



# NASA Engineering and Safety Center (NESC) Nondestructive Evaluation (NDE) Efforts in the Space Transportation System (STS)

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# Outline

- Definition of NDE
- NESC NDE Super Problem Resolution Team (SPRT)
- Unique Inspection Issues on STS
- Selected NESC NDE SPRT Activities
- Flow-liner Cracks
- External Tank (ET) Thermal Protection System (TPS) Integrity
- Composite Over-wrapped Pressure Vessels (COPV) Aging
- Primary Reaction Control Thruster Cracks
- Future Options to Mitigate Risk with NDE
- Summary



## Definition of NDE

NDE is the application of any technology that nondestructively determines the integrity of physical systems.

- Entire spectrum is available - interrogating energy sources include vibrations, sound, microwave, infrared, optical, x-ray, through to cosmic radiation
- General applications to materials and structures
- Typically characterizing integrity of structures and materials by evaluating engineering properties, geometries, interfacial properties, flaws, constituent component orientations, etc.
- Inorganic & organic systems
- Used in manufacturing process control, after manufacturing, in-service inspection, and health monitoring



## **NESC NDE Super Problem Resolution Team**

### **SPRT Charter**

The NDE discipline SPRT is a technical resource that will support the NESC and NESC Review Board (NRB) approved independent assessment or inspection (ITA/I) teams. The NDE discipline SPRT will identify the NDE resources (experts and test facilities) required by ITA/I teams and other NESC activities. The NDE discipline SPRT shall be cognizant of NDE related ITA/I's to ensure proper NDE expertise support. The NDE discipline SPRT will proactively engage NDE related issues throughout the agency when directed by the NRB.

### **Scope of the SPRT**

The NDE discipline SPRT shall consist of individuals that are experts in a wide range of NDE sub-disciplines. The NDE discipline SPRT experts shall focus their expertise on identifying and solving NDE related issues as directed by the NESC. To help promote engineering excellence, the SPRT will be engaged (assist, coach, mentor, etc.) with the NASA community. 4



# Unique Inspection Issues on STS

- Unique one-of-a-kind components
- Commercial off the shelf equipment and procedures are not applicable or available
- Complex Inspection
  - Inspection requirements evolve with time
  - Difficult access to inspection areas
  - In-situ inspections impose severe limits on inspection options

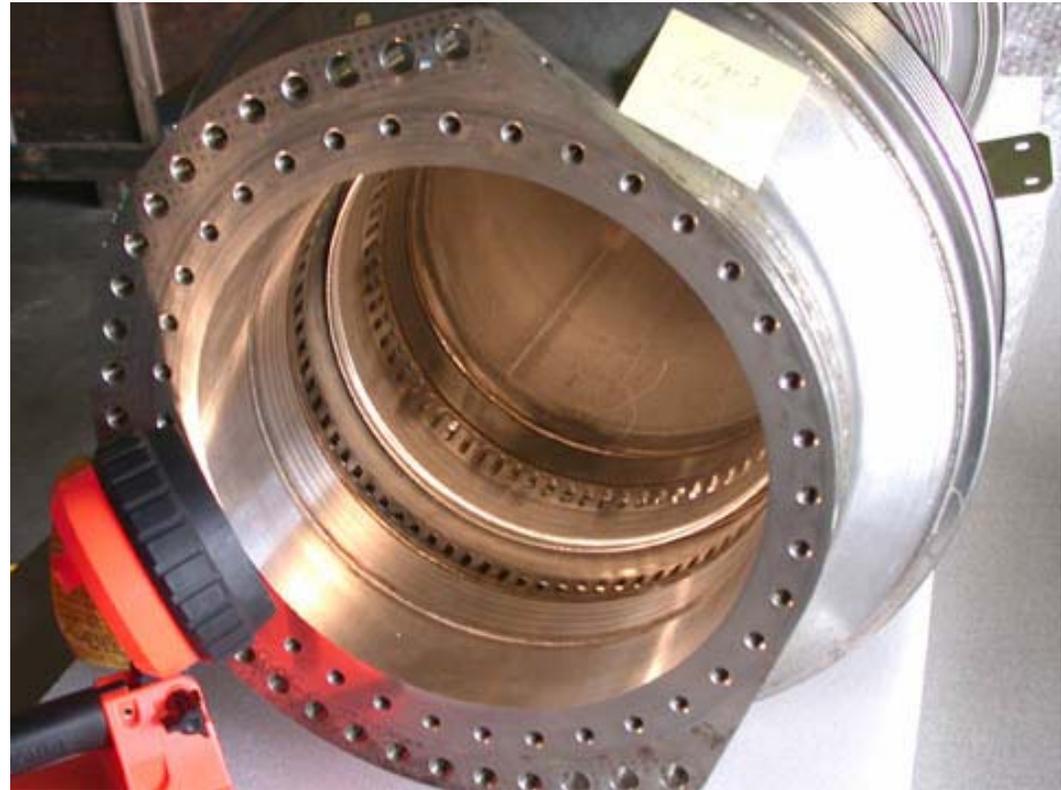


# Selected NESC NDE SPRT Activities

- Space Shuttle Main Engine Flow-liner Cracks
- Space Shuttle External Tank (ET) Thermal Protection System (TPS) Integrity
- Space Shuttle and International Space Station (ISS) Composite Over-wrapped Pressure Vessels (COPV) Aging
- Space Shuttle Primary Reaction Control Thruster Cracks
- X-43 Rudder Spindle Integrity
- ISS European Modules Weld Integrity



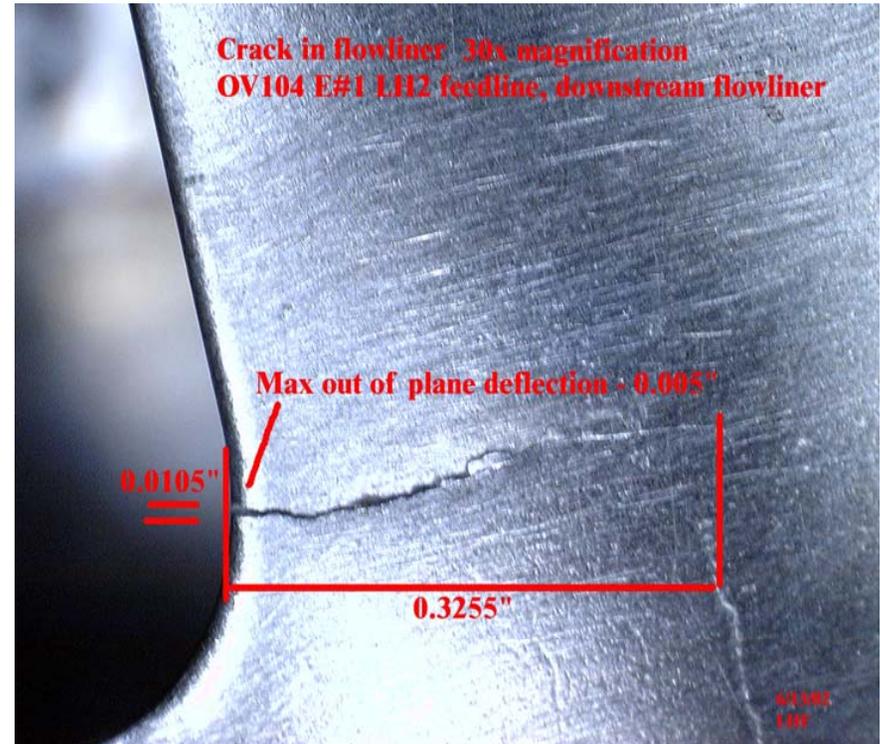
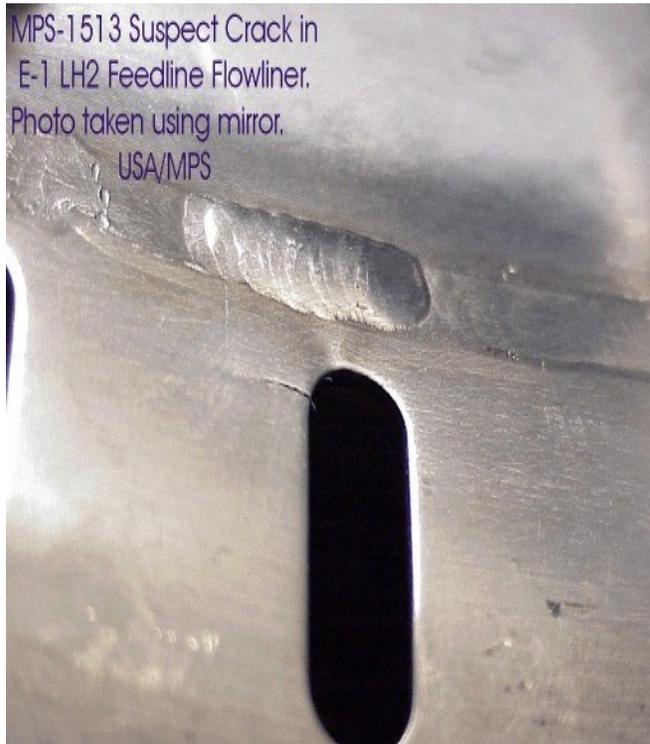
# FLOW-LINER





# FLOW-LINER

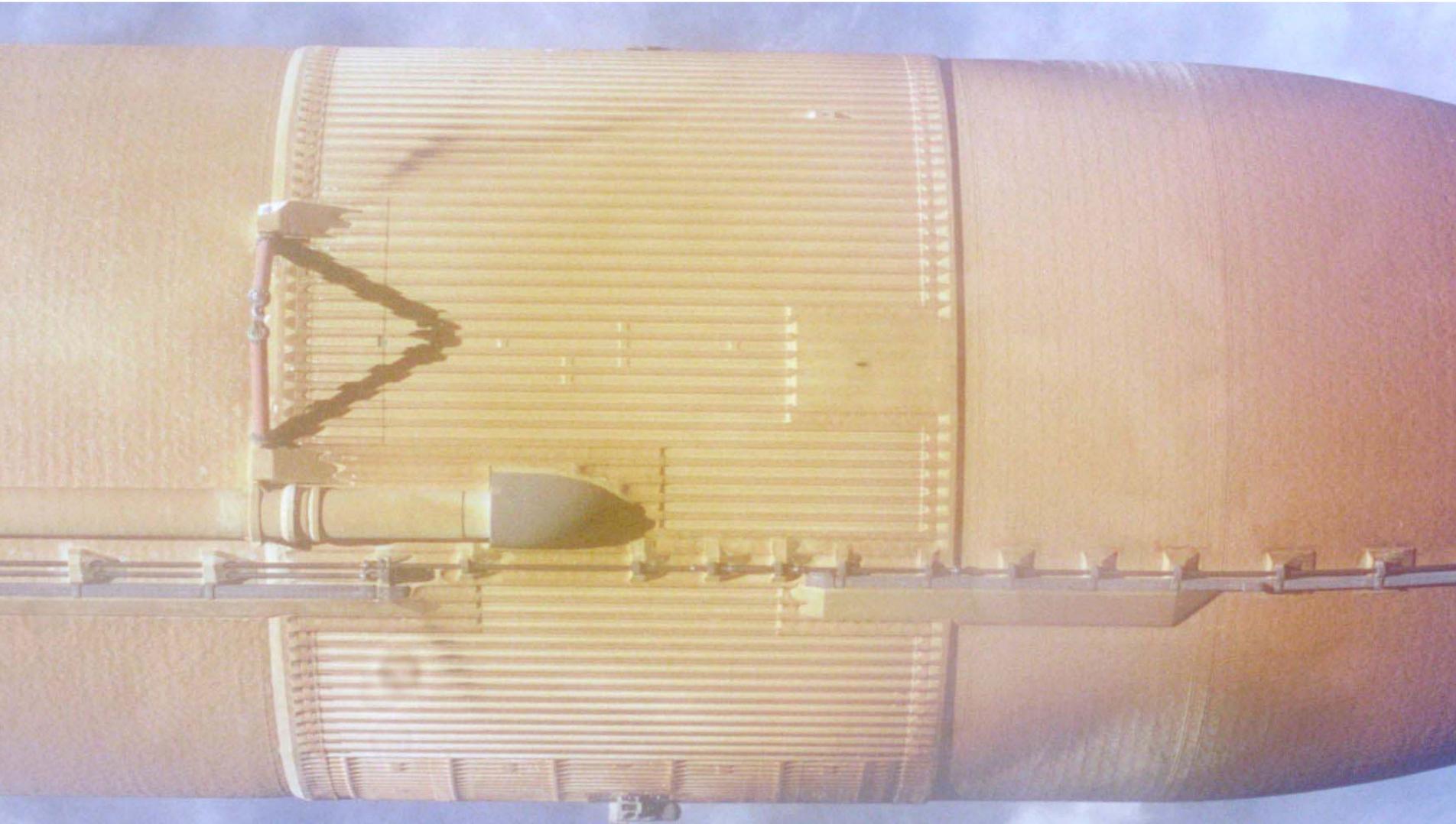
## Pre-Repair Inspections



- Original crack in OV-104 was found visually
  - During interface inspections prior to SSME installation
- All OV-104 flowliners were then inspected using eddy current

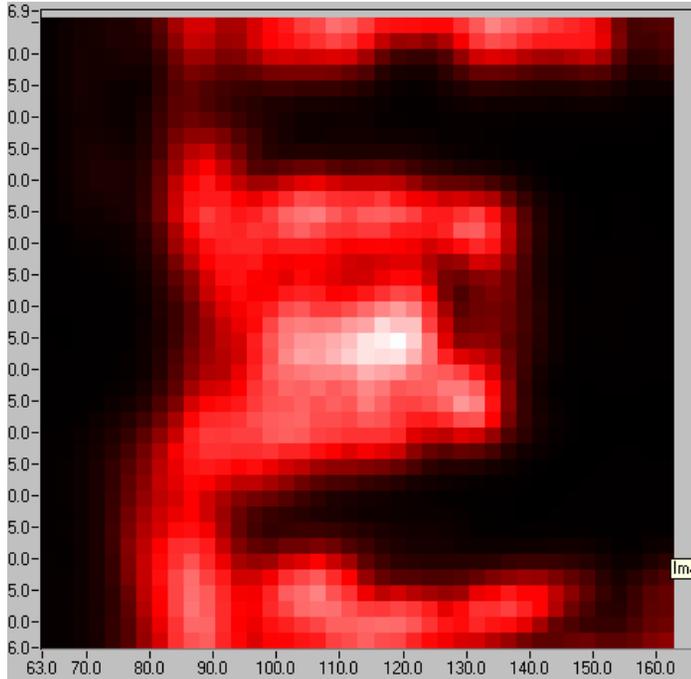


# External Tank TPS

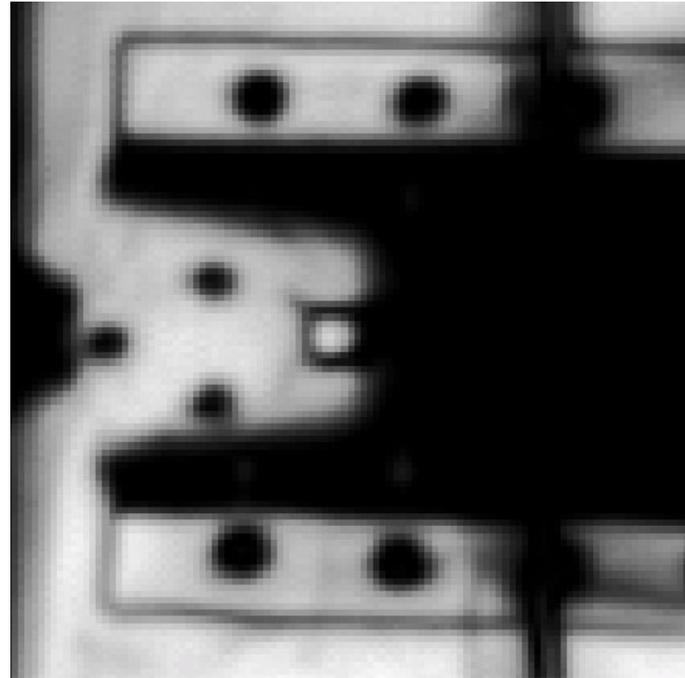




# Comparison of PAL#3 Images



Compact Prototype  
(Picometrix)  
Circa 7/2003

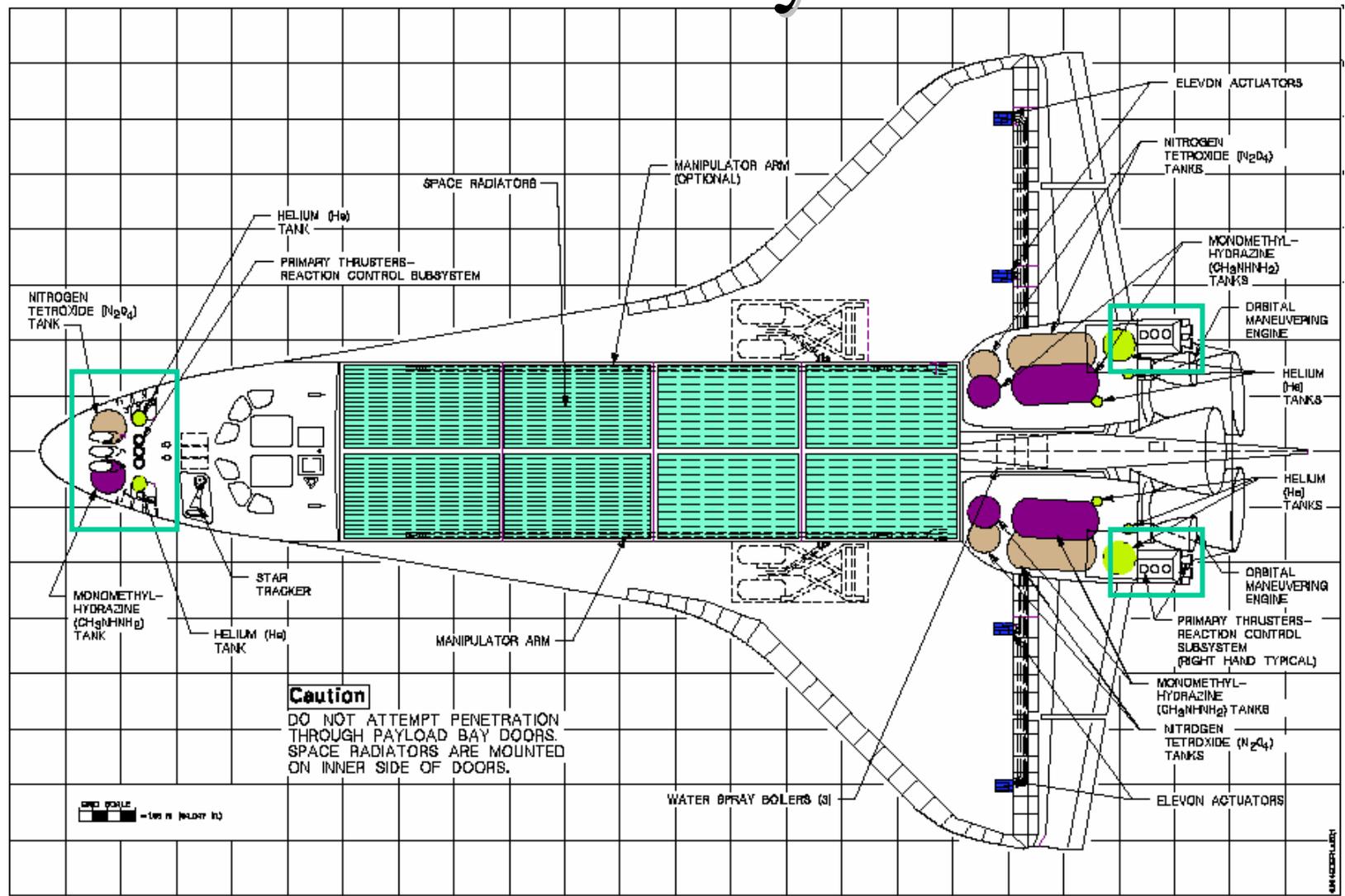


Hi-Res Co-Linear  
(Picometrix)  
9/2004

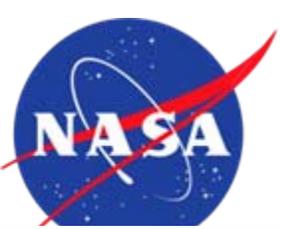


# PRCS Layout

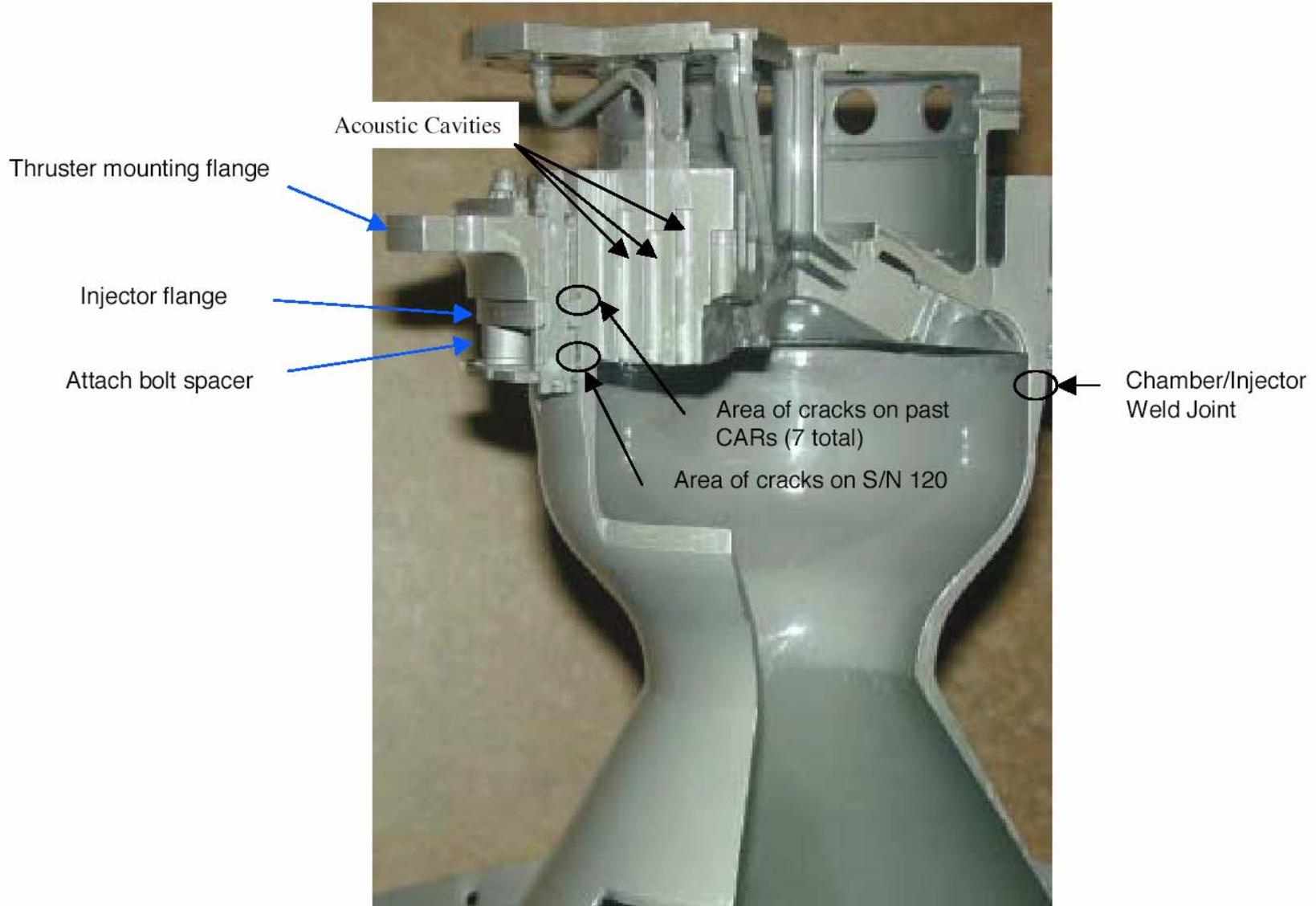
FRCS (14)



ARCS (24)



# THRUSTER CRACKS





# Composite Overwrapped Pressure Vessels

COPV



COPV failed test article





## Future Options to Mitigate Risk with NDE

- Design for inspectibility
- Health monitoring sensors
- Remote robotic assisted NDE tools like those needed for upstream flow-liner
- For procurements, require NDE procedures and tools for component life cycle as currently drafted Diaz report.



# Summary

- NASA NDE level of effort has jumped about an order of magnitude since the Columbia Accident Investigation Board (CAIB) findings.
- Critical NDE challenges are being addressed by the NESC SPRT.
- Increased mission assurance can be secured by proactive efforts in addressing design for inspectibility, healthy monitoring, enhanced NDE tools, and better procurement practices that include NDE.