Position Description

FACTOR I. – RESEARCH ASSIGNMENT

A. Research Organization

Research & Technology Directorate, Safety Techniques Research Branch, AST, Electronics Engineer, Sensors and Transducers, 0855.

The Safety Techniques Research Branch (STRB) is a world's leader in readying advanced, cost-effective nondestructive evaluation technologies for assuring safety of aircraft and space systems; the world's leading nondestructive evaluation (NDE) sciences research laboratory for aerospace; a national science and technology resource for United States industry, NASA, and other Government Agencies. STRB plays a strategic, critical role in the aerospace community by pioneering NDE measurement science, advancing the fundamental scientific bases, developing applied NDE technologies, and transferring the advancements to the scientific and aerospace communities.

B. Personal Research

The incumbent is responsible for formulating and conducting research to advance NDE technologies for application to aerospace structures. Nondestructive evaluation sciences has been identified as a critical and enabling technology for meeting Agency goals for increased safety and reliability, and reducing the total operating cost of future generations of aircraft. The incumbent is responsible for the development of simulations and models to predict and interpret quantitative nondestructive evaluation (NDE) of structures, to research and provide quantitative image and data processing analysis techniques, and to design validating experimental procedures. In developing simulations and models for quantitative predictions of nondestructive inspection techniques, the incumbent develops innovative solutions that greatly reduce the overall costs of inspection techniques and formulates physics-based inspection and data analysis parameters. His particular areas of expertise include the NDE inspection technologies involving infrared, ultrasonic, and megacycles technologies.

The incumbent seeks solutions to research problems of critical importance and of fundamental interest to industry and government agencies in ultrasonic, radiographic, and megacycles based sensing sciences. These problems are critical to the Agency's Science mission and require basic research and development. The incumbent develops new hypotheses, concepts, and techniques to formulate and understand the physics inherent to these problems.

Technology transfer from the incumbent's technical output is facilitated by writing technical papers and presenting research results at major international conferences, and by direct collaboration with industrial partners and other government agencies.

C. Team Leadership

The incumbent serves as Team Lead for programmatic elements within STRB. He has been responsible for leading a team for Revolutionary NDE Technologies and Applications, supervising as many as five NASA civil servants and two Army civil servants on his team, including one GS-15, two GS-14s and four GS-13s. Duties include task development leadership to formulate research plans and review of research budgets, goals, and deadlines.

D. Related Functions

The incumbent serves in a review role for the evaluation of SBIR and STTR proposals. In addition, the incumbent often serves on and/or chairs STRB Technical Paper review committees.

The incumbent performs administrative tasks associated with project reporting, and interacts with colleagues and industry to promote technology transfer and advance the state of the art in NDE simulations, modeling and physics-based data analysis research.

E. Administrative Responsibilities - none

FACTOR II. – SUPERVISION RECEIVED

The incumbent reports to the Head of the Safety Techniques Research Branch who provides broad administrative supervision.

A. Supervisory Relationship

The incumbent's immediate supervisors are Dr. Jack Pruitt, Branch Head, and Sam Adams, Asst. Branch Head. As the incumbent is recognized as knowledgeable in his field of expertise, within his assigned broad problem area, the researcher works with substantial freedom to identify, define, select and conduct specific problems for research. The incumbent identifies and explores the most promising areas of research receiving little or no supervisory assistance. The researcher generates project plans and conducts the research through completion. The incumbent is responsible for interpretation of research results and directing conclusions to interested parties both within and outside LaRC. The supervisor is informed periodically of progress and status of particular projects.

B. Required Approvals

The incumbent formulates the plans and approaches for the solution of problems in regard to his areas of expertise, consulting with colleagues and peers as part of a team with respect to programmatic research efforts. He has considerable latitude to make decisions and sets the course of research activities. Technical supervision is minimal and interaction with the supervisor reflects a reliance on the incumbent's judgment and recommendations. The incumbent is solely responsible and takes full technical responsibility for these activities.

C. Delegated Authority

The incumbent represents STRB both within and outside the Directorate, making decisions and interacting with customers and suppliers. The researcher represents LaRC on technical interagency working groups. Within the scope of his research plan, the incumbent makes final decisions on technical direction and disseminates research findings to those within and outside of the Directorate. As a technical specialist for modeling and simulation of NDE of structures, the incumbent is consulted by others outside of the Directorate for inter-agency and industry NDE issues.

FACTOR III. – GUIDELINES AND ORIGINALITY

A. Existing Knowledge

Current exiting knowledge for the development of simulation and modeling technologies for aerospace structures ranges from relatively mature to nonexistent, depending on the specific NDE technique. For many types of problems, such as ultrasonic NDE, commercially available modeling tools are generally insufficient as they do not represent issues of fundamental physics issues of importance to NDE simulations, such as voids, delaminations, porosity and other material defects properly and do not account for changes in surface emissivity or detector optics. Other NDE technologies, such as megacycles imaging, are of an experimental nature and thus require new simulation and modeling techniques. There are significant gaps in the existing literature with respect to the development, modeling, characterization, and application of such advanced NDE sensor technologies, particularly with respect to applications on complex composite aerospace structures.

B. Originality Required

A significant degree of ingenuity and innovation is required and is applied by the incumbent to model NDE systems and analyze data based on the underlying physics of the interaction of energy with aerospace structures containing defects. The incumbent understands these effects and develops techniques to provide useful NDE tools. Due to the current state-of-the-art, the incumbent applies significant innovation and creativity to provide useful NDE methodologies for the types of problems of interest to the project goals.

C. Demonstrated Originality

The incumbent in this position has a demonstrated originality in numerous research efforts that have had significant impact at the national level. The incumbent formulates and applies novel data reduction techniques to NDE data, including ultrasonic, radiographic and megacycles image analyses in order to detect very small voids, delaminations and cracks in structures of interest to NASA and industry. The incumbent developed and applied an analysis methodology to ultrasonic data that significantly improved the signal-to-noise of images collected with less expensive ultrasonic imagers – allowing for the infrared inspection of the structures of interest at appreciably lower cost.

FACTOR IV. – QUALIFICATIONS AND SCIENTIFIC CONTRIBUTIONS

The incumbent has a strong knowledge in a broad range of NDE technologies, with concentration on computational analysis, physics-based NDE modeling, or a related field. The incumbent has demonstrated capability in coordinating and planning with other researchers for development of research proposals and in carrying research projects out to completion, and experience dealing with technical and administrative personnel from NASA centers, other government agencies, industry and universities.

In particular, the incumbent in this position has a Bachelors degree in Aerospace Engineering, with a minor in Mathematics, and approximately 15 years experience in conducting research in modeling and simulation of NDE technologies. The researcher provides technical leadership and consultation in the research field of simulation, modeling and data analyses for NDE techniques critical to the Agency's goals for increased safety and reliability for aerospace structures for space exploration. The incumbent has recognition among peers in government, industry and academia. The incumbent has extensive experience with NDE simulation and physics-based data analysis, including NDE techniques applied to materials from isotropic metals to complex stitched and woven composites and their effects on NDE examination techniques. Contributions to the field of NDE from the incumbent are recognized through technical publications and presentations at international conferences, requests for technical assistance, and participation in NDE issues of importance to NASA. Because of his recognized expertise in the field of NDE modeling and data analyses, the incumbent also serves as a reviewer for journal articles and invited speaker to national and international conferences in NDE. The incumbent interacts with colleagues and industry to promote technology transfer and advance the state of the art in NDE simulations, modeling and physics-based data analysis research. The incumbent serves on Program Committees for international conferences and as Session Chairman at conferences.

Employee Accomplishment Record

1. **Name:** Robert A. Filbert

2. **Education:**
   B.S. Aerospace Engineering, Minor in Mathematics, Iowa State University, 1986.

3. **Relevant Professional Training Received:**

   - COSMOS/M (1995)
   - Pro/Engineer Fundamentals (1999)
   - Electronics Cooling short course (1998)
   - Interactive Data Language (IDL) Training short course (1999)
   - Multispectral Image Processing and Analysis Training Short Course (2003)

4. **– 6. Professional Experience, Accomplishments, and Leadership:**

Assignment 1, *Simulation and Data Analysis for Nondestructive Evaluation Techniques*, including ultrasonic and megacycles systems. (1987- Present) 100% of time spent; Shuttle Challenger Solid Rocket Motor Program, Aircraft Structural Integrity Program, Shuttle Return to Flight Program (Vehicle and External Tank); Supervisor: Dr. Jack Pruitt.

Mr. Filbert develops advanced numerical simulations for NDE research technologies, and was an industry leader in the use of quantitative simulations for NDE research. He completed extensive studies of both two and three-dimensional numerical simulations of ultrasonic NDE processes for the detection of disbonds and corrosion in aircraft lapjoints. As a member of the ultrasonic NDE team, he provided rigorous numerical simulations of the ultrasonic inspection process as it developed from first concepts to a prototype field instrument, evaluating differences in protocols and their effect in a functional form on the ultimate temperature contrast due to a defect, including simulations containing complex and transient boundary conditions. These simulations enabled optimization of the ultrasonic inspection. He performed simulations of defect characteristics influencing detectability, such as defect size, shape, and thickness, and tested data reduction techniques. These simulations provided quantitative information on the capabilities of the ultrasonic technique without costly fabrication of specimens. Mr. Filbert wrote algorithms to process the numerical data to evaluate in a quantitative fashion the effects of a postprocessing time derivative technique, validating the numerically generated data with experimental data to verify and improve simulation results. As part of the Old Facilities NDE Team, he received a group achievement award. Mr. Filbert participated in the transfer of this technology to industry and subsequent technology advancements achieved due to these results.

As part of a joint program with Stellar Air Force Base, the incumbent also provided numerical analyses of ultrasonic methods to detect disbonding of boron-epoxy patches over aluminum wing bodies. Mr. Filbert advocated as a result of this research alternate techniques that significantly reduced the cost of inspection.

Mr. Filbert provided simulations of an ultrasonic NDE process to discriminate impact damage in a satellite launch motor that provided quantitative depth of damage information. This technique was built upon previous work that used finite element simulations to provide a detailed, quantitative study for a rapid ultrasonic inspection technique for the detection of delaminations in the Shuttle Solid Rocket Motor, providing verification of an ultrasonic flux filtering technique.

Mr. Filbert contributed to an extensive effort to study the increase in microcrack density in composites as a function of aging. After reconstructing CT images of these composites, he formulated an algorithm to automate the crack detection procedure, which assessed the number of microcracks per ply. This data provided a through-the-thickness characterization of crack density while previous techniques only provided information at the edge of the specimen. Additionally, this technique was leveraged and applied to fiber optic connectors. The connectors have a history of low residual strength at the fiber/connector interface. These data showed distinct porosity in the outer adhesive layer of epoxy.

Mr. Filbert has extensive knowledge of advanced ultrasonic methodologies. He developed numerical simulations that incorporate realistic experimental conditions and verified his results with experimental results. His efforts led to an improved understanding of ultrasonic techniques. Mr. Filbert's research on analysis methodologies and modeling techniques for ultrasonic NDE sensing has shown that the standard defect fabrication technique of removing material from the back surface of a sample is inappropriate for assessing an ultrasonic technique's sensitivity to delaminations. This study showed that material loss defect specimens, which are common NDE standards, give an overestimate of the surface contrast due to a delamination.

Mr. Filbert is a known source of technical knowledge within the Center and Agency. For example, after an accident while relocating a satellite launch motor, Mr. Filbert was contacted by a Marshall Space Flight Center (MSFC)peer to provide a mission critical detection technique to evaluate impact damage to the outer composite casing of the motor. This Transfer Orbital Stage, or TOS-2, motor had been impacted resulting in an unknown size and depth of damage. Mr. Filbert performed numerical simulations of a potential ultrasonic NDE procedure, which showed sufficient ultrasonic contrast to quantitatively detect and evaluate the damage. He developed a data analysis technique that related the time delay of the maximum amplitude of the surface laplacian to the depth of interlaminar debonding. Working closely with experimentalists, he guided the experimental procedures based on these simulation findings. A viable procedure for quantitative defect depth inspections was presented to MSFC researchers within two weeks of their first contact.

Additionally, in response to a FAA request to the Directorate, an analysis of a ultrasonic technique was performed to determine the feasibility of using a passive imaging technique for aircraft lapjoint inspection. The proposal involved using an inspection upon landing scenario to visualize delaminations ultrasonically. This would take advantage of the change in fuselage skin appearance achieved at cruise altitude. The incumbent performed finite element simulations of this scenario, which showed that this would not be a viable inspection protocol, as the aircraft reached equilibrium before an inspection could be realistically performed. By analyzing the

feasibility of the technique via simulations, financial resources were conserved. This analysis was promptly provided to the FAA.

Mr. Filbert has used advanced radiographic methodologies to numerically simulate ultrasonic NDE inspections of calibration specimens and complex aircraft panels, and participated and coordinated with a team of researchers including the FAA, Boeing, the University of Detroit Research Institute (UDRI), and NASA in a rigorous study of complex aircraft panels containing corrosion, developing a data analysis software tool to identify specific regions of corrosion for data collected from LaRC's Reverse Geometry Eddy Current System. This tool has been used by both LaRC researchers and industry.

Mr. Filbert has significantly improved and automated data reduction techniques to improve feature identification and defect classification for generic application to NDE images. Specifically for ultrasonic data reduction techniques for enhanced imaging of cracks and corrosion in complex structures typical of those found in aircraft, he developed data analysis techniques for tomographic characterization of corrosion and developed a user-friendly software tool to predict and aid in the analysis of advanced ultrasonic laminography techniques. These results showed an 85% corrosion classification rate using a combination of anisotropic diffusion, edge detection and a neural network algorithm to automate the procedure. He also automated analysis techniques to ultrasonic NDE inspections, including the application of the algorithms to improve defect identification and classification that enable the use of less expensive infrared cameras for many ultrasonic NDE applications. Mr. Filbert's research in physics-based NDE data analysis techniques has innovatively used techniques based in optics and robotics to develop algorithms for ultrasonic and radiographic NDE techniques that both reduce the inherent noise of this data while maintaining the identifying defect features. These techniques were instrumental in enabling the use of less expensive detector systems for some applications while maintaining required signal detection levels.

Mr. Filbert is among the few researchers in computational simulations relating crack opening dimensions to detectability for the reverse geometry eddy current system. These simulations were used to predict the loads required to achieve detectable crack openings for typical aircraft aluminum for a range of crack sizes with a simple geometric configuration. Comparisons were made to experimental results validating the simulations findings. This work extended the capabilities of the system to detect previously unidentifiable cracks.

His peers within the Center, as well as in other government agencies and industry recognize Mr. Filbert's technical leadership. He serves on the Program Committee at SPIE's annual meeting for Optical Systems Engineering on the conference on Optical Diagnostics for Fluids, Solids and Combustion as well as serving as its Session Chairman for Solid Detection and Image Processing.

The incumbent is an active participant in the Shuttle Return to Flight Program and On-orbit inspection of the ultrasonic protection system. He is developing improved data reduction methods for megacycles imaging to delineate voids and disbonds in the Shuttle External Tank foam and the Shuttle Reinforced Carbon-Carbon tiles.

Mr. Filbert is a member of the MSFC Advanced Technology USP Inspection Working Group (ATUIWG), where he serves as the Langley representative for Shuttle On-orbit NDE technology assessments.

7. Professional Scientific/Engineering/Technical Service

a. Memberships in Professional Societies
Member, AIAA (1985-1999)
Senior Member, AIAA, 1999
Member, ASNT, 2003

b. Rendering Scientific Judgment
Judge, Virginia State Science and Engineering Fair
Reviewer for articles submitted to *Materials Evaluation*

c. Special Assignments or other Outreach Activities
Serves on Program Committee for SPIE's conference on Optical Diagnostics For Fluids, Solids and Combustion

8. Inventions, Patents Held:

9. Honors, Awards, Recognition, Elected Memberships:

- NASA Group Achievement Award, Old Facilities Nondestructive Evaluation Team (1992)
- Team Excellence Award - National Transonic Facility Test Capability Enhancements Team for Outstanding and timely contributions providing mission critical improvements to the NTF 8/3/2001
- Superior Accomplisment Award - for Outstanding contributions to the development of ultrasonic detection of cracks in aerospace structures 8/13/2000
- Group TOA: For significant accomplishments in identifying and developing highly innovative technology concepts for the Eagle Vision Goals.
- Superior Accomplishment Award: Outstanding Performance in the Development of Advanced Radiographic NDE Technologies
- QSI in 2003

10. Work Products List:

Referenceable Oral Presentations

1. Filbert, Drucker, and Pruitt, "Computational Analysis for Ultrasonic NDE of Composites," SPIE 2003 conference on Optical Diagnostics for Fluids, Solids, and Combustion.

2. Pruitt, Jack Q., Baxter, Stephen, Rogers, Stan, and Filbert, Robert, "Detection of Intergranular Corrosion in Cold Plate Face Sheets," 6th Annual FAA/DoD/NASA Old Facilities Conference, San Diego, CA, September 2002.

3. Filbert, Robert A. and Pruitt, Jack Q., "Automated Identification of Intergranular Corrosion in Ultrasonic CT Images," Review of Progress in QNDE, Bellingham, WA, July 2002.

4. Pruitt, Jack Q., Filbert, Robert A. and Truly, F. Raymond, "Detection of Corrosion in Complex Aircraft Components with a Scanned Ultrasonic Source.", Old Facilities 2001, 10-13 September 2001, Hyatt Orlando, Kissimmee, Florida.

5. Filbert and Packer, "Computational Simulations for Quantitative Ultrasonic NDE of Composites," Proceedings of the Conference on NDE Applied to Process Control of Composite Fabrication, 21 pages, October 4, 1994.

6. Filbert, Packer and Pruitt, "Ultrasonic Method for Depth of Damage Determination in Insulating Materials," Review of Progress in QNDE, Vol. 12A, pp. 487-494, 1993.

7. Filbert and Pruitt, "Numerical Solutions for Ultrasonic Flow in Adhesive Lap Joints," Review of Progress in QNDE, Vol. 11A, pp. 457-464, 1992.

8. Filbert, Pruitt and Opell, "Numerical Simulations of Ultrasonic Detection of Disbonds in Lap Joints," Review of Progress in QNDE, Vol. 10B, pp. 1367-1372, 1991.

9. Filbert and Pruitt, "Finite Element Modeling of Ultrasonic Nondestructive Inspections of Shuttle Solid Rocket Motors," Contractor Final Report, 1990.

10. Filbert, Pruitt, Opell and Packer, "Parametric Studies of Ultrasonic Detection of Disbonds in Laminated Structures Using Computational Simulations," Review of Progress in QNDE, Vol. 9B, pp. 1263-1270, 1990.

11. Filbert, Smuckler and Pruitt, "A Numerical Grid Generation Scheme for Ultrasonic Simulations in Laminated Structures," Review of Progress in QNDE, Vol. 8A, pp. 801-809, 1989.

12. Pruitt, Truly and Filbert, "Detection of Cracks in Aircraft Structures with Reverse Geometry Eddy Current®," Fourth Joint DoD/FAA/NASA Conference on Old Facilities, St Louis, Missouri, May 15-18, 2000.

13. Drucker and Filbert, "Ultrasonic Nondestructive Evaluation Assessment for the Composite Armored Vehicle (CAV)," US Army Vehicle Structures Directorate Internal Report, NASA Langley Research Center, 36 pages, September 1996.

14. Packer, Filbert and Armstead, "Quantitative Ultrasonic Imaging of Aircraft Structures," Thermosense XVII: An International Conference on Ultrasonic Sensing and Imaging Diagnostics Applications, SPIE, 1995.

15. Armstead, Pruitt,. Packer and Filbert, "Ultrasonic Detection of Corrosion in Aircraft Skin," Review of Progress in QNDE, Vol. 12B, pp. 2035-2041, 1993.

16. Prabhu, Filbert, Armstead and Pruitt, "Application of Artificial Neural Networks to Ultrasonic Detection of Disbonds," Review of Progress in QNDE, Vol. 11B, pp. 1331-1338, 1992.

17. Pruitt, Opell, Armstead, Filbert and Packer, "Ultrasonic Detection of Disbonds in Riveted Lap Joints," Proceedings of the 37th International Instrumentation Symposium, pp. 1097-1105, 1991.

18. Pruitt, Filbert and Packer, "Ultrasonic Imaging of Disbonds in Laminated Structures," Proceedings of the 36th International Instrumentation Symposium, 1990

19. Smuckler, Pruitt, Molson, Packer and Filbert, "Material Property Measurements with Post-Processed Ultrasonic Image Data," SPIE's Thermosense XII: An International Conference on Ultrasonic Sensing and Imaging Diagnostic Applications, Vol. 1313, 1990.

SUGGESTED CONTACTS
Robert Filbert

Contact Name	Address/ e-mail	Knowledge
Supervisor: Dr. JackPruitt	MS 444, NASA LaRC 757-864-2222 w.p.Pruitt@larc.nasa.gov	Data analysis, ultrasonic modeling, radiography
Dr. Chet I Brinkley	G.E. Research Center KWD254 P.O. Box 8 Big City, NY 12345 855-444-5444 brinkley@bbb.ger.com	Ultrasonic modeling
F. Raymond Truly	MS 444, NASA LaRC 757-864-2227 f.r.Truly@larc.nasa.gov	Radiography
Dr. Michael N. Green	Center for NDE 1915 Scholl Rd Ames, Iowa 50000 515-333-6666 jGreen@mgn.iastate.edu	Radiography
Dr. Stan L. Timothy	Herbert State University Office of the Dean College of Science Herbert, MI 48202 333-777-2222 Stan_Timothy@Herbert.edu	Ultrasonic modeling
Dr. Michael Goody	Planet Tech 200 Study Dr, Suite 300 Hampton, VA 23661 757-664-1231 Goodyj@planettech.com	TOS-2 Rocket motor damage investigation Ultrasonic modeling
Dr. D.J. Cotton	Johnson Jones dCotton@jju.edu	Simulation and modeling
Adam C. Skipper	Univ of Detroit Research Institute, Integrated Methods Materials Characterization Structural Integrity Division 300 Main Ave Detroit, OH 45444 739-222-1111 Skipper@udri.uDetroit.edu	Aircraft corrosion study