NASA Testing of PWST

Presented by Cy Wilson
NASA Langley Research Center

Emilio Valencia
NASA Kennedy Space Center

Richard Barton
NASA Johnson Space Center

Jay Ely
NASA Langley Research Center

PWST Workshop
July 27-28, 2011
Houston, TX

Outline

- Transducer Characterization
- Functional Testing
- Environmental Testing
- Compliance Testing
  - RF Testing
  - Industry Standards
  - Mil Spec Qualification
  - Space Qualification
- RFID Testing Performed at NASA
- Conclusions

Executive Summary









- NASA has the capability for most forms of testing!
  - Transducer characterization
  - Functional testing
  - RF testing
  - Compliance testing
    - Industry standards
    - Mil Spec Qualification
    - Space Qualification

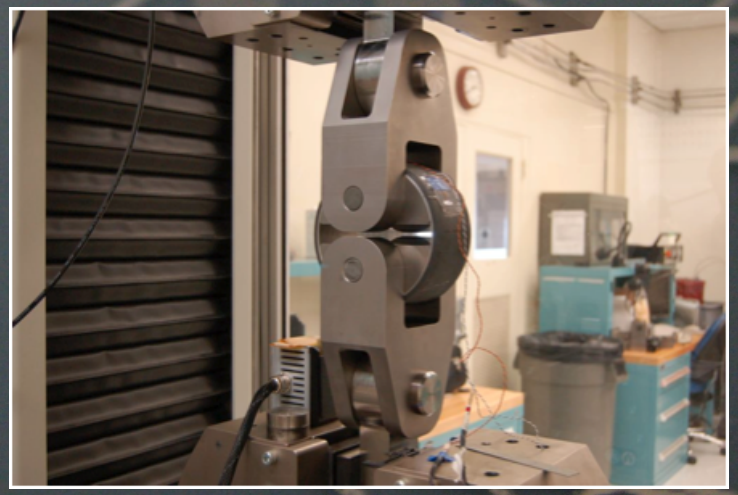
Transducer Characterization

Expertise

- Technical expertise in the area of transducers/sensors
- Transducer qualification and compliance testing services
- KSC originators of transducer specification documents for Shuttle and Space Station programs

Cryostat





Strain Measurement - COPV

Transducer Characterization

Transducer Testing

Areas of temperature, pressure, flow, acceleration, gas leak detection, flame detection, voltage/current sensing, load/force measurements



High/Low Temperature Baths

Mechanical compliance, materials compatibility, environmental testing (vibe, EMI/EMC, thermal-vacuum) and long duration testing



Pressure/thermal Testing

Transducer Characterization (cont)

Testing Capabilities

- Temperature testing - 15 Kelvin (-432° F) to 700 Kelvin (800° F)
- Pressure testing - near vacuum (0.10 mTorr) to high pressure (2000 psig)
- Flow testing - gas flow range from 0.2 lpm to 260 lpm, liquid flow range from 0.1 gpm to 320 gpm

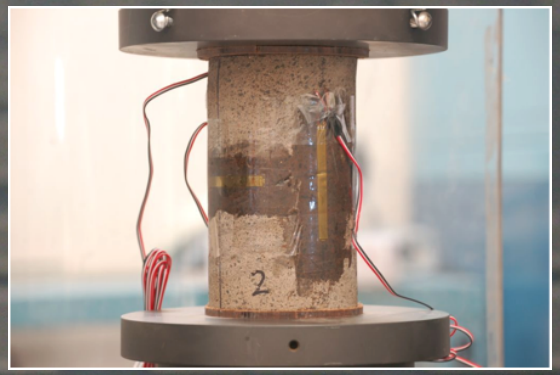
Piston Prover
(flow meter testing)



Transducer Characterization (cont)

Testing Capabilities (cont)

- Measuring compressive strain in the longitudinal and transverse directions
- Measuring elastic modulus of materials using extensometer
- Hydrogen leak detection testing
- Burn testing area for flame detectors (hydrogen, alcohols and hypergol burns)



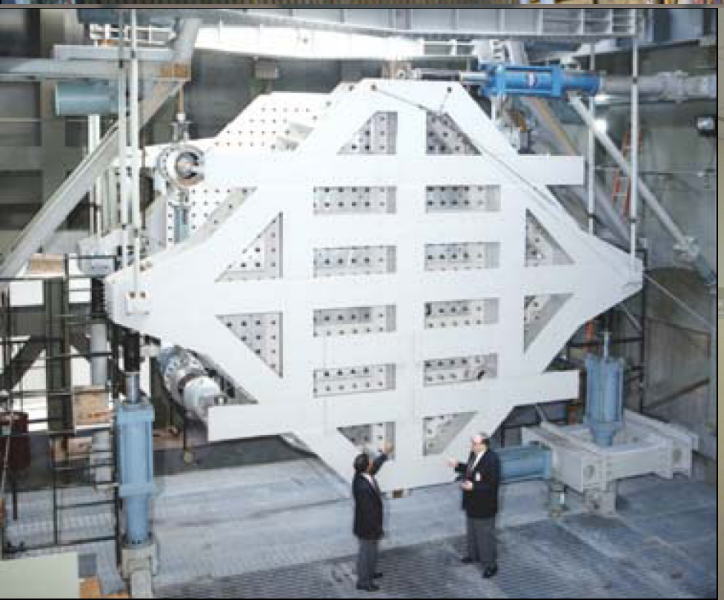
Compressive Strain



Tensile Test

Functional Testing (Loads)

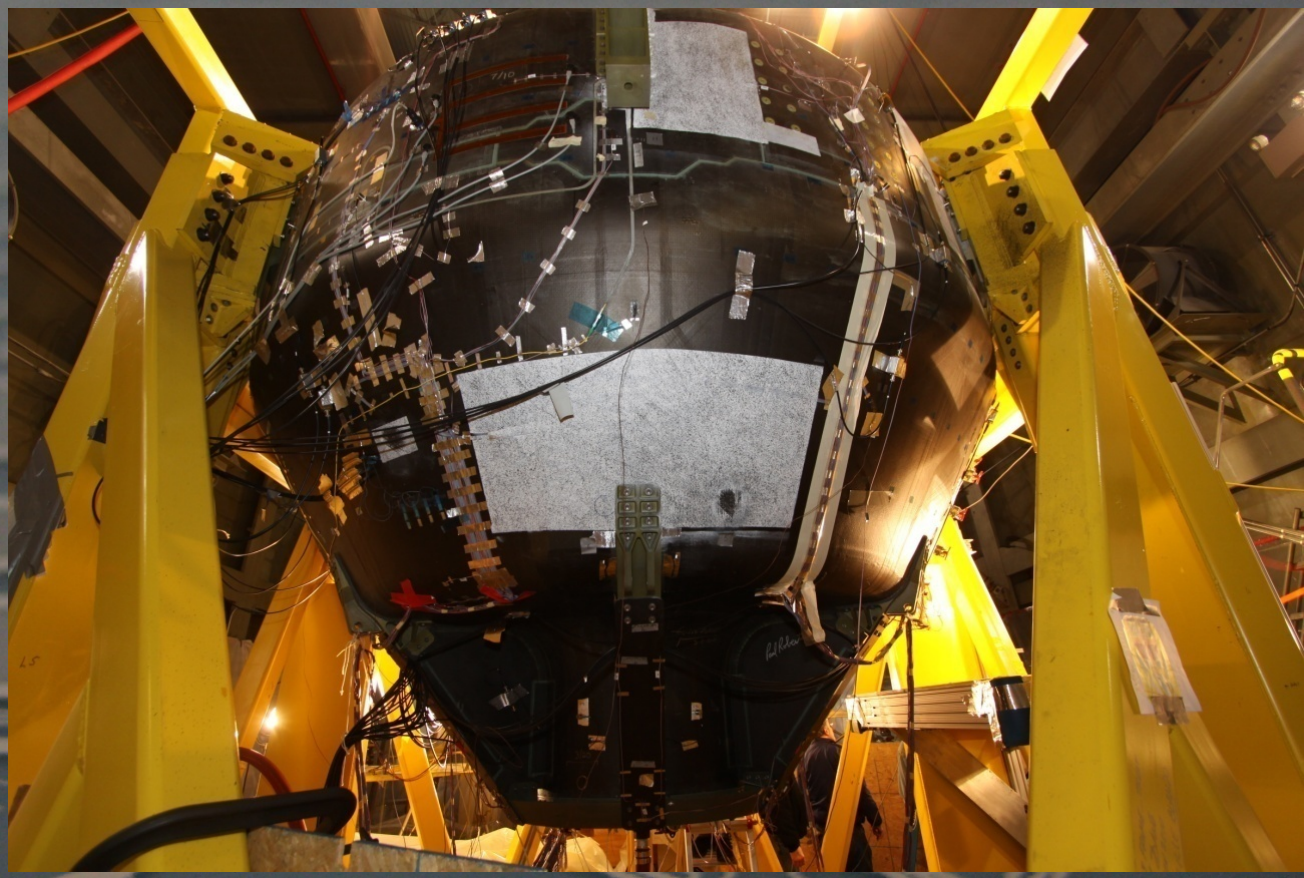






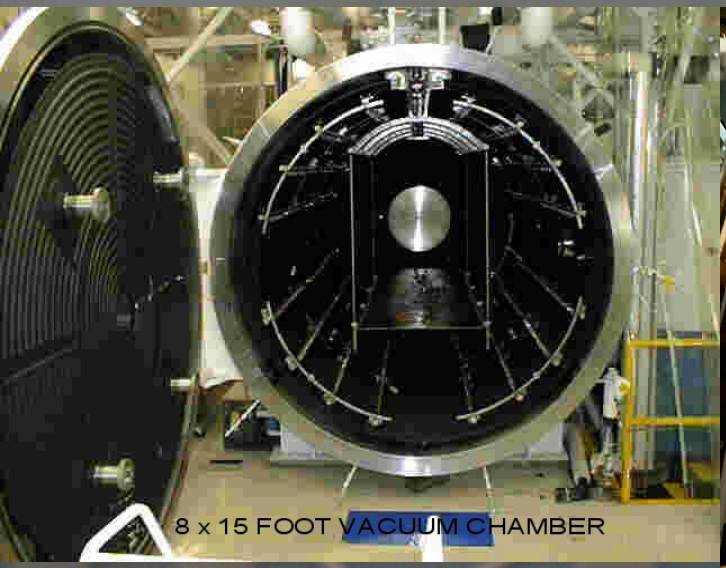


Functional Testing
(Combined Loads Test Facility)

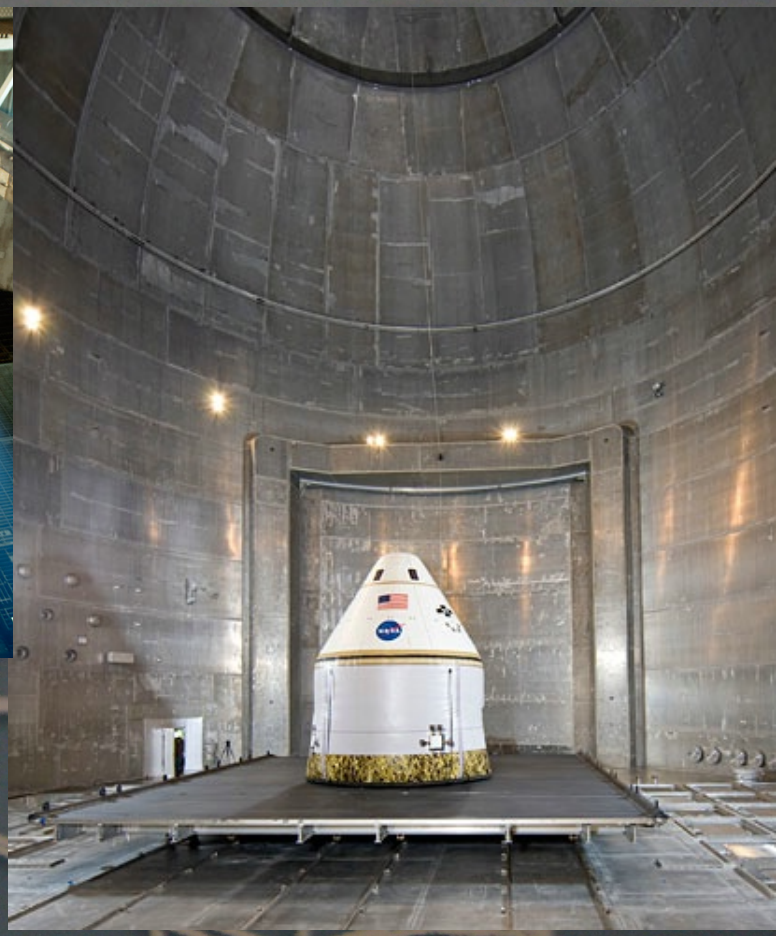


- **CCM Testing**
- Temperature
- Thermography
- Ultrasonics
- Acoustic Emission
- Photogrammetry
- Strain Gauges (load, fatigue)
  - Conventional wire gauges
  - Fiber Optic Strain gauges

Environmental Testing







- Acoustic, Thermal, vibration, vacuum, etc.
- Radiation testing through EEE parts (external).

Compliance Testing (Max Range)

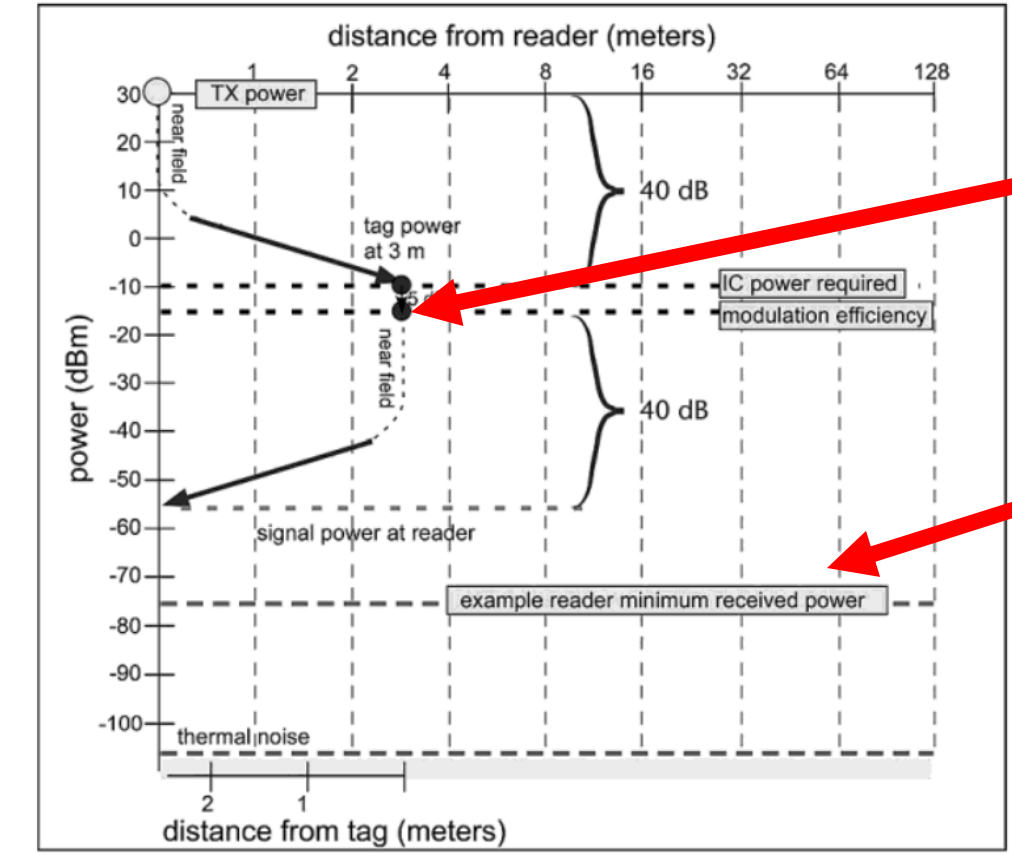


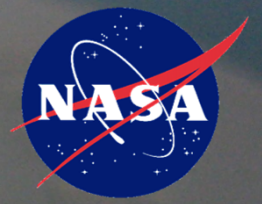
Figure 3.23: Forward- and Reverse Link Budget Calculation for Passive Tag, United States Operation.

RFID* ~4m

SAW† ~60m

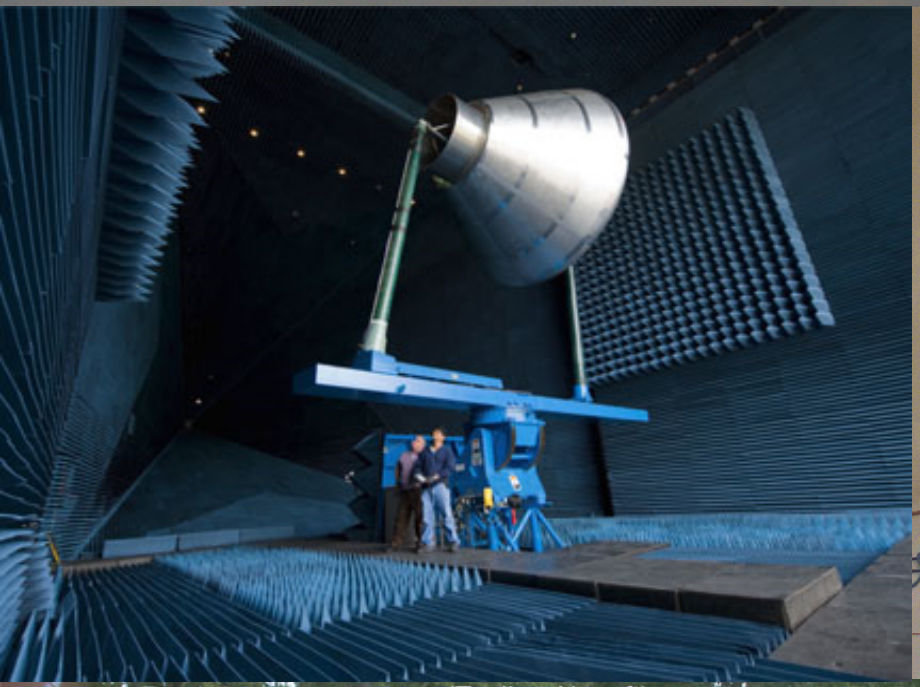
- Passive RFID Tags are forward link limited, max distance ~3m.
  - Power drops off with distance limiting power available at tag for IC.
  - SAW PWST are reverse link limited (limited by the receiver sensitivity)
- *From D. M. Dobkin, *The RF in RFID: Passive UHF RFID in Practice. New* York: Elsevier, 2007, p. 440.
- †From DC Malocha, MA Belkerdid, "Spread Spectrum Wireless Passive Surface Acoustic Wave Sensor System", JANNAF Wireless Sensor Workshop Orlando, FL, Dec. 6-7, 2010, p.38.

Compliance Testing

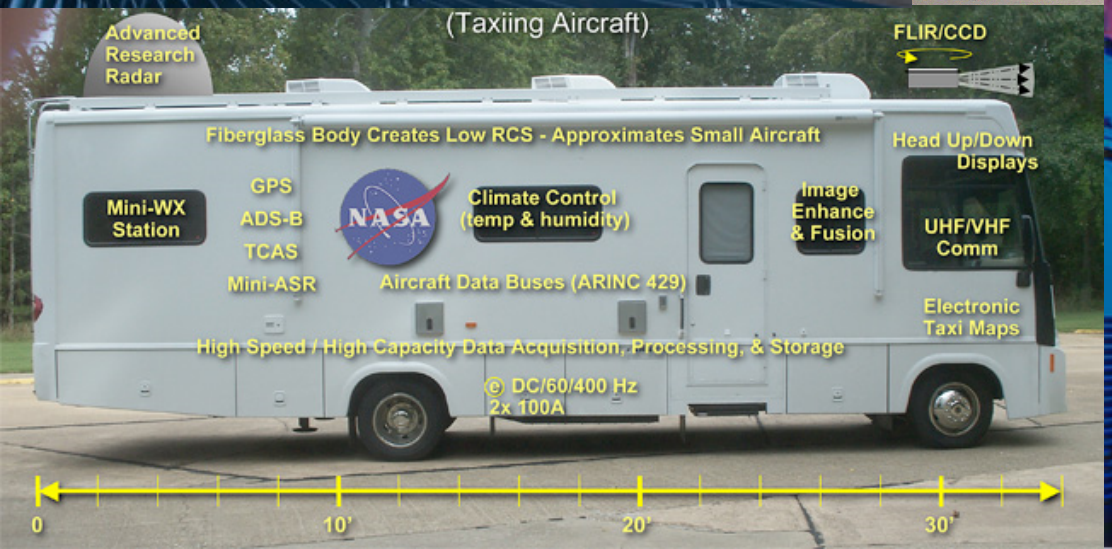


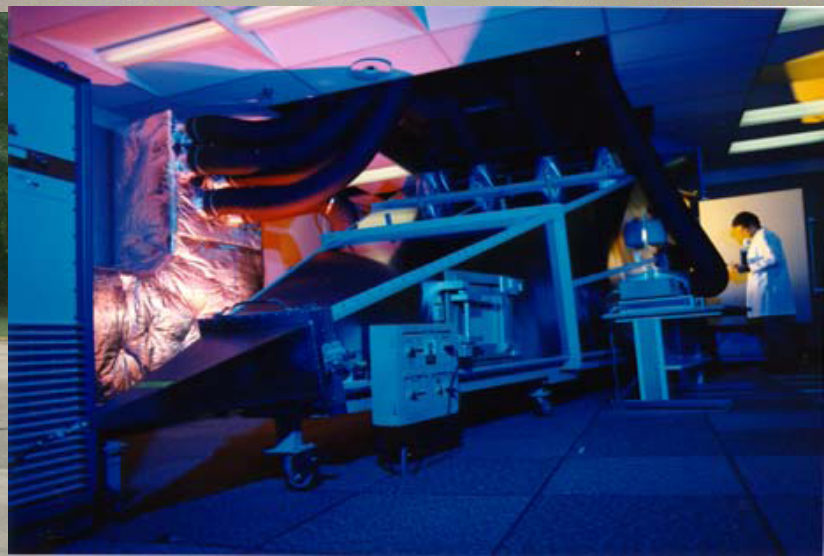
- Standards exist for RFID PWST that include an IC.
  - ECPGlobal and ISO have many standards for RFID.
- Standards do not exist for non-IC PWST.
  - Standards will have to be developed separately for each.
- Standards testing can easily be performed
  - MIL STD-461 for spaceflight hardware and
  - RTCA-DO-160 for aeronautics hardware.
- Recommend that a standard power level be chosen for each frequency range. This will allow comparison of various technologies to give the maximum range, data rate, # sensors, etc. One suggestion is the highest allowable USA power level for the frequency range. (36dBm US, 33dBm EU for ISM band).

Compliance Testing (RF)









NASA Experience in RFID Testing

- RFID tags have been investigated for interference with aircraft RF systems.
- RFID tags have been tested for operation on ISS.
- RFID sensors have been tested in Antarctica for operation on inflatable structures on Mars.

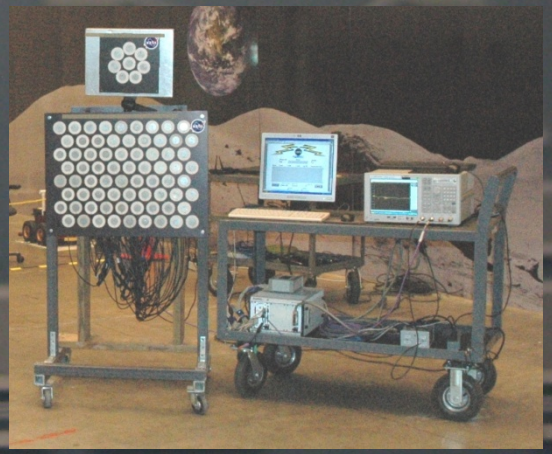


Max Launch Abort System (MLAS) flight vehicle stack.

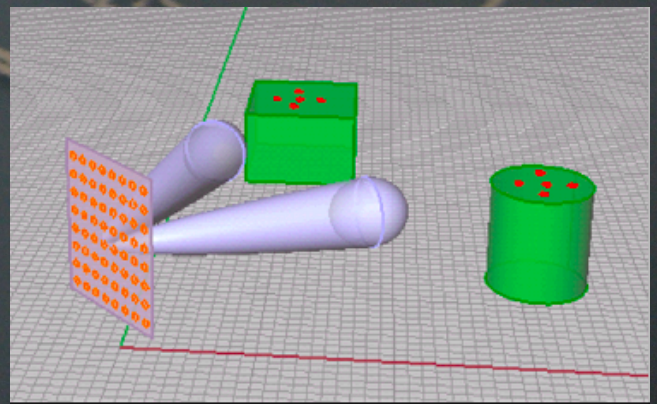
- RFID tags are being tested in Arizona desert for lunar habitats.
- RFID tags were tested as part of the smart sensor system for the MLAS to track TEDs for sensors.

JSC RFID Sensor Technology Development and Testing

- **IC-Based RFID**
  - Extensive testing of EPC Global Class-1, Gen-2 tags for inventory tracking and asset management
  - Asset tracking systems have been space qualified for testing on ISS
  - Initiated work on sensing capability



- **SAW RFID**
  - Currently working on technology development and testing for:
    - Extended read range
    - New sensing modalities
    - Waveform design for improved collision resolution
  - Testing of tags from multiple manufacturers for:
    - Temperature, range estimation accuracy/precision
    - Collision resolution capability
    - Operation in small enclosed environments
    - Read range



RFID Testing History

- **NASA has tested multiple RFID tags for operation on aircraft.**
  - **The *interference path loss was measured for the cargo bays of a Boeing 747 and an Airbus A320 aircraft.***
  - ***Multiple devices were tested to determine if the level RF exceeded RTCA/DO-160E category L & M limits.***



  - ***A wireless acceleration and acoustics system was tested on NASA's 757 aircraft.***



Testing Issues

- Need a determination of level of qualification necessary for PWST testing from projects.
- Need for PWST comparison testing
  - RFID vs SAW vs etc.
  - In representative environments
- Need for PWST standards where they do not exist.
- Need funding to perform testing to demonstrate technologies to Programs and Projects.
- Interrogators need to be tested and qualified also.

Conclusions

- NASA has the capability to perform most forms of testing!
  - Transducer characterization
  - Functional testing
  - Environmental
  - RF testing
  - Compliance testing
    - Industry standards
    - Mil Spec Qualification
    - Space Qualification