NASA SBIR 2019 Phase I Solicitation

Z11.01 NDE Sensors, Modeling, and Analysis

Lead Center: LaRC

Participating Center(s): ARC, LaRC

Technology Area: TA8 Science Instruments, Observatories & Sensor Systems

NDE sensors and data analysis

Technologies enabling the ability to perform inspections on large complex structures will be encouraged. Technologies should provide reliable assessments of the location and extent of damage. Methods are desired to perform inspections in areas with difficult access in pressurized habitable compartments and external environments for flight hardware. Many applications require the ability to see through assembled conductive and/or thermal insulating materials without contacting the surface.Â

Techniques 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. Advanced processing and displays are needed to reduce the complexity of operations for astronaut crews who need to make important assessments quickly. NDE inspection sensors are needed for potential use on free-flying inspection platforms. Integration of wireless systems with NDE may be of significant utility. It is strongly encouraged to provide explanation of how proposed techniques and sensors will be applied to a complex structure. Examples of structural components include but are not limited to multi-wall pressure vessels, batteries, tile, thermal blankets, micrometeoroid shielding, International Space Station (ISS) Radiators or aerospace structural components.Â

Additionally, techniques for quantitative data analysis of sensor data are desired.Â Â It is also considered highly desirable to develop tools for automating detection of material Foreign Object Debris (FOD) and/or defects and evaluation of bondline and in-depth integrity for light-weight rigid and/or flexible ablative materials are sought. Typical internal void volume detection requirements for ablative materials are on the order of less than 6mm and bondline defect detection requirements are less than 25mm.Â

NDE Modeling

Technologies sought under this SBIR include near real-time realistic nondestructive evaluation (NDE) and structural health monitoring (SHM) simulations and automated data reduction/analysis methods for large data sets. SimulationÂ techniques will seek to expand NASAâ€™s use of physics based models to predict inspection coverage for complex aerospace components and structures and to utilize inverse methods for improved defect characterization.Â Â Analysis techniques should include optimized automated reduction of NDE/SHM data for enhanced interpretation appropriate for detection/characterization of critical flaws in space flight structures and components, and may involve methods such as machine learning, domain transformation, etc. NASA's interest area is light weight structural materials for space flight such as composites and thin metals. Future purposes will include application to long duration space vehicles, as well as validation of SHM systems.Â

Techniques sought include advanced material-energy interaction (i.e., NDE) simulations for high-strength lightweight material systems and include energy interaction with realistic damage in complex 3D component geometries (such as bonded/built-up structures). Primary material systems can include metals but it is highly desirable to target composite structures. NDE/SHM techniques for simulation can include ultrasonic, laser, Microwave, Terahertz, Infrared, X-ray, X-ray Computed Tomography, Fiber Optic, backscatter X-Ray and eddy current. It is assumed that any data analysis methods will be focused on NDE techniques with high resolution high volume data. Modeling efforts should be physics based and it is desired they can account for material aging characteristics and induced damage, such as micrometeoroid impact. Examples of damage states of interest include delamination, microcracking, porosity, fiber breakage. Techniques sought for data reduction/interpretation will yield automated and accurate results to improve quantitative data interpretation to reduce large amounts of NDE/SHM data into a meaningful characterization of the structure. It is advantageous to use co-processor/accelerator based hardware (e.g., GPUs, FPGAs) for simulation and data reduction. Combined simulation and data reduction/interpretation techniques should demonstrate ability to guide the development of optimized NDE/SHM techniques, lead to improved inspection coverage predictions, and yield quantitative data interpretation for damage characterization.Â

Phase I Deliverables - For NDE sensors focused proposals, lab prototype and feasibility study or software package including applicable data or observation of a measurable phenomenon on which the prototype will be built. For NDE modeling focused proposals, Feasibility study, including demonstration simulations and data interpretation algorithms, proving the proposed approach to develop a given product (TRL 2-4). Inclusion of a proposed approach to develop a given methodology to Technology Readiness Level (TRL) of 2-4. All Phase I's will include minimum of short description for Phase II prototype/software. It will be highly favorable to include description of how the Phase

II prototype or methodology will be applied to structures.

Phase II Deliverables - Working prototype or software of proposed product, along with full report of development, validation, and test results. Prototype or software of proposed product should be of Technology Readiness Level (TRL 5-6). Proposal should include plan of how to apply prototype or software on applicable structure or material system. Opportunities and plans should also be identified and summarized for potential commercialization.Â

Relevance to NASAÂ

Several missions could benefit from technology developed in the Area of nondestructive evaluation.Â Â Currently NASA is returning to manned space flight. The Orion program has continuing to have inspection difficulties and continued development and implementation of NDE tools will serve to keep our missions flying safely. Currently Orion is using several techniques and prototypes that have been produced under the NDE SBIR topic. Space Launch System is NASAâ€™s next heavy lift system. Capable of sending hundreds of metric tons into orbit. Inspection of the various systems is on-going and will continue to have challenges such as verification of the friction stir weld on the fuel tanks. As NASA continues to push in deeper space smart structures that are instrumented with structural health monitoring system can provide real time mission critical information of the status if the structure.**Â**

References:Â

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- Burke, E. R.; and Waller, J.: NASA-ESA-JAXA Additive Manufacturing Trilateral Collaboration. Presented at Trilateral Safety and Mission Assurance Conference (TRISMAC), June 4-6, 2018, Kennedy Space Center, Florida.
- Campbell Leckey, C. A.; Juarez, P. D.; Hernando Quintanilla, F.; and Yu, L.: Lessons from Ultrasonic NDE Model Development. Presented at 26th ASNT Research Symposium 2017, March 13-16, 2017, Jacksonville, Florida.
- Campbell Leckey, C. A.: Material State Awareness: Options to Address Challenges with UT. Presented at World Federation of NDE Centers Short Course 2017, July 15-16, 2017, Provo, Utah.
- Campbell Leckey, C. A.; Hernando Quintanilla, F.; and Cole, C.: Numerically Stable finite difference simulation for ultrasonic NDE in anisotropic composites. Presented at 44th Annual Review of Progress in Quantitative Nondestructive Evaluation, July 16-21, 2017, Provo, Utah.
- Cramer, K. E.; and Klaassen, R.: Developments in Advanced Inspection Methods for Composites Under the

NASA Advanced Composites Project. Presented at GE Monthly Seminar Series, April 13, 2017, Cincinatti, Ohio.

- Cramer, K. E.; and Perey, D. F.: Development and Validation of NDE Standards for NASAÃ¢â‚¬â„¢s Advanced Composites Project. Presented at ASNT Annual Conference, October 30-November 2, 2017, Nashville, Tennessee.
- Cramer, K. E.: Current and Future Needs and Research for Composite Materials NDE. Presented at SPIE Smart Structures and NDE 2018, March 4-8, 2018, Denver, Colorado.
- Cramer, K. E.: Research Developments in Non-Invasive Measurement Systems for Aerospace Composite Structures at NASA. Presented at 2018Ã‚ International Instrumentation and Measurement Technology Conference, May 14-18, 2018, Houston, Texas.
- Dehaven, S. L.; Wincheski, R. A.; and Burke, E. R.: X-ray transmission through microstructured optical fiber. Presented at QNDE - Review of Progress in Quantitative NDE, July 17-21, 2017, Provo, Utah.
- Dehaven, S. L.; Wincheski, R. A.; and Burke, E. R.: X-ray transmission through microstructured optical fiber. Presented at 45th Annual Review of Progress in Quantitative Nondestructive Evaluation (QNDE), July 15-19, 2018, Burlington, Vermont.
- Frankforter, E.; Campbell Leckey, C. A.; and Schneck, W. C.: Finite Difference Simulation of Ultrasonic Waves for Complex Composite Laminates. Presented at QNDE 2018, July 15-19, 2018, Burlington, Vermont.
- Gregory, E. D.; and Juarez, P. D.: In-situ Thermography of Automated Fiber Placement Parts: Review of Progress in Quantitative Nondestructive Evaluation. Presented at QNDE - Review of Progress in Quantitative NDE, July 17-21, 2017, Provo, Utah.
- Gregory, E. D.; Campbell Leckey, C. A.; and Schneck, W. C.: A Versatile Simulation Framework for Elastodynamic Modeling of Structural Health Monitor.