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Space Applications for Wireless Sensors

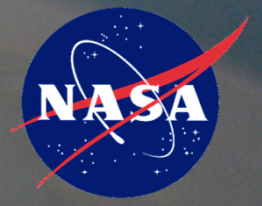
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Outline



- Ground Testing Applications
- Space Applications
  - Hypersonics
  - Inflatable Habitats
  - Propulsion Systems
  - Rockets
  - Space Capsules
- Conclusions
- Funding Opportunities

Aerospace Applications

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- Common sensors in almost all space applications
  - Temperature
  - Strain
  - Pressure sensors
  - Accelerometers

Ground Testing Applications

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Wiring necessary for ~89 strain gauges and thermocouples on Discovery's external fuel tank in preparation for a tanking while on Launch Pad 39A.

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Ground Testing Applications

Testing within Thermal Vacuum Chambers.

- Full size Orion Mock-up
-Plum Brook Thermal Vacuum chamber.
- 100 ft. (30.5 m) diameter
- 122 ft. (37.19 m) high
- Aluminum Test Chamber
-7 MW infrared heat lamps
-400 kW solar simulator
- -320°F (-195.5°C)variable geometry cryogenic cold shroud.
- high vacuum (10^{-6} torr)



Hypersonic Applications

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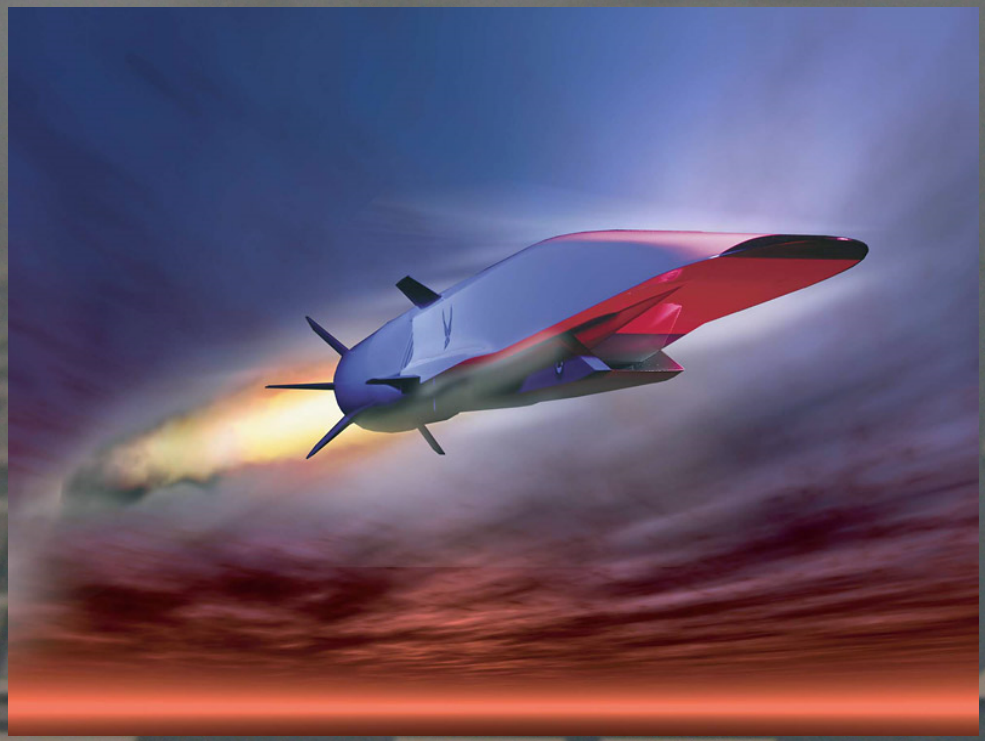


X-43A Hypersonic Experimental Vehicle.

- High temperature sensors
  - Temperature, pressure, strain, hydrogen, etc.
- Cryogenic temperature and fluid level sensors

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Hypersonic Applications





The X-51A Waverider set a hypersonic flight record when it flew at Mach 5 for 200 seconds. Ground tests of the X-51 engine were conducted in the 8 ft high temperature tunnel at NASA Langley Research Center. The engine is visible in the middle of the blue flame.

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Aerospace Applications

Space vehicles are require small lightweight, low power sensors are needed.

The U.S. Airforce's X-37B mini unmanned shuttle was launched on April 22, 2010, and flew for 220 days.



Inflatable Habitats

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Model of inflatable lunar habitat.



"Wedges" concept for a Mars tumbleweed rover.



Titan Aerover inflatable concept for exploration of Saturn's moon.

Propulsion Applications

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Max Launch Abort System (MLAS)

- Launched on July 8, 2009 from Wallops Island, VA
- The MLAS flew with ~176 sensors on board.
  - 13 thermistors
  - 52 strain gauges
  - 23 accelerometers
  - 87 pressure sensors
  - 1 microphone





ARES 1-X Rocket

- The ARES 1-X flew with over 700 sensors on board.
  - 99 temperature sensors
  - 98 strain gauges
  - 108 accelerometers
  - 298 pressure sensors



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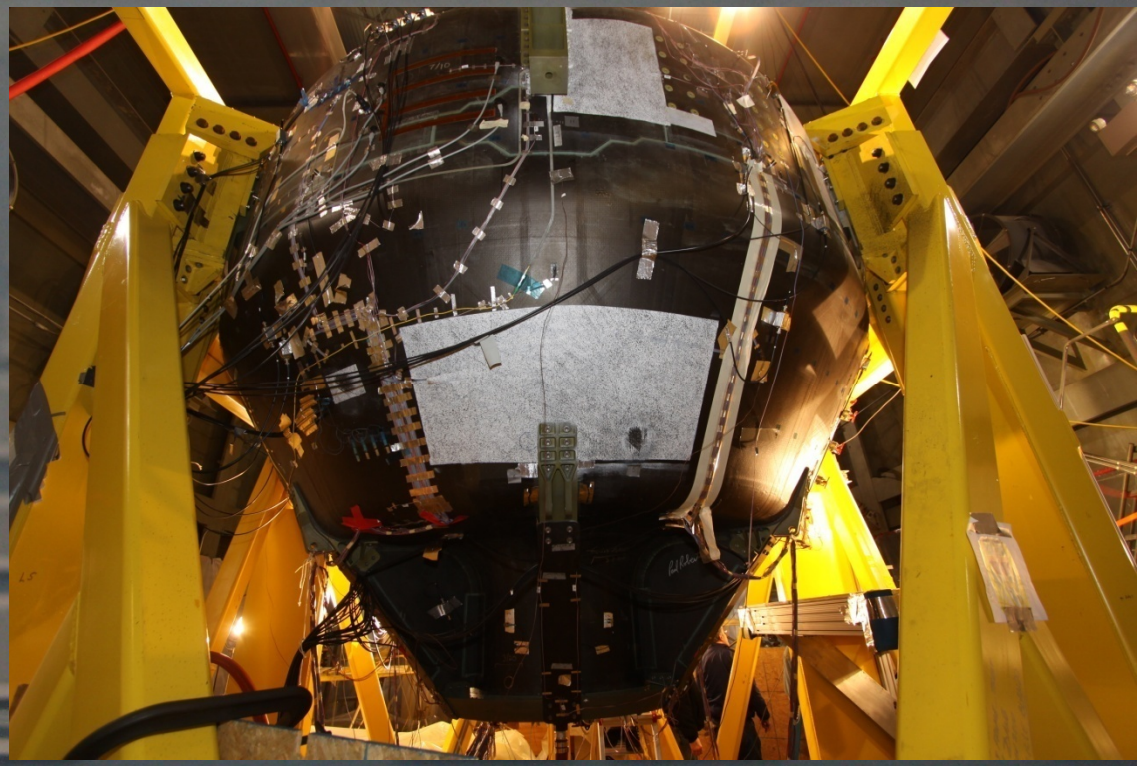
Composite Crew Module (CCM)



Orion capsule alternative, the Composite Crew module (CCM)

CCM Testing at NASA Langley

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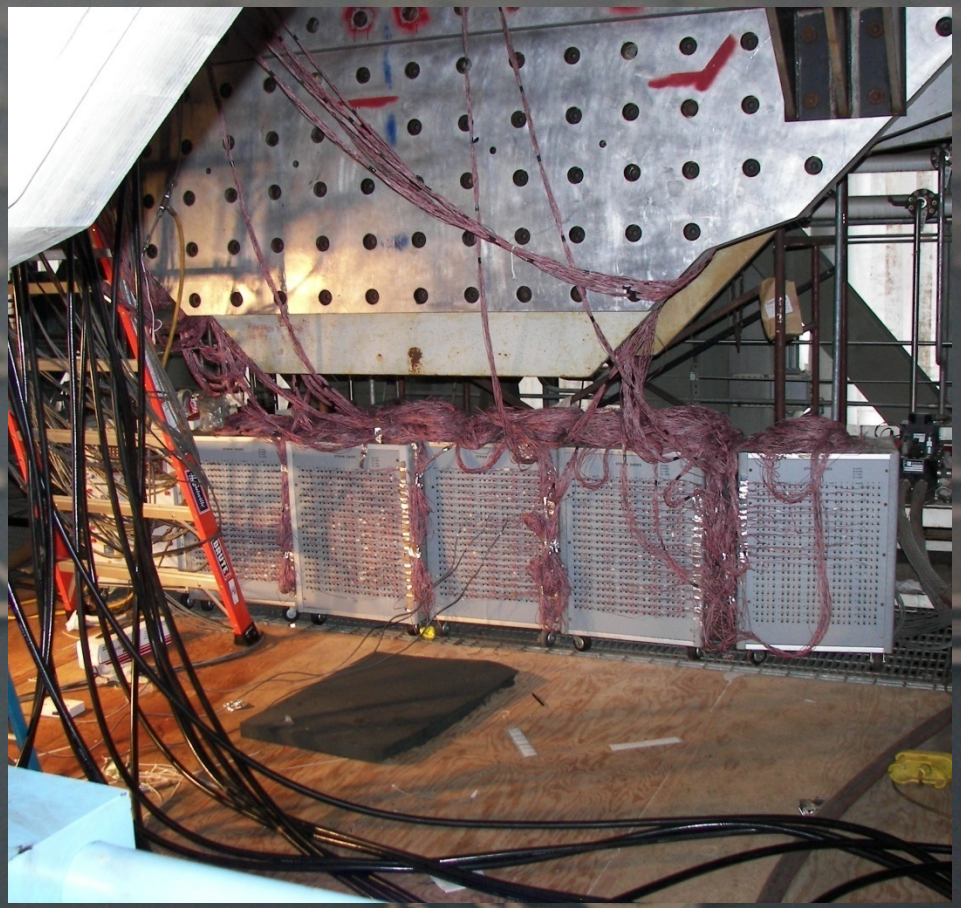


- Temperature
- Thermography
- Ultrasonics
- Acoustic Emission
- Photogrammetry
- Strain Gauges (load, fatigue)
  - Conventional wire gauges
  - Fiber Optic Strain gauges

CCM Testing at NASA Langley

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- CCM was covered in sensors.
  - 280 strain gauges
  - 3000 FO strain gauges
  - 80 Acoustic Emission sensors

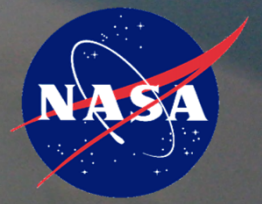


Cabling patch panels for sensor attached to the CCM module.



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Wireless Sensor Issues



- Power
  - No Batteries (due to temperature extremes and accessibility issues)
- Harsh Environments
  - Radiation hardened, radiation tolerant
  - Extreme temperatures (high and low)
  - Shock and vibration
  - High Pressure and vacuum
- Reduced: volume and mass
- RF/Communication Issues
  - Higher data rates than are available with RFID tags.
  - Modulation techniques (interference single and multipath, multiple sources)
  - Frequency Allocation and RF power levels
  - Certification for flight
  - RF nulls and availability in enclosed areas

Conclusions

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- Passive wireless sensors have many NASA applications
  - Ground Testing
  - Space Applications
    - Hypersonics
    - Inflatable Habitats
    - Propulsion Systems
    - Rockets
    - Space Capsules

- Wireless sensors will have to operate in harsh environments and without batteries.
- NASA does not have the resources to develop all of the sensors it needs for its applications, therefore, we are looking for partners!

Funding Opportunities

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- NASA Research Opportunities (NRAs)
  Grants & Contracts
  - http://nspires.nasaprs.com/

- Small Business Innovation Research (SBIR)
  Small Business Technology Transfer (STTR)
  - http://sbir.gsfc.nasa.gov/