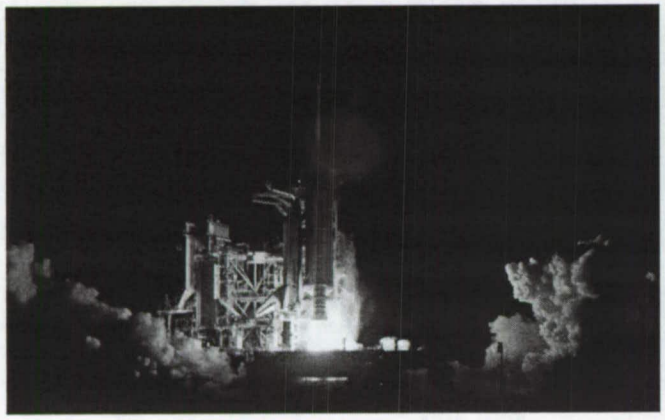
Cooke pco.dimax



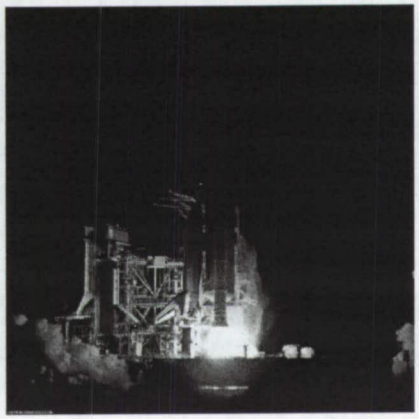
IDT / Redlake MotionPro Y5

HSD Review

Field Test – Imagery comparison (T+2.1s)



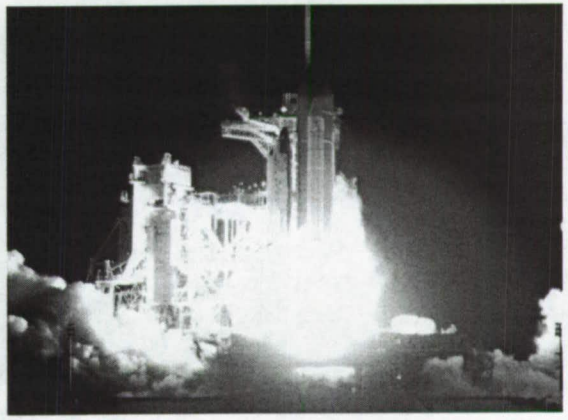
Vision Research v640



VR Phantom HD

Photron SA-2

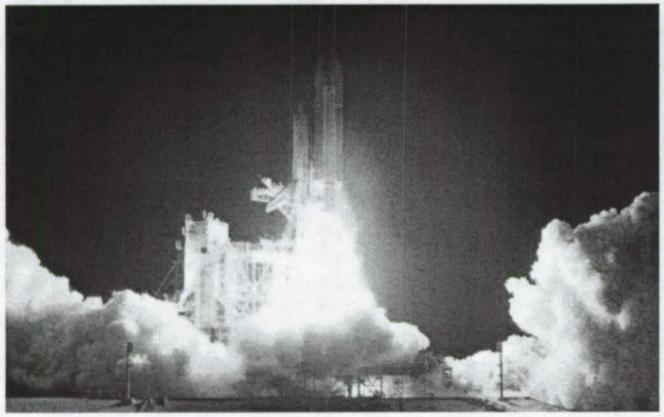
Cooke pco.dimax



IDT / Redlake MotionPro Y5

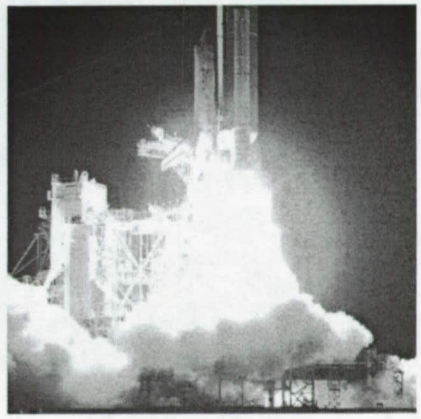
HSD Review

Field Test – Imagery comparison (T+4.1s)



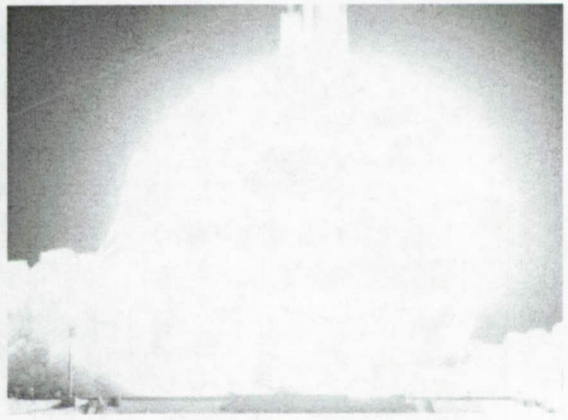
Vision Research v640

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

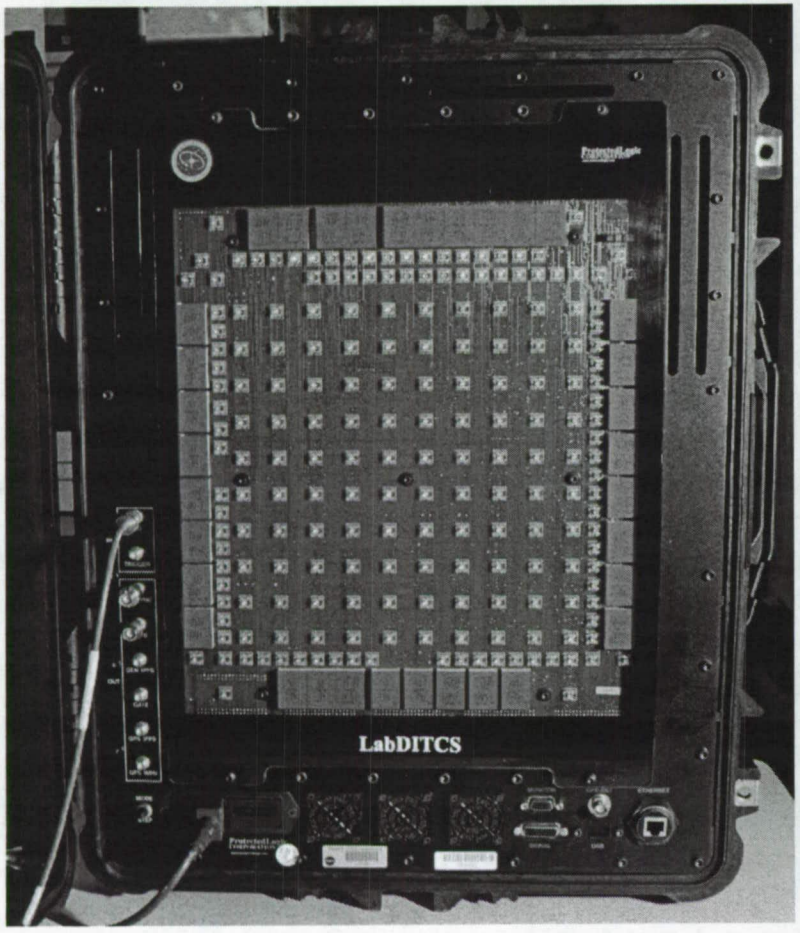
References:

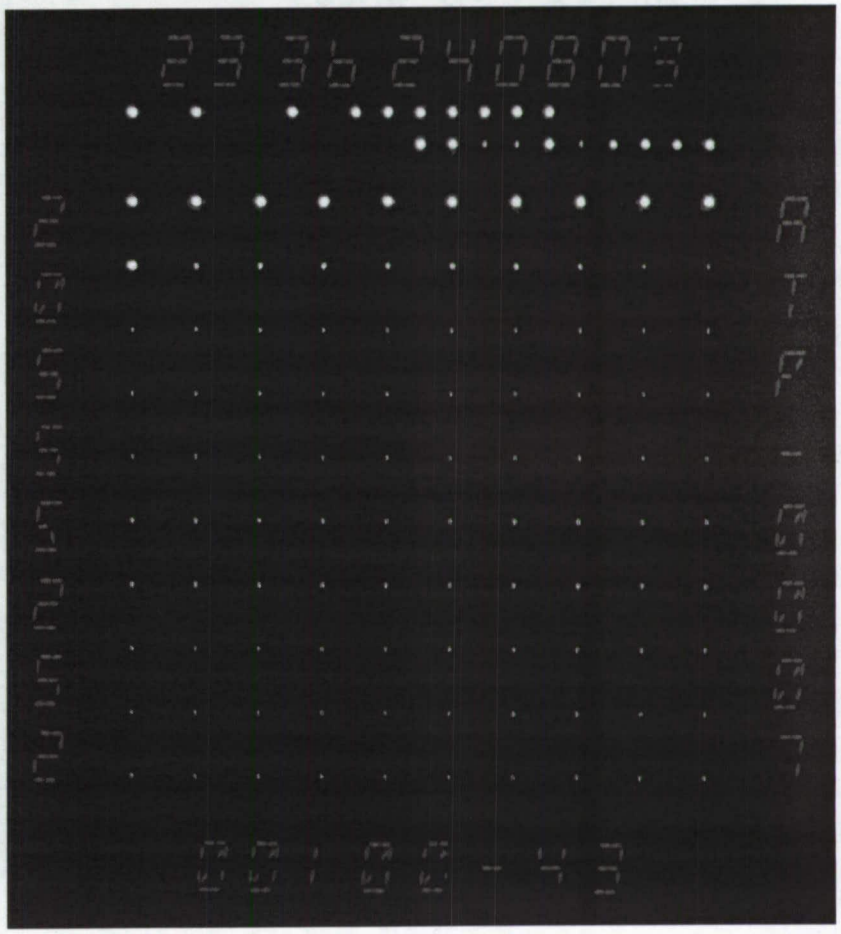
Telles, D. & Husman, E. (2005)
WSMR Film Elimination Plan

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

HSD Review

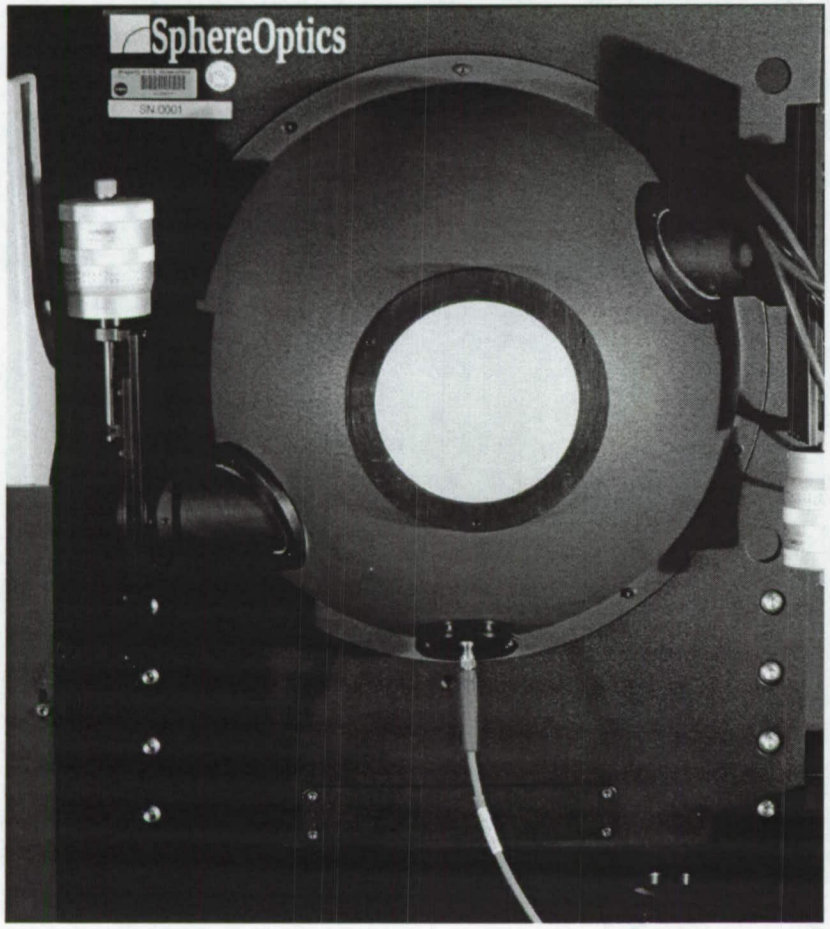
Bench Testing – Timing tests with the LabDITCS

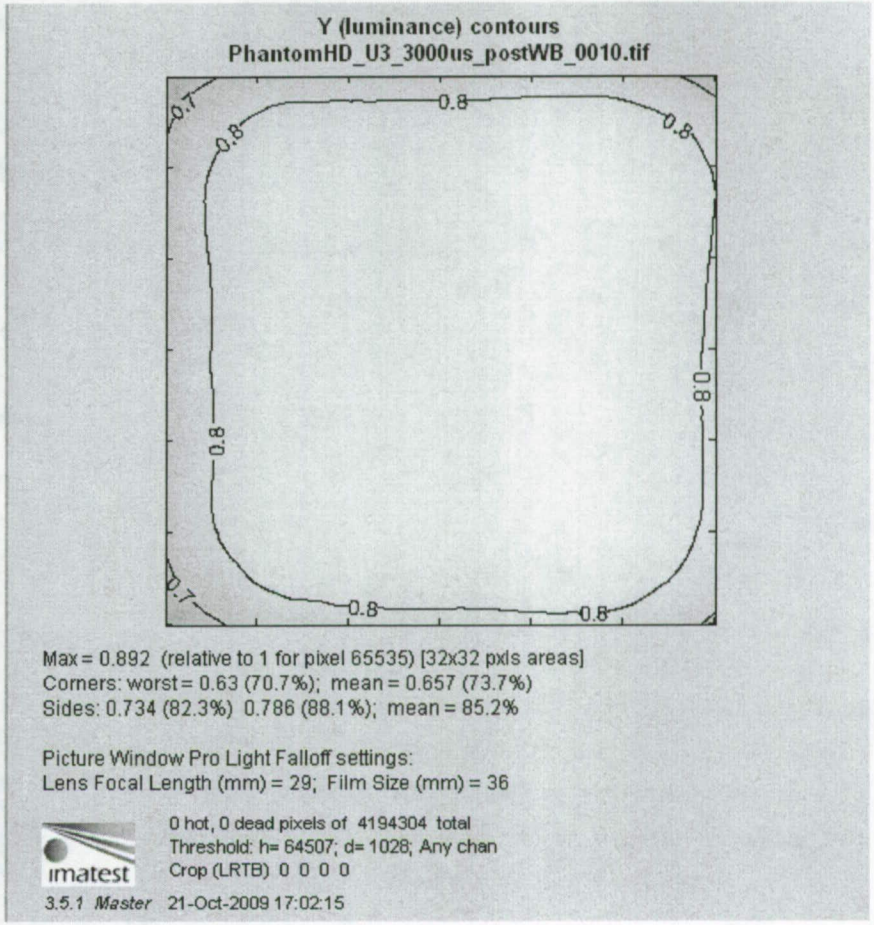




HSD Review

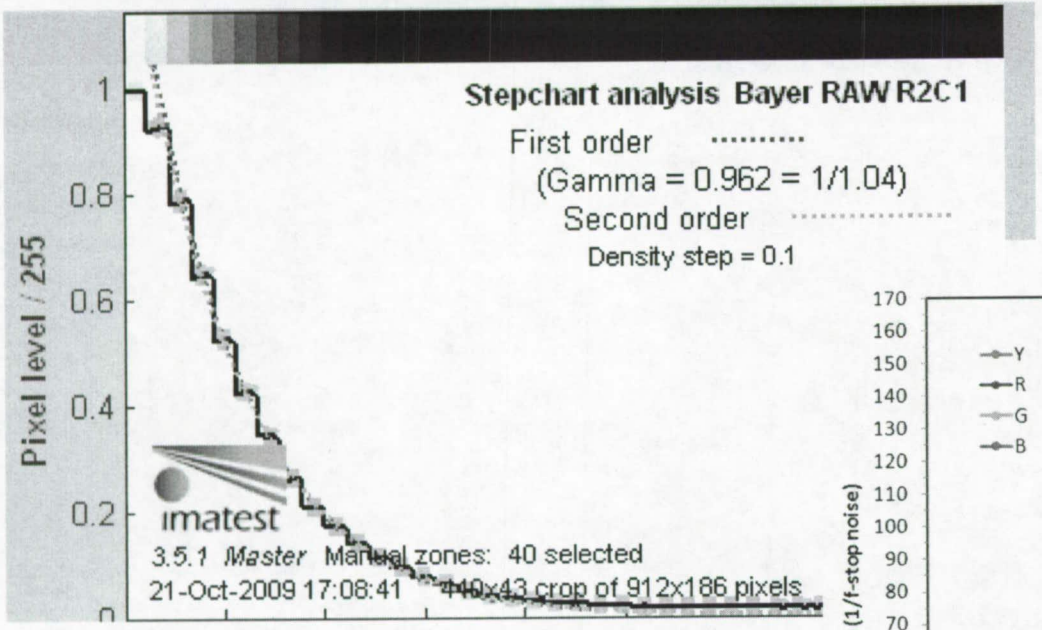
Bench Testing - Sensitivity & Uniformity tests

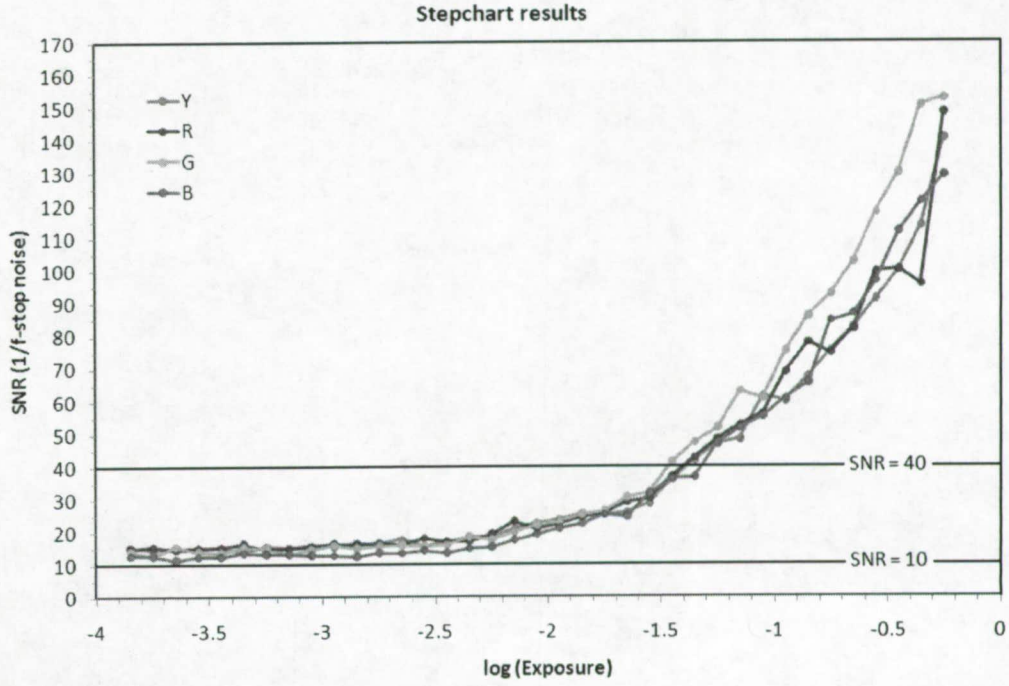




HSD Review

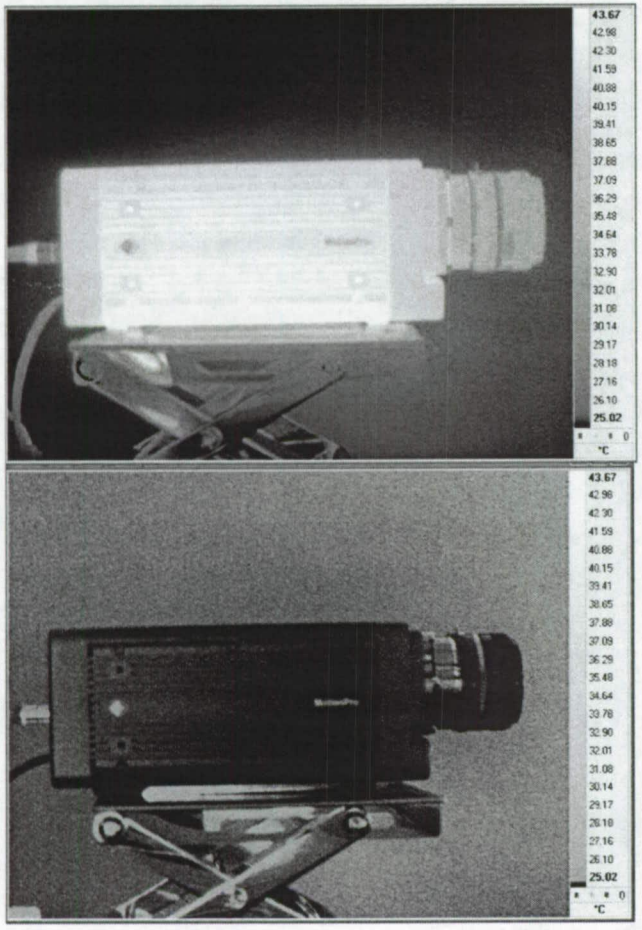
Bench Testing – Step chart: sensitivity & dynamic range

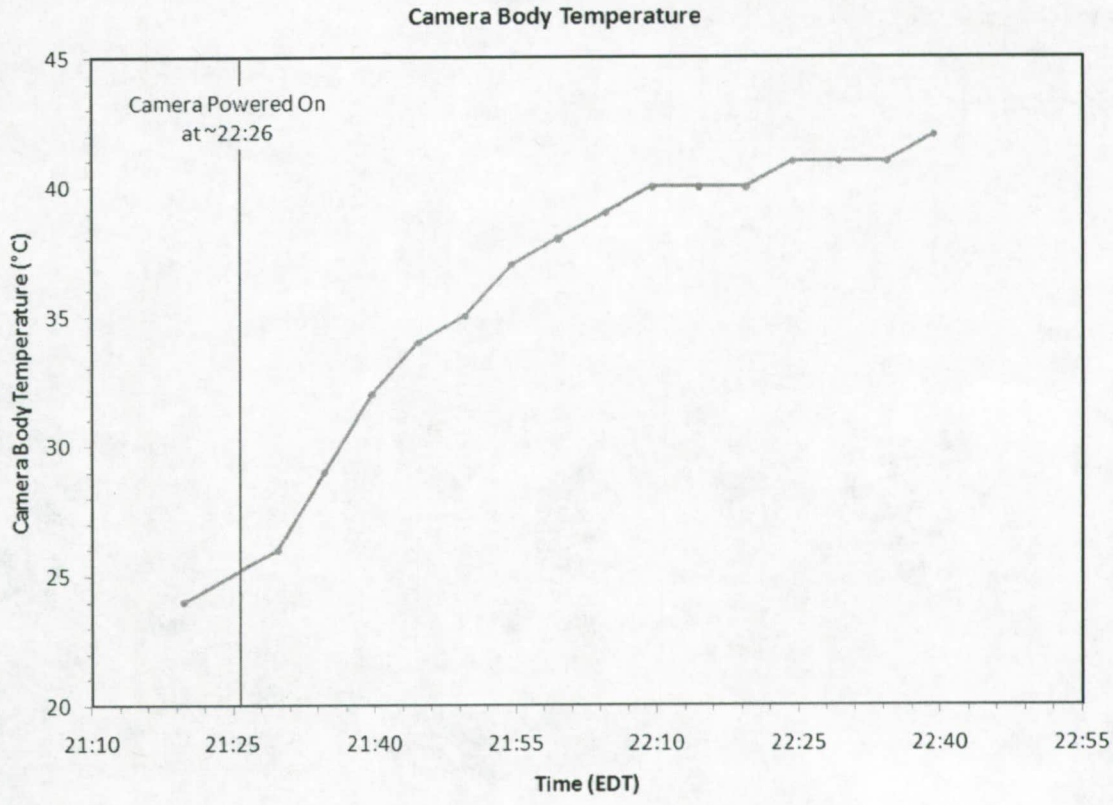




HSD Review

Bench Testing – Thermal properties





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

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
27-10-2009	Oral/Visual Presentation (Powerpoint)	Jun 2009 - Oct 2009

4. TITLE AND SUBTITLE
High Speed Digital Camera Technology Review

5a. CONTRACT NUMBER
NAS10-03006

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Space Shuttle KSC Integration Office
Kennedy Space Center, FL 32899
Mail Code: MK-SIO

10. SPONSORING/MONITOR'S ACRONYM(S)
MK-SIO

11. SPONSORING/MONITORING REPORT NUMBER

12. DISTRIBUTION/AVAILABILITY STATEMENT

13. SUPPLEMENTARY NOTES

14. 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.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19b. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Dr. Sandra Clements
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