NASA SBIR 2010 Phase I Solicitation

X5.04 Spaceflight Structural Sensor Systems and NDE

Lead Center: LaRC

Participating Center(s): ARC, JSC, MSFC

Spaceflight Structural Sensor Systems

Technologies sought include: modular/low mass-volume systems, stand-alone smart sensor systems that provide answers as close to the sensor as practical, Surface Acoustic Wave (SAW)-based sensors, passive wireless sensor-tags, flexible sensors for highly curved surfaces and direct-write film sensors. These systems allow for additions or changes in instrumentation late in the design/development process and enable relocation or upgrade on orbit. They reduce the complexities of standard wires and connectors and enable sensing functions in locations not normally accessible with previous technologies. They allow NASA to gain insight into performance and safety of NASA vehicles as well as commercial launchers, vehicles and payloads supporting NASA missions.

Mission Application Areas (Interior or Exterior):

(1) Add-on in-space modular sensors for:

- Commercial human-rated transportation systems
- Composite Overwrapped Pressure Vessels (COPVs) and other pressure-vessels
- International Space Station (ISS) habitable modules and exterior structure
- Inflatable habitat modules

(2) Built-in flight monitoring systems for:
• New COPV and other pressure vessels
• New manned and unmanned spacecraft
• New propulsion system tankage and transfer systems
• New heavy-lift vehicles: fairings, transition sections, engines, Thermal Protection Systems (TPS), tanks
• New transformational habitats and structures like inflatables

(3) Mobile sensor interrogation systems - robotic, wireless network or interrogation which can:

• Program and download data from smart systems without wires
• Acquire active/passive sensor-tag data
• Determine real-time position/orientation for other sensors or tools

Performance Goals/Metrics:

Ability to establish new functionality in one of the 3 areas above, and:

• Increase number of sensor locations per pound of monitoring weight by 50%
• Decrease the system monitoring electronics weight by 50%
• Decrease total wiring required for monitoring by 50%
• Decrease the time to plan and install monitoring by 50%
• Decrease the overall life-cycle cost per sensor by 50%
• Decrease total data rate required from sensor data acquisition location by 50%
• Decrease the expected cost of instrumentation changes/upgrades by 50%

NDE Systems for use during Spaceflight

Technologies sought include: modular/low mass/volume smart NDE sensors systems and associated software that enable effective use with minimum crew training or re-familiarization after extended periods of no use. Systems should include ability to perform inspections with minimal human interaction. These systems need to provide reliable assessments of the location and extent of damage with the minimal data transfer between vehicle and Earth. Methods are desired to perform inspections in areas with difficult access in pressurized habitable compartments and external environments. Many applications require the ability to see through conductive and/or thermal insulating materials without contacting the surface. Sensors that can dynamically and accurately determine position and orientation of the NDE sensor are needed to automatically register NDE results to precise locations on
the structure. Structural design and material configurations are sought that can enhance NDE and monitoring. Advanced processing and displays are needed to reduce the complexity of operations for astronaut crews who may only use the NDE tool infrequently, but need to make important assessments quickly. Micro-miniature, low power NDE inspection sensors are needed for potential use on free-flying inspection platforms. Integration of wireless systems with NDE may be of significant utility.

Mission Application Areas:

Enabling NDE (Interior and Exterior):

(1) On-orbit NDE sensor systems (e.g., Visual, Laser, Micro-wave, Terrahertz, Infra-red, X-ray backscatter, eddy current or other) that have high resolution and small form-factor to inspect:

- Thermal protection - Multi-Layer Insulation (MLI) and TPS) structures
- Inflatable habitats, Extra-Vehicular Activity (EVA) suits and visiting vehicles
- Electronic systems, environmental control systems, and other vehicle systems
- Conductive structures, Micro-Meteoroid and Orbital Debris (MMOD) shields, primary structure, pressure vessels
- Structures (COPV, module walls) under MLI/MMOD shielding
- Be deployed/used without the need for robotic manipulators or EVA crew

(2) On-orbit NDE sensor systems that can be used:

- In difficult access areas: flexible borescopes, micro-robots, smart sensors
- To identify, locate and quantify potential damage areas: MMOD damage, module and pressure vessel leaks, corrosion, etc.
- On robotically operated platforms: free-flyers, micro-robots, dexterous robots, or remote manipulators

Performance Goals/Metrics:

Ability to establish new functionality in one of the 2 areas above, and:
• Decrease total data/rate required from the NDE sensor by 50%

• Decrease time to perform NDE inspections by 50%

• Decrease the size, weight and power of NDE systems by 50%