Kennedy Space Center Applied Physics Lab: NDE and SHM Activities

Presentation to the

Georgia Tech

July 30, 2008

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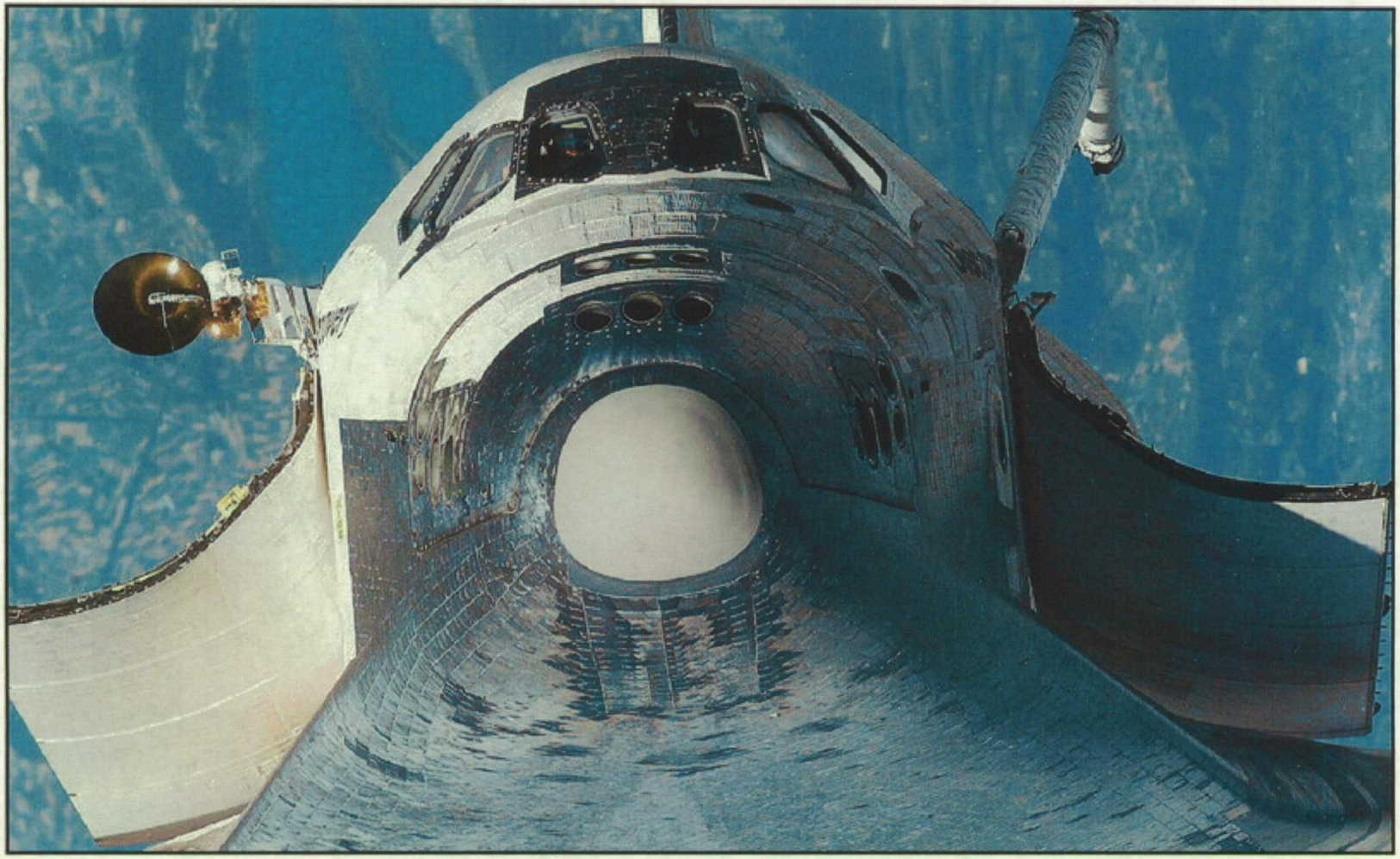
Outline

- Orbiter Window Inspection Tools
- Moisture in Fairings
- X-ray Backscatter
- Large Cryo Tank IR Thermography
- Flame Trench Brickwork
- KSC Needs

Orbiter Window Inspection Tools

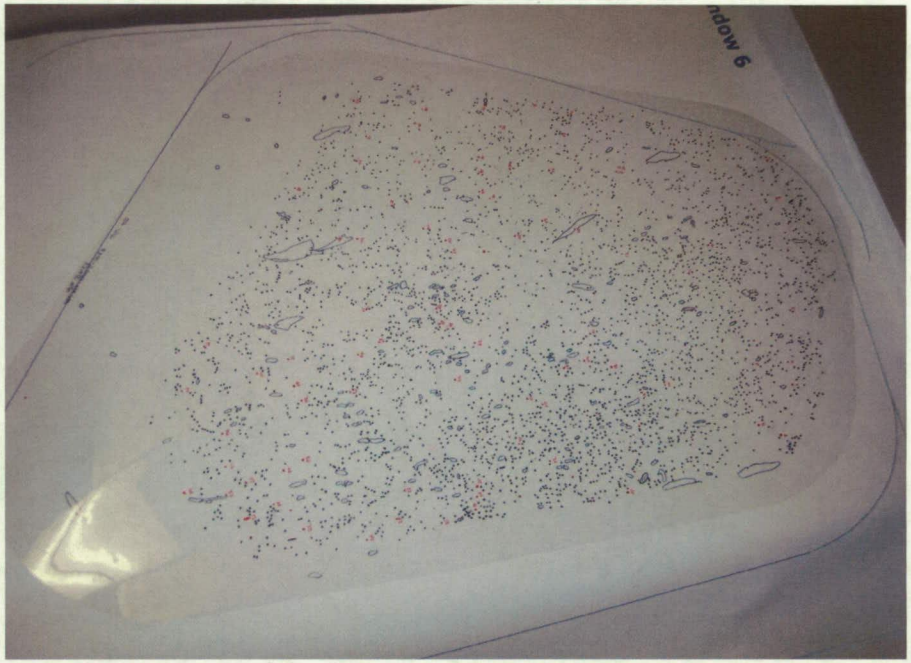


Hypervelocity Impacts

QuickTime™ and a
decompressor
are needed to see this picture.

Old Methods of Inspection

Previous method of on-vehicle inspection was flawed:

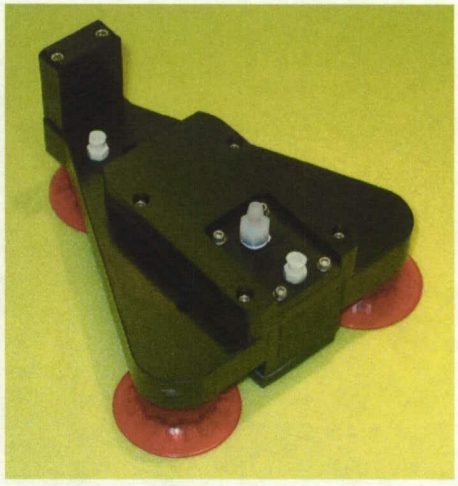


Inspectors arduously search for and document the location of defects on Mylar sheets. There might be hundreds of suspect defects on a single window and more appear after each mission.

SLOT Tool

We have significant involvement in the detection and measurement of glass defects on the Orbiter windows.

Mid 1990's version



2006 version.

Three generations of the SLOT (Surface Light Optimizer Tool) used to couple light into the Orbiter windows so that defects stand out as points of light against a dark background.

Need for Improved Inspection

After finding a defect, it must be determined if it is more than 0.0006 inches deep.

Previously this measurement was performed using a refocus microscope:

If the bottom of a defect is out of focus, its depth is > 0.0006”

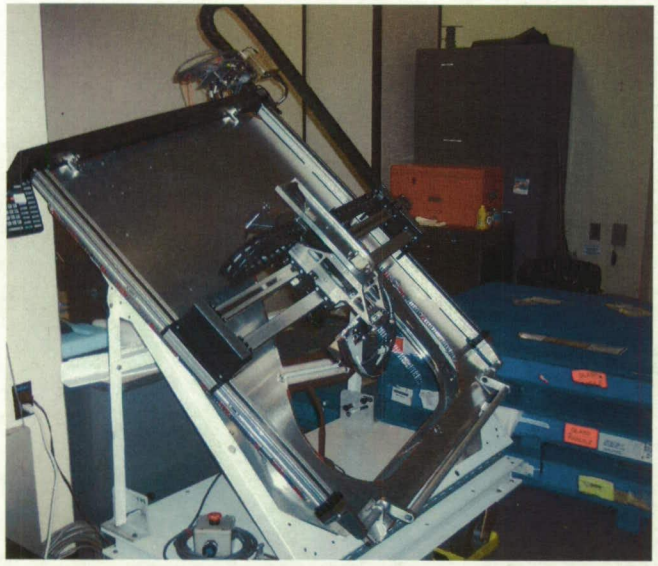
However, tests showed that the refocus test had an unacceptable error rate (ergonomics).

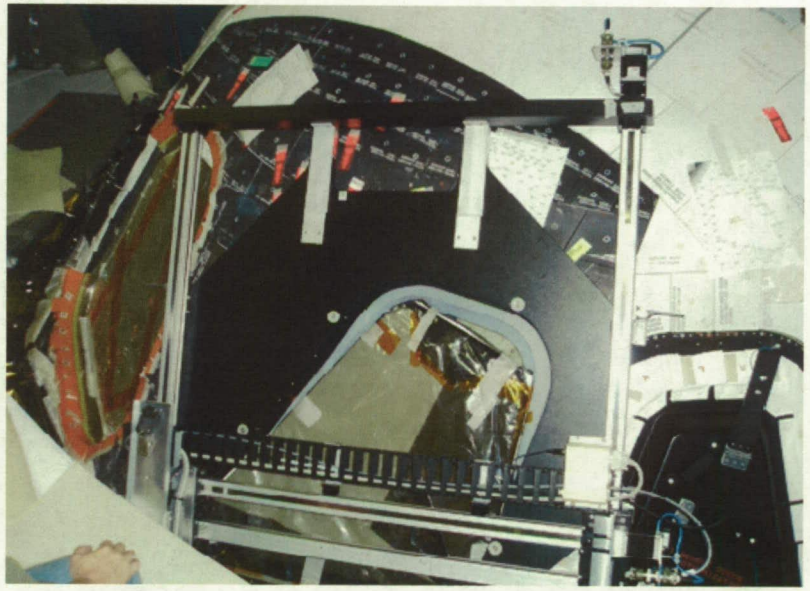
Now the windows are removed and inspected out of the Orbiter. Mold impressions are made of all suspect defects and then measured off-line.

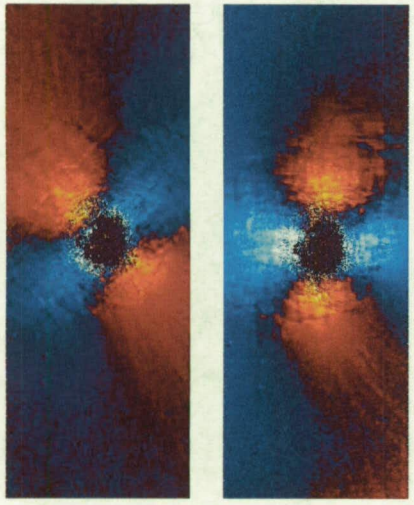
The Refocus Microscope

An Orbiter Window Defect

New Window Tools In Development



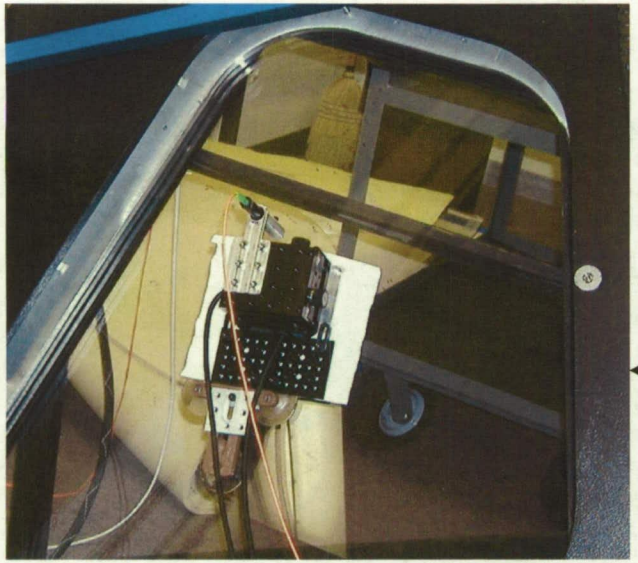




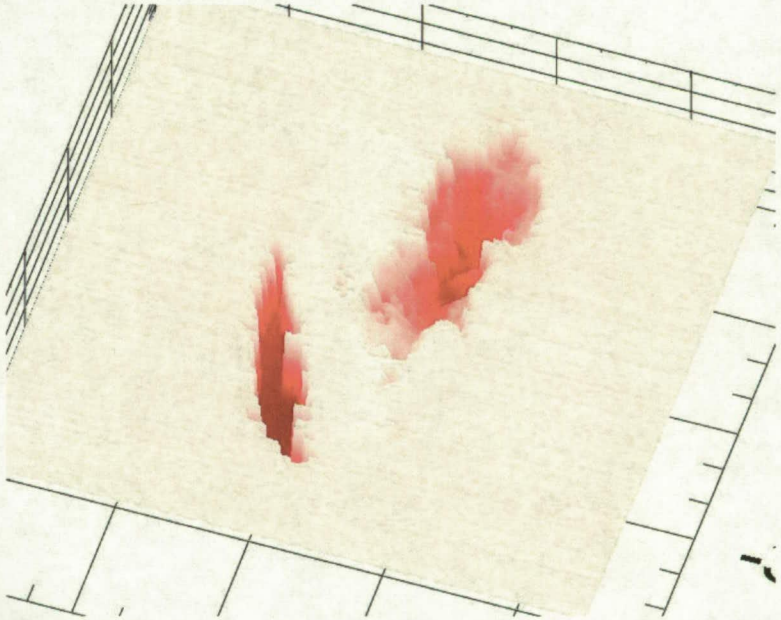
Stress fields associated with a defect

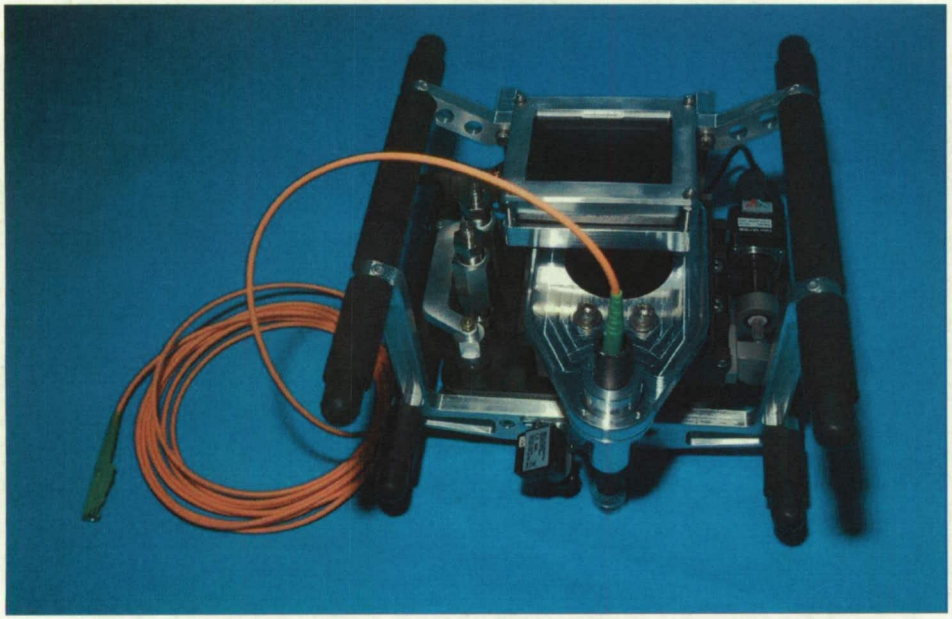
A scanning window inspection system is in development which uses stress induced polarization changes in light to detect the stress field associated with a defect. It has been tested on two Orbiters and is currently scanning four scrapped Orbiter windows to develop a data base for comparison against the current off-line manual inspection process.

New Window Tools In Development



PHOWID
defect
scanner





To replace the need for mold impressions a highly accurate surface topography scanning system is being developed. This device will be handheld and will be placed on a window where it will scan a defect and produce a 3-D contour map.

Constellation Composites

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

The Constellation Program involves the design and build of two new launch vehicles involving large composite structures.

Ares 1 Artist Conception

Example: Delta II Fairing

TIFF (Uncompressed) decompressor and a QuickTime™ are needed to see this picture.

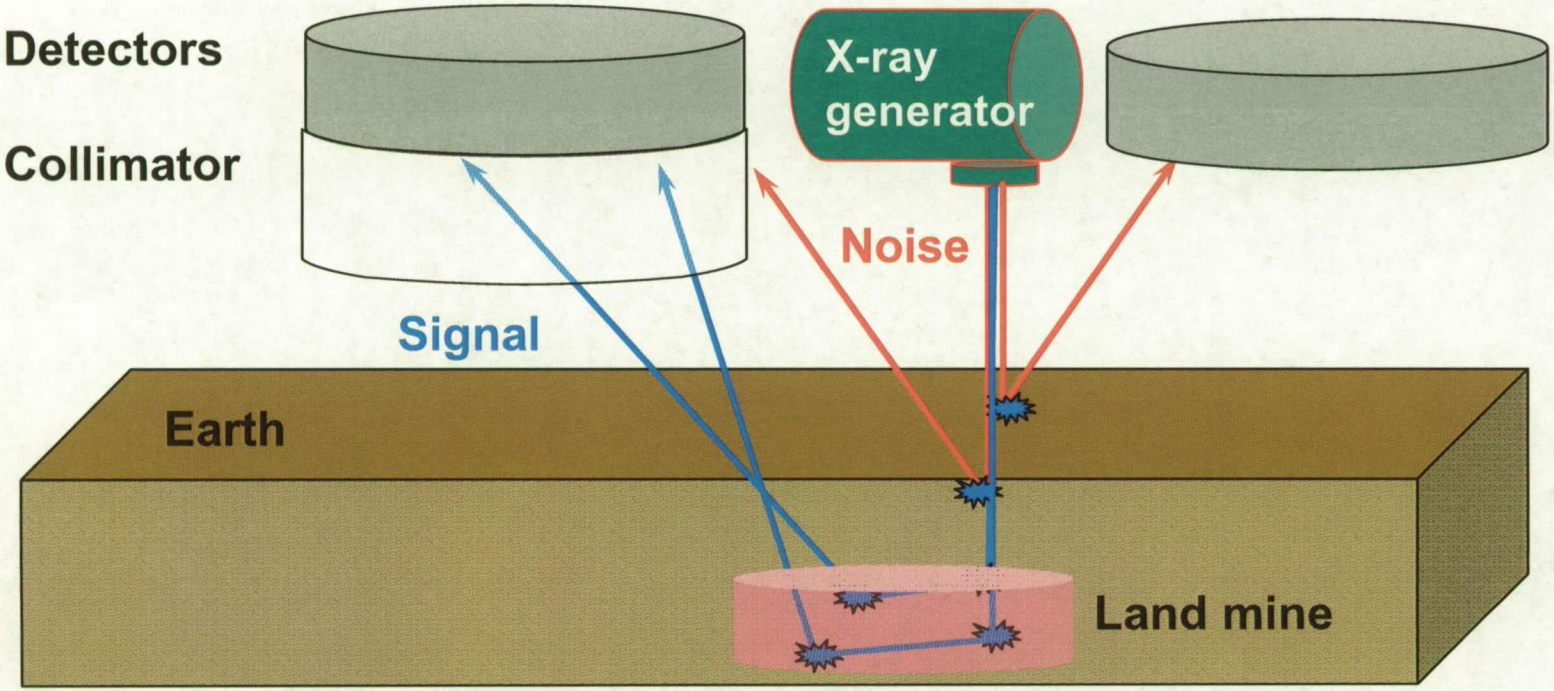
Mars Pathfinder on the Delta II booster with 1/2 fairing.

The Delta II fairing is a complex structure that includes Rohacell foam core material, and graphite epoxy face sheets.

Moisture in Fairings

- The fairing polymer materials absorb up to about 1-2% by weight moisture from the air through diffusion.
- During ascent the fairing is aerodynamically heated and the moisture content weakens the material at higher pressure.
- Problem: Determine moisture content and potentially keep material drier.
- Current practice: Use math model to estimate moisture content and no attempt at moisture control.
- Need: Method for moisture measurement and moisture maintenance methods.

X-Ray Backscatter: Lateral Migration Radiography (LMR)

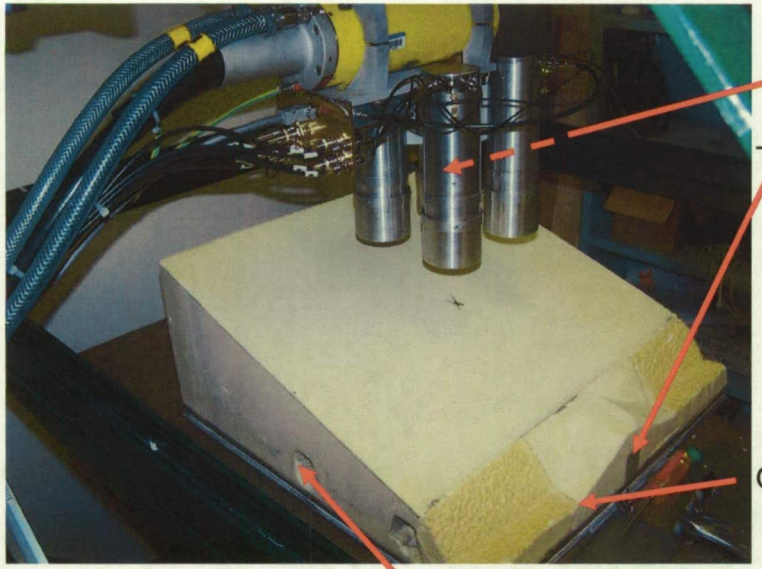


LMR was developed by Ed Dugan, PhD, et. al. at University of Florida for land mine detection.

Spray on Foam Insulation (SOFI)

- Used to prevent the buildup of ice on the external tank of the of the space shuttle
- Low density ~0.03 g/cm^3
- Application process has a tendency to produce voids and delaminations

Flange Ramp Panel

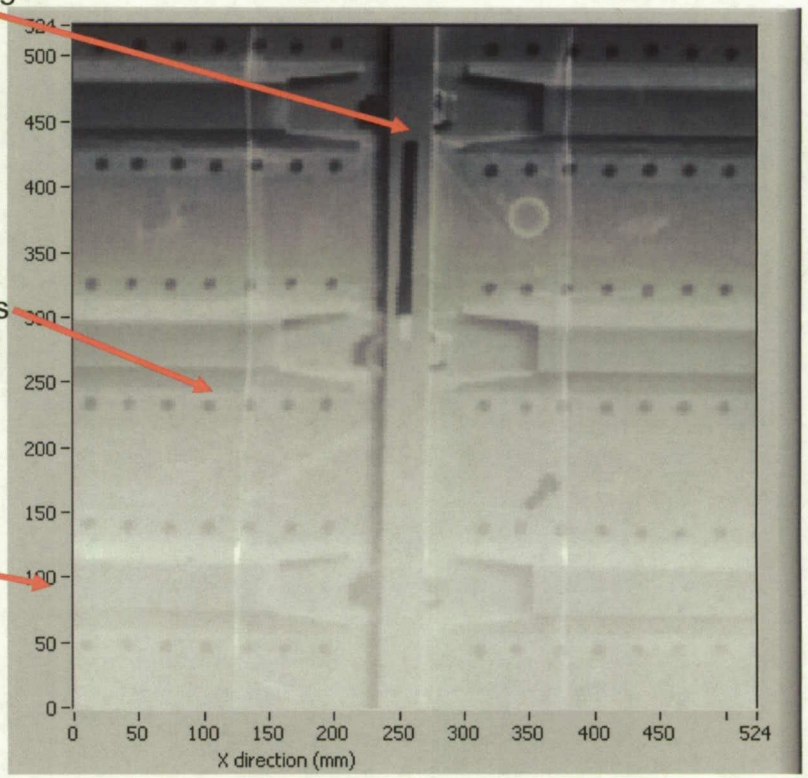


Origin of scan images
(corner behind detectors)

Tank Flange

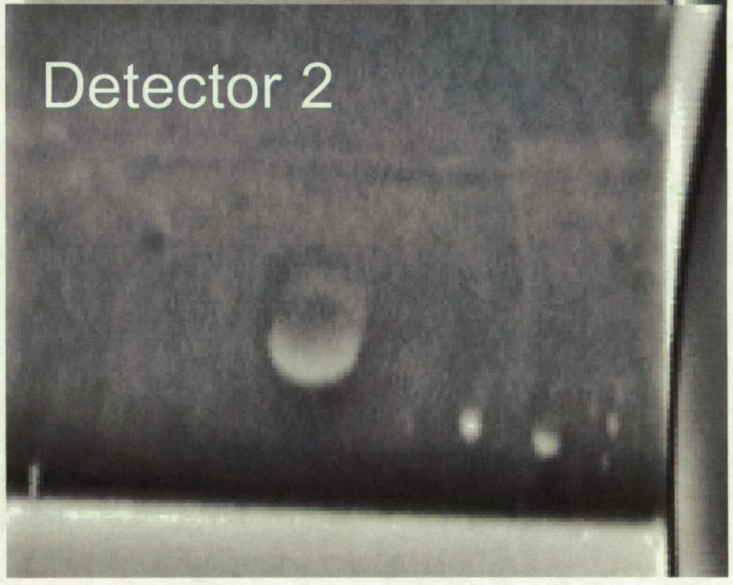
Glue Lines

Stiffener
Stringer



- 610 x 610 mm
- 25.4 mm to 305 mm thick
- 2 mm pixels, 0.1 s/pixel

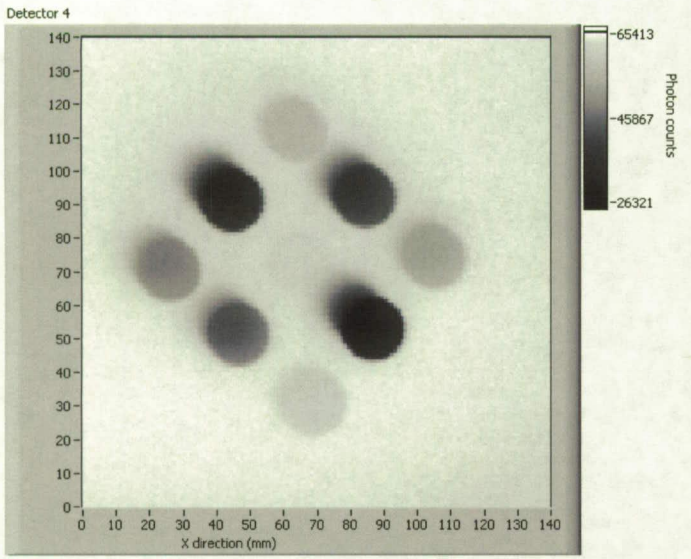
KSC X-ray Backscatter System

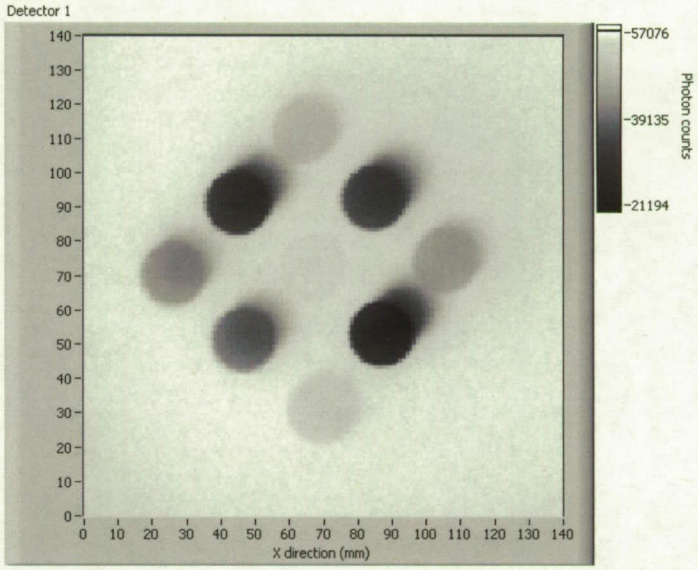


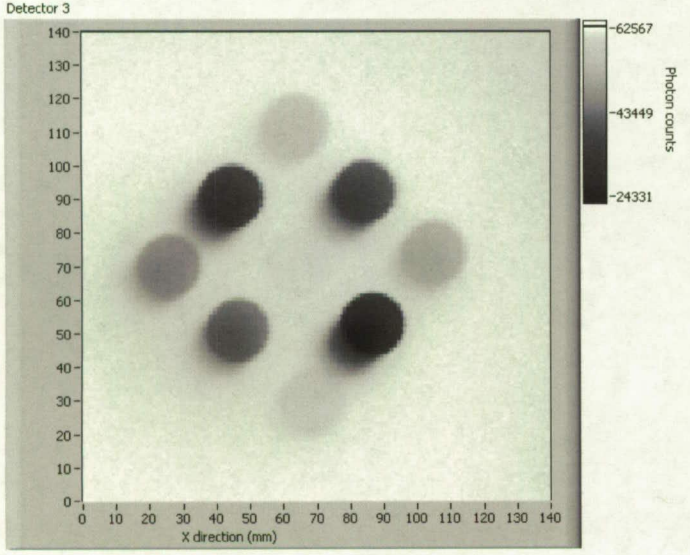
KSC X-ray Backscatter

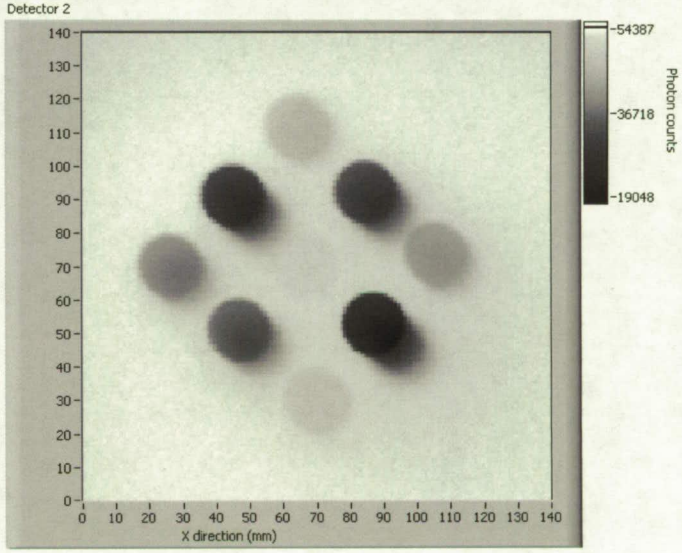
- Advantages:
  - Allows one-sided inspection
  - Low Z materials stand out bright against darker (high Z backgrounds)
  - Can scan through skins of boxes to inspect electronics and tubing.
- Disadvantages:
  - Finite penetration capability for metals & other high Z materials.

Current Investigations

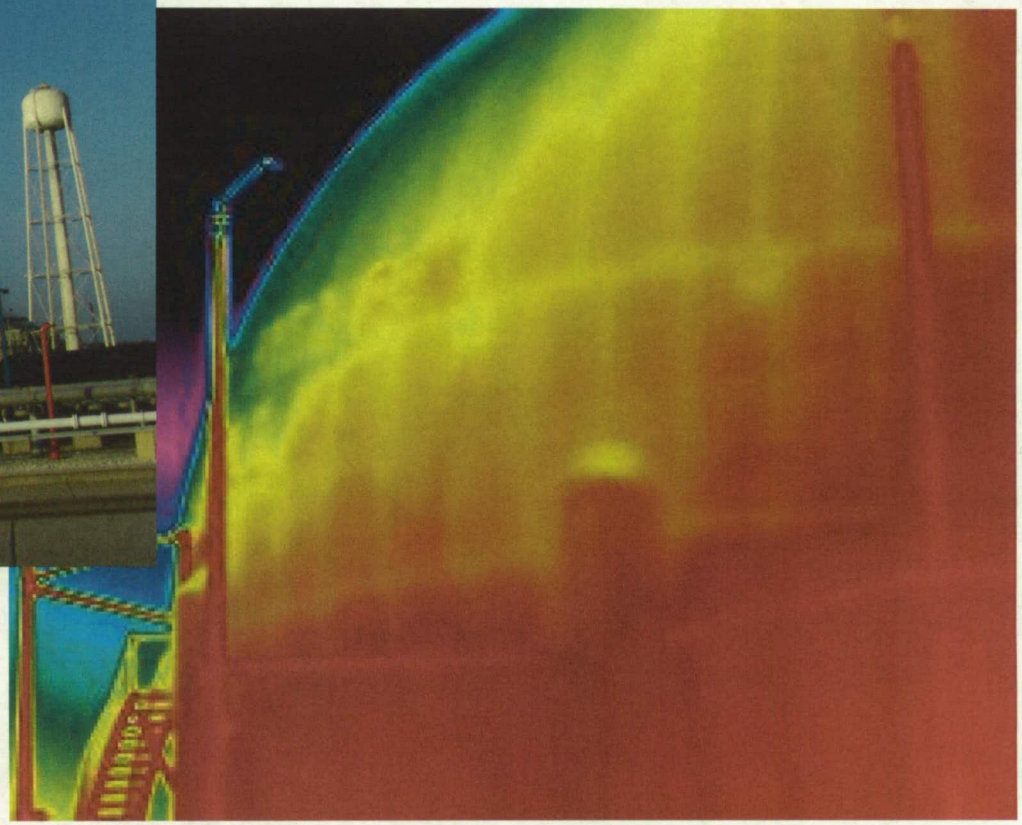




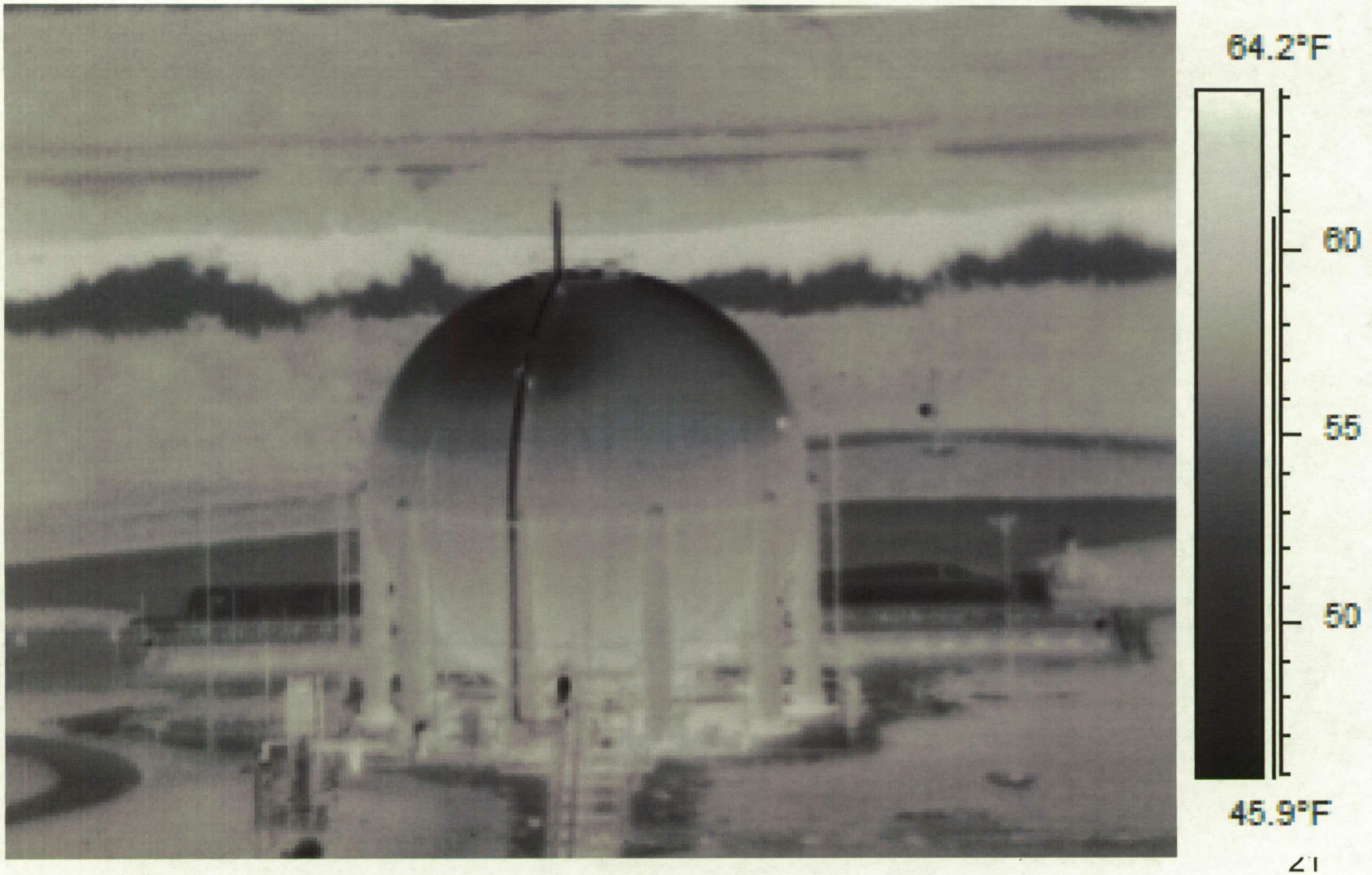




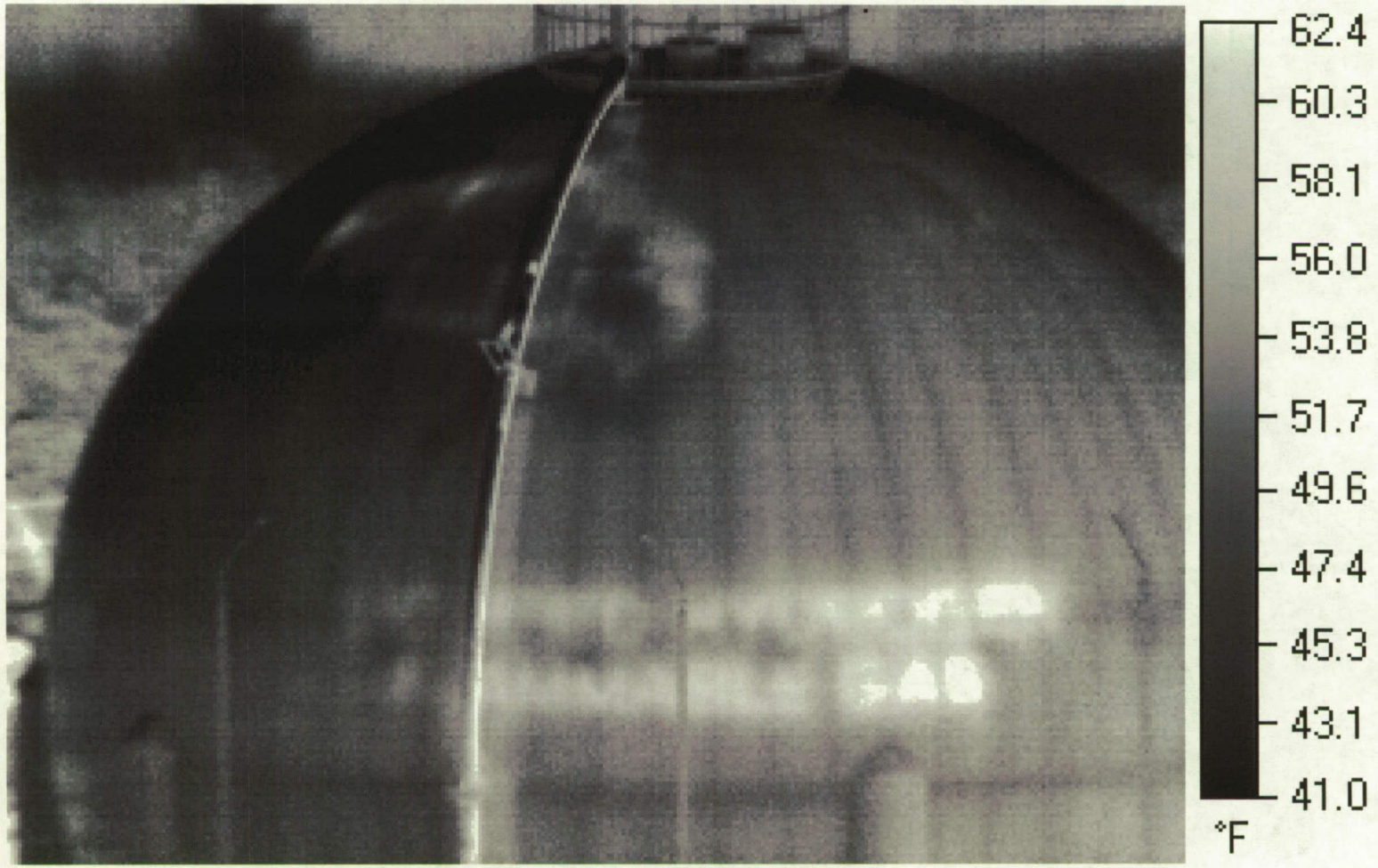
Thermography of LH2 Tank



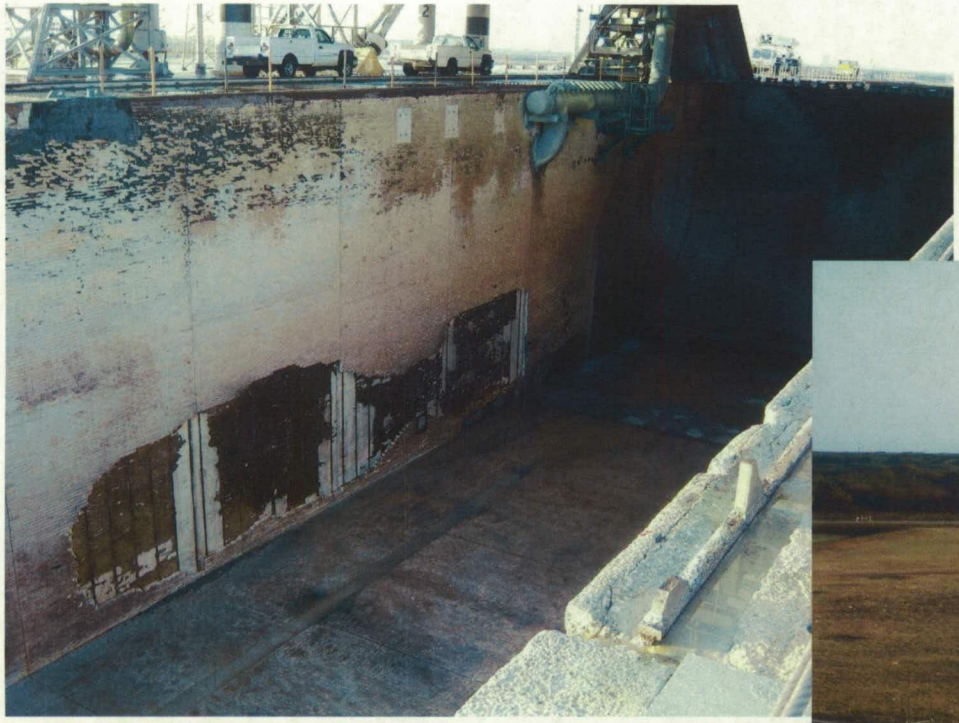
- Sunrise IR Data From: Camera S65 W/ 7° Lens – Looking From 255” Level



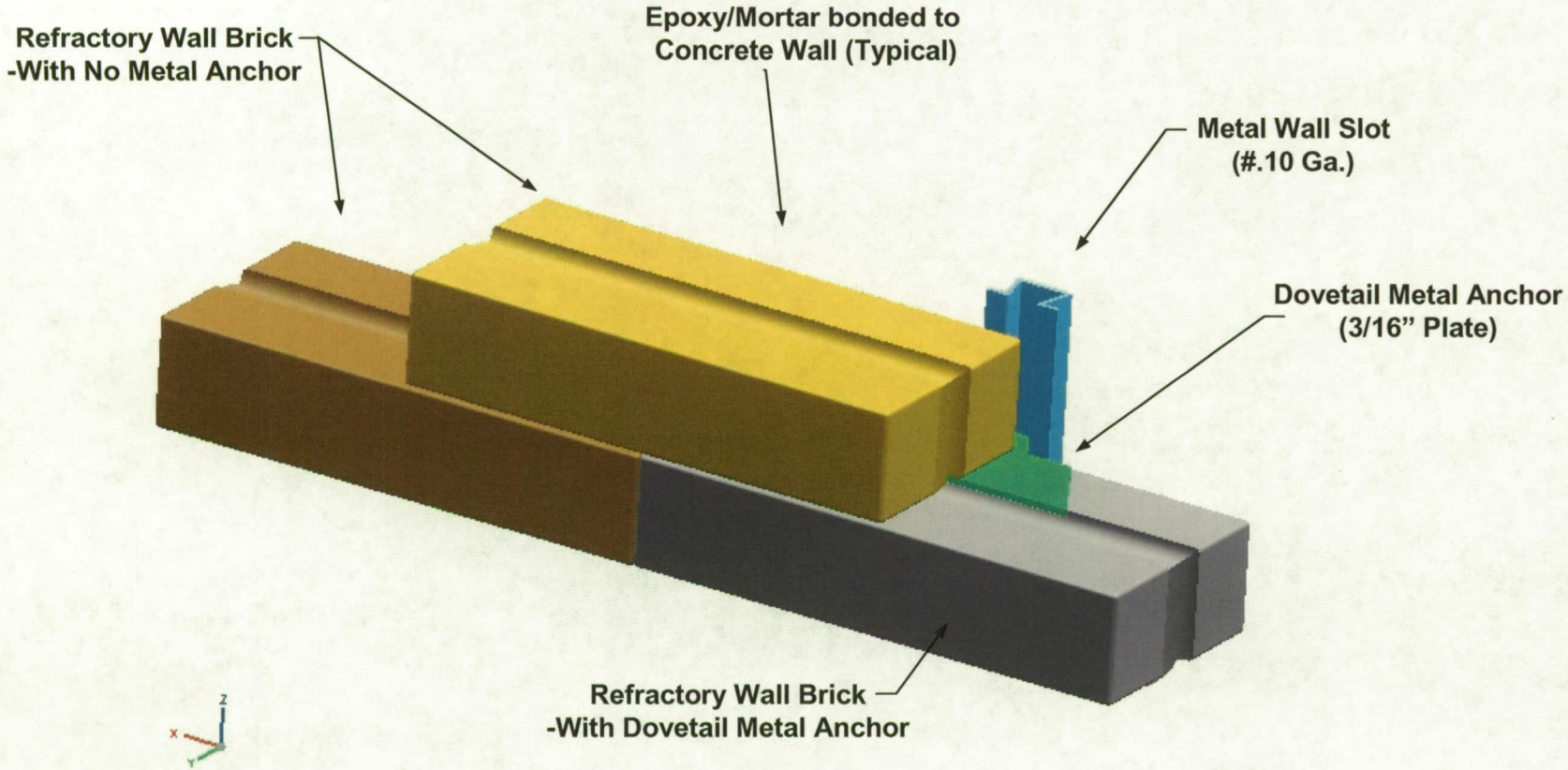
- Noon IR Data From: Camera 7600pro W/ 10x Lens – Looking From 255” Level



Flame Trench Brick NDE



Brick, Anchor and Wall Slot Typical Configuration



Shearography of Flame Trench at PAD A

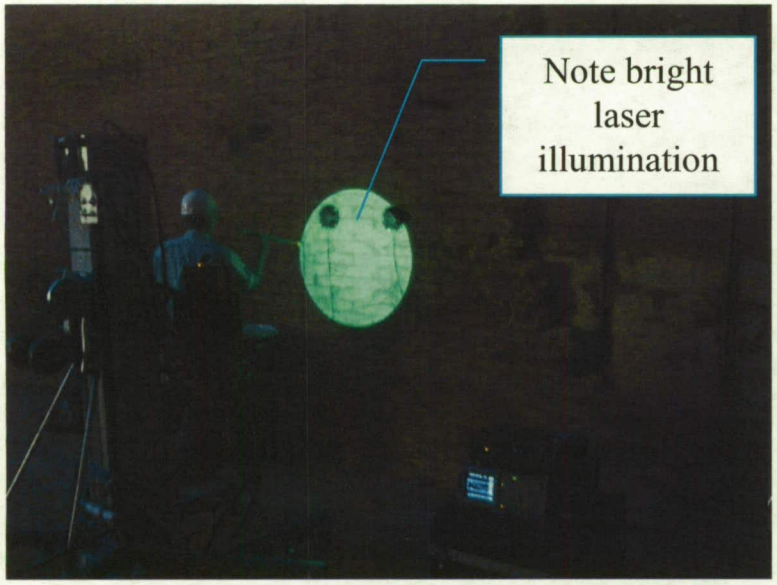
(Flash report)

James Walker, Don Lovell; MSFC

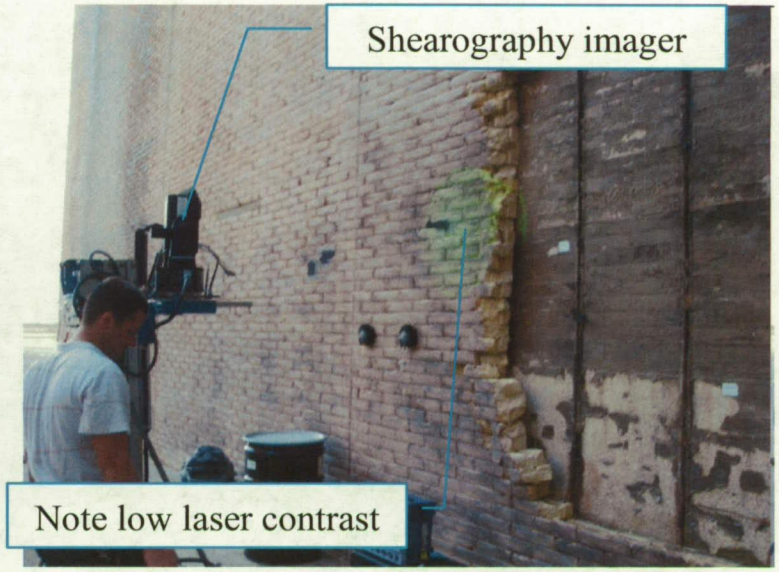
Eric Burke, Jim Landy; KSC USA

Ben Feferman, LTI

Shearography setup

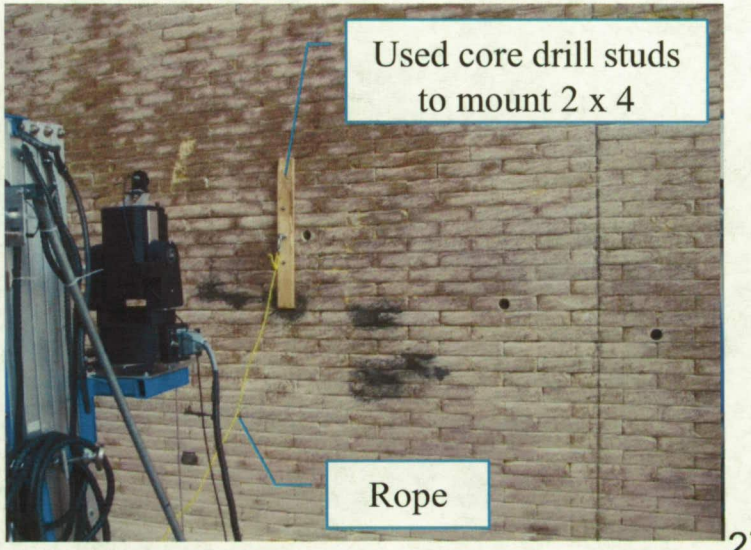


Shearography before dawn



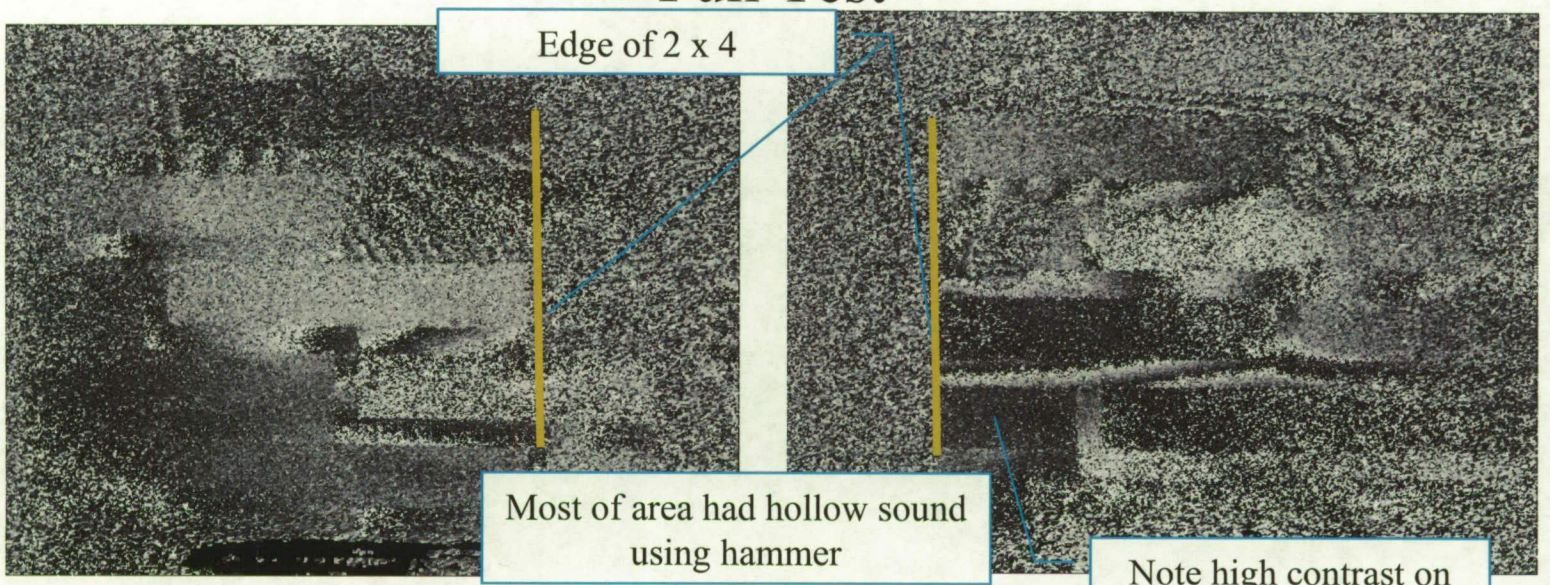
Morning shearography

"Butt Kicker" shaker excitation

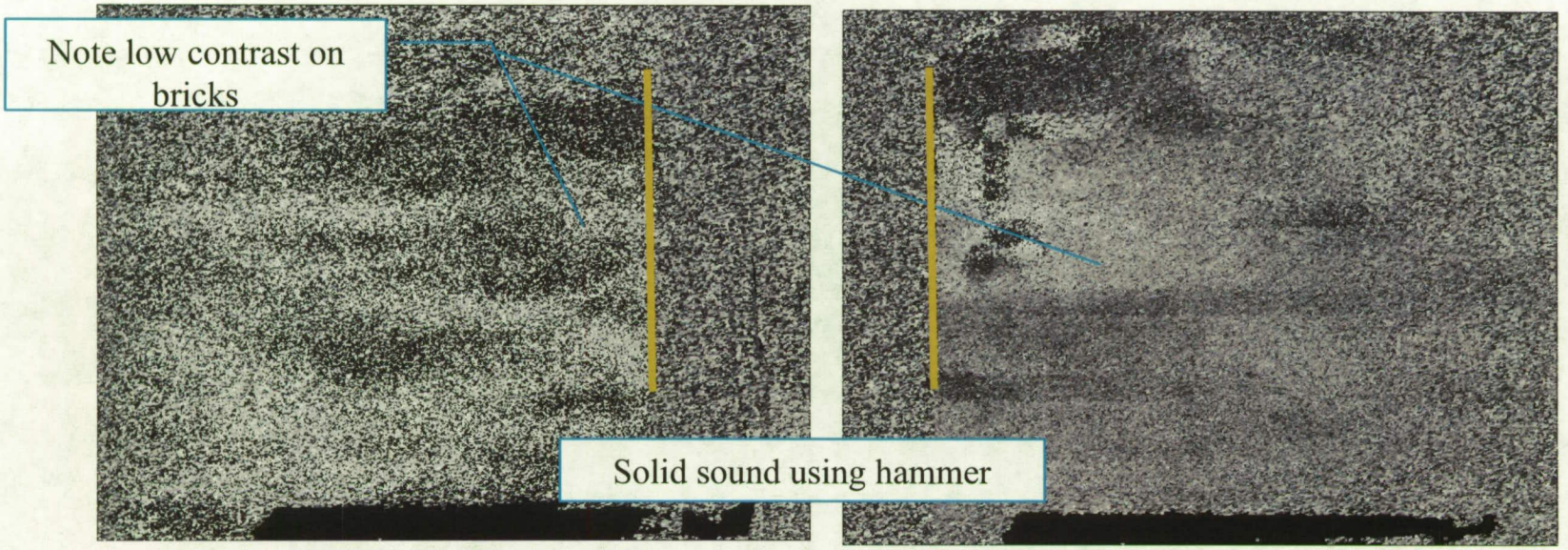


Pull load excitation

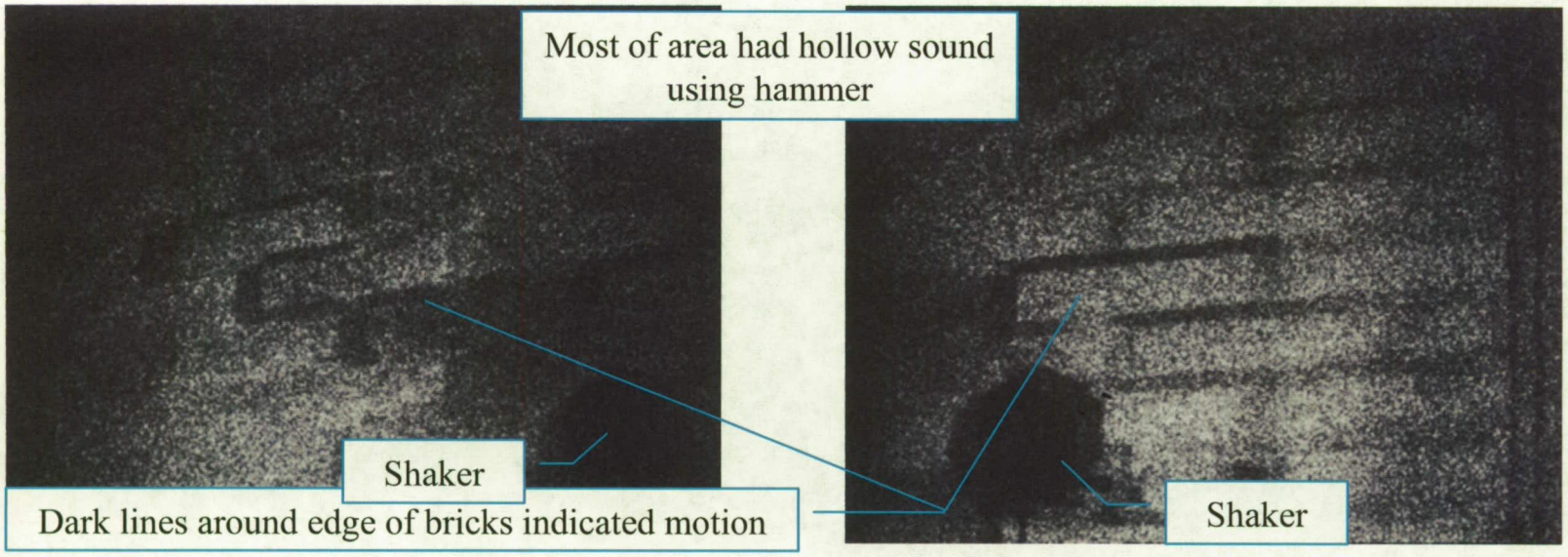
Pull Test



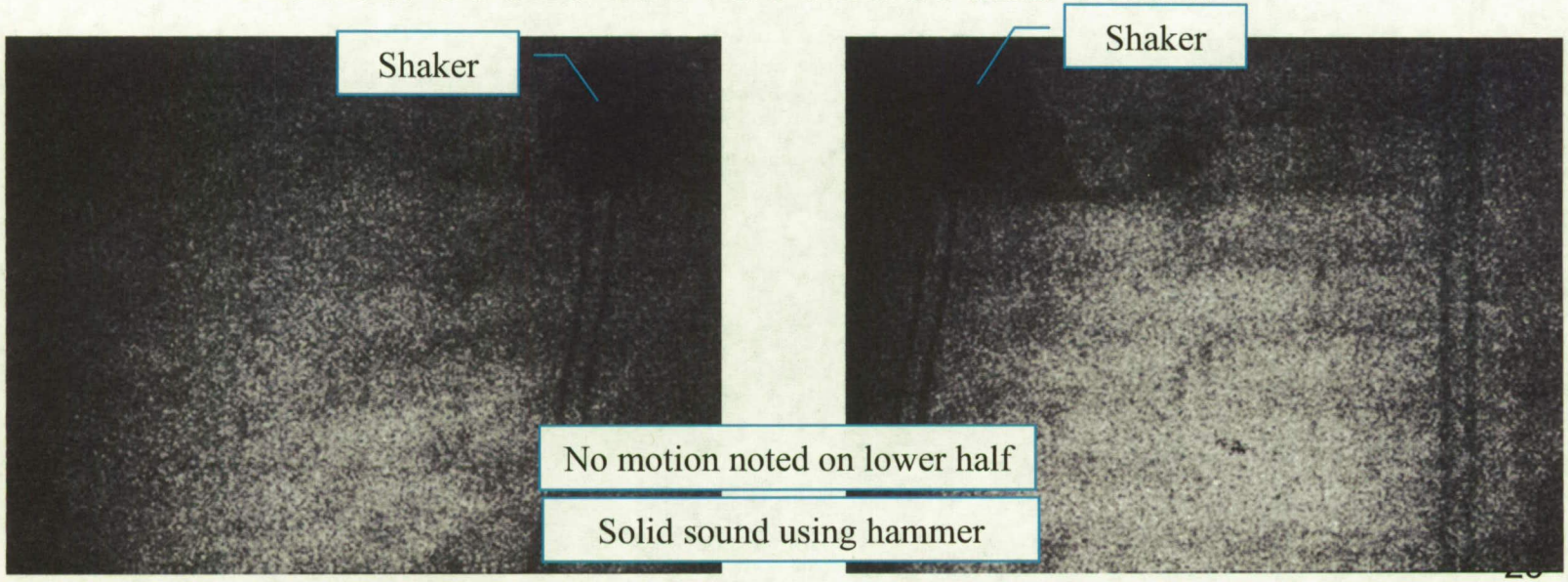
Core 3



Core 9



Hollow sound above/solid sound below



60 Hz 50% power vibration

NDE Needs (KSC Perspective)

- SHM for large composite structures (e.g. 10 m diameter cylinders).
- NDE systems for large structures (adaptable to shop environments)
- Direct and Inverse modeling for IR, X-ray and other technologies.

Thank you.