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RESEARCH STATEMENT

My long-term research goals have been focused on the implementation of a holistic structural integrity process for the mechanical, aerospace, and maritime engineering industries. Primarily, my research is on the use of smart materials [1-3] and the development and evaluation of systems for Structural Health Monitoring (SHM) and Non-Destructive Evaluation (NDE) methods for aerospace structures. Since 2005, I have been working on analyzing and understanding the capabilities of academic and commercially developed "off-the-shelf" systems, which are available to perform SHM and load monitoring. However, SHM cannot be tackled independently, since it is just one component of a much larger system. The design and aging of structures requires that structural problems be analyzed by taking a holistic approach, which requires an understanding of the loads supported by the structure, the initial structural conditions, environmental effects on the structural performance, and material properties of the components composing the structure.

All these conditions and properties interact and, thus, a multi-physics-based model is required, which is a fundamental part of the Holistic Structural Integrity Process (HolSIP) framework. Clearly, HolSIP requires multiple inputs to fully provide the required outputs that structural integrity engineers need to assess the remaining useful component life of their assets. Through my research, I have contributed to, and continue to work on, the development and execution of a road map that interconnects HolSIP with the mechanical, aerospace, and maritime engineering industries, as shown in Figure 1.

As seen in Figure 1, the remaining component life of a structure is directly dependent on being able to identify and quantify structural damage. As such, NDE and SHM are critical in assessing the location and size of the damage. There are a wide variety of NDE and SHM techniques, however, in-situ NDE or SHM, is still challenged in being able to identify the sources and location of damage in complex aerospace structures [4]. Therefore, if SHM will ever receive wide acceptance in the field, a holistic framework that accounts for environmental effects, structural complexity, material aging, costs, and embedding of computing capabilities within the structure, just to name a few, will be essential.

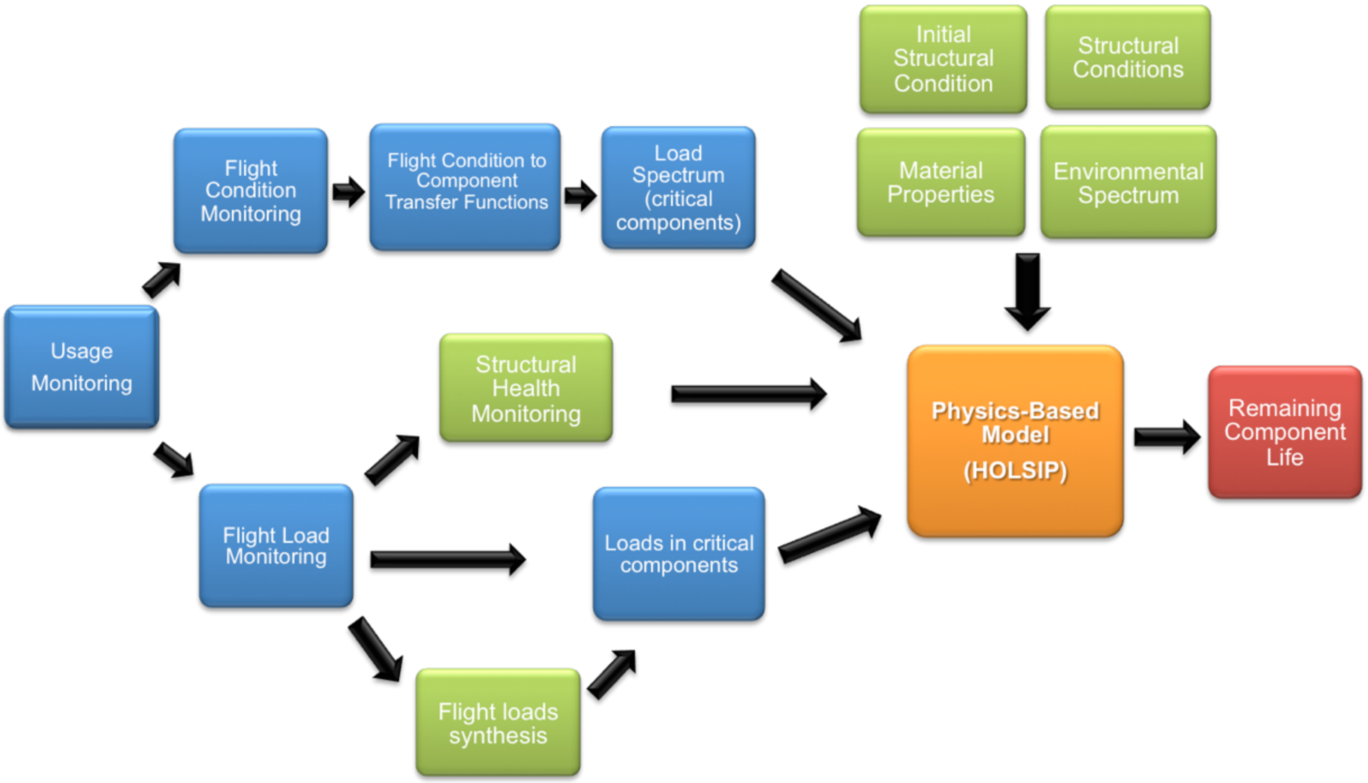

Figure 1: HolSIP - Usage Monitoring Flow Chart.

Currently, I have an active program on developing 3D computational models to generate A, B and C-Scans for detecting small delamination cracks emanating from thin composite structures (funded by industry and the Office of Naval Research). However, identification of damage site and size is not sufficient for determining remaining component life of a structure. Thus, the HolSIP framework requires load measurement and stress determination for damage growth prediction. My research in this thrust area has focused on Flight Load Monitoring, which combines the use of sensors to directly measure the loads acting on the structure. This research has led to a novel load monitoring technique that makes use of Micro-Electro Mechanical Systems (MEMS) [3] and distributed sensing fiber optic systems [5-7]. It is important to note, that this research was awarded €100,000 by the European Commission Madame Marie Curie Fellowship, under the project titled: Monitoring Aerospace Structural Shapes (MASS) through the FP7 Marie Curie Career Integration Grant (Grant no. 618316). I believe that monitoring the shape of structures using MEMS and/or distributed fiber optic systems can provide structural integrity engineers real time deformation that can be used for determining the strain and stress fields in critical locations. Over the past 5 years, I have been working on the development and implementation of algorithms for monitoring the structural shapes of our critical assets. Our studies have focused on the use of the inverse Finite Element Methods (iFEM) to evaluate the deformation of our structures, and thus determine the strain and stress distribution in critical areas [8]. In addition, the loads on the structure may be determined through a flight condition monitoring approach, as shown in Figure 1. This approach consists of developing transfer functions that relate structural maneuvers to strain/stresses acting on critical locations. However, this approach has certain advantages and disadvantages. In part the use of maneuver data is simpler to measure, however the development of transfer function and use of Machine Learning (ML) in some cases generates "black boxes," which airworthiness authorities are unable to certify.

Currently, one of the biggest challenges facing the HolSIP community, and, thus, an opportunity for my team and I to work on, has been the development of physics-based nucleation models to determine remaining component life of a structure. The primary challenge of this research is the combination of fatigue loading, initial structural conditions such as residual stresses, material aging, and environmental factors during the operational life of the structure, as depicted in Figure 1. My research in the past 10 years, has been looking at how all these synergistic effects interact as part of the design process. As such, my students and I have been evaluating fatigue crack growth behavior in residual stress fields in metallic [9, 10], and composite structures [11-14]. My team and I are aware of how residual stresses play a critical role in remaining component life and crack growth prediction [9] in, welding, cold hole expansion (Cx) processes, and structural notches [7]. Many of these applications are modeled using Finite Element Methods, either using commercial off-the-shelf software like ABAQUS CAE™, VRWeld, and/or in-house developed FEA codes. My Ph.D. dissertation was on the development of finite element code for analyzing piezoelectric structures. More recently, we have used this code for the development and application of an inverse finite element method (iFEM) for load monitoring [8, 15].

I have an active collaboration program with Lockheed Martin Corporation on Cx, that is also a primary research interest within the HolSIP community. Fatigue crack growth emanating from Cx holes requires the use of manufacturing processes like EDM. The HolSIP community meets on a yearly basis to discuss the advancements and implementation of the HolSIP framework with members like Lockheed Martin Corp., USAF, TRI Austin, Southwest Research Institute, NRC Canada, and DND Canada, just to name a few. The workshop is dynamic and exciting, and truthfully where I have been able to find many of my industry and federal research contracts.

My short-term research goals are to develop and implement SHM techniques for aerospace and maritime structures. As part of a first phase, I would focus on the design and development of amphibious solar powered Unmanned Air Vehicle (UAV). The primary intention of these designs is to develop a full-scale test for the development of SHM systems and morphing technology [16-18], while serving as a unique facility for training graduate and undergraduate students. The test platforms will need to include loads, vibrations, and environmental factors typically found in the field. The evaluation of these SHM systems should not be limited solely to the sensors but expanded to the entire system, i.e., fatigue of structures, structural optimization, viscoelastic response of composites, fluid structure interaction, etc. In the past, while working as a research officer at the National Research Council of Canada I helped develop and document different test platforms that mimic the service life of aerospace structures. These SHM platforms consisted of a simple cantilever beam and wing box with aluminum spars to an actual wing from a CF18 fighter aircraft, as documented in [19, 20]. These platforms would allow us to increase the Technology Readiness Level (TRL) of our sensors and SHM & load monitoring systems. This type of high-level infrastructure would allow us to use them as research and educational tools to form the next generation of structural design engineers. At NRC the development of these platforms allowed me to build academic relationships with organizations in the US, Canada, and the U.K., providing unique opportunities for adding my expertise to that of other researchers in the field.

As the complexity of UAVs increase, it is becoming more apparent that these structures are no longer disposable platforms. Their level of sophistication has dramatically increased, to the extent that their costs are quickly approaching those of regular military and civilian aircrafts. This level of sophistication requires the use of structural topology optimization for which I envision the development and implementation of novel FEA techniques. In recent years, I have formed part of a group in charge of designing a structurally optimized exoskeleton suit for firefighters (funded by the National Science Foundation, Award No. 2128907). This is a collaborative project with Prof. Michael Bazzocchi at York University. These topology optimized structures will need advanced CAD/CAM techniques, embedding of sensors for SHM applications, and be analyzed for residual stresses, fatigue, and life assessment considerations.

Life assessment considerations include topics like viscoelasticity. This has led to collaborative research projects with my colleague Prof. Craig Merrett. I foresee this collaboration to continue in the future.

The research, to date, has resulted in 3 Ph.D. who are currently working at the National Research Council of Canada (Dr. Shashank Pant), Universidad Autónoma de San Luis Potosí, Mexico (Dr. Christian Garcia), and WEG Electric Corporation, USA (Dr. Alessandro Baldassare), respectively. In addition, I have been able to graduate over 31 M.Sc. students (11 at Clarkson University, 7 at TU Delft, 5 at Carleton University, and 8 in collaboration with the University of Bologna and Universidad de Nuevo Leon, Mexico). All M.Sc. graduates are currently working either in industry or pursuing their Ph.D at various universities around the world. Furthermore, while working at TU Delft I received funding to support a Post-Doc for 2 years (Dr. Aubryn Cooperman) from the Far and Large Offshore Wind power (FLOW) Project funded by the Dutch Ministry of Economic Affairs. My current research team is formed by 3 Ph.D candidates (2 at Clarkson University and 1 at TU Delft) and 3 M.Sc. students at Clarkson University.

This success has not been an independent effort, it is the result of a clear vision, determination, persistence, and collaborative effort with many colleagues and partners. The funding has allowed me to build an incredible laboratory with access to the latest generation of computing, manufacturing, testing, and experimental mechanics techniques, as documented in www.marciasmartinez.com.

Finally, I would like to re-iterate that my research goals are directly linked to solving, from fundamental principles, the real challenges faced by the mechanical, aerospace, and maritime community. The main objective of my research is to develop a physic-based understanding of fatigue of materials and the parameters that influence this phenomenon. This goal requires a combined effort between numerical, analytical, and computational techniques. It is for this reason that most of my funding and support has come from my industrial partners. I look forward to continuing to develop a multicultural research team of students, who can aid in solving some of the challenges that we face in both the mechanical, aerospace, and other structural Industries for the 21st century.

REFERENCES

1. Martinez, M. and A. Artemev, *Finite Element Analysis of Broken Fibers effects in Active Fiber Composites.* Composite Structures, 2009. **88**: p. 6.
2. Martinez, M., R. Kernaghan, and A. Artemev, *Finite element analysis of broken fiber effects on hollow active fiber composites.* Journal of Intelligent Material Systems and Structures, 2010. **21**(1): p. 107-113.
3. Martinez, M., et al., *Load monitoring of aerospace structures utilizing micro-electro-mechanical systems for static and quasi-static loading conditions.* Smart Materials and Structures, 2012. **21**(11).
4. Falcetelli, F., et al., *Broadband Signal Reconstruction for SHM: An Experimental and Numerical Time Reversal Methodology.* Journal of Intelligent Material Systems and Structures, 2020: p. 30.
5. Martinez-Bueno, P., et al., *Strain Monitoring using a Rayleigh Backscattering System for a composite UAV wing instrumeted with an embedded Optical Fiber.* Advanced Materials Research, 2016. **1135**: p. 1-19.
6. Truong, H.T.X., et al., *Mode I Fracture Toughness of Hybrid Co-cured Al-CFRP and NiTi-CFRP Interfaces: An Experimental and Computational Study.* Composites Part A: Applied Science and Manufacturing, 2020.

7. Ball, D.L., et al., *Analytical and Experimental Investigation of Elastic–Plastic Strain Distributions at 2-D Notches.* Journal of Testing and Evaluation (ASTM), 2020: p. 21.
8. de Mooij, C., M. Martinez, and R. Benedictus, *iFEM Benchmark Problems for Solid Elements.* Smart Materials and Structures, 2019.
9. Garcia, C., et al., *Fatigue crack growth in residual stress fields.* International Journal of Fatigue, 2016. **87**: p. 326-338.
10. Martinez, M., et al., *Residual stress effects of a fatigue crack on guided lamb waves.* Smart Materials and Structures, 2017. **26**(11).
11. Ribeiro, F.N., M. Martinez, and C. Rans, *Evaluation of mode II fatigue disobnding using Central Cut Plies specimen and distributed strain sensing technology.* Journal of Adhesion, 2018.
12. Ribeiro, F.N., M.J. Martinez, and C. Rans, *Fiber-optic sensors shed light on the toughest composite design challenges*, in *CompositesWorld*. 2018. p. 7.
13. Baldassarre, A., et al., *Accuracy of Strain Measurement Systems on a Non-Isotropic Material and its Uncertainty on Finite Element Analysis.* The Journal of Strain Analysis for Engineering Design, 2020.
14. Baldassarre, A., M. Martinez, and C. Rans, *Residual stress evaluation of adhesively bonded composite using central cut plies specimens.* Journal of Adhesion, 2019. **96**: p. 31.
15. de Mooij, C., M. Martinez, and R. Benedictus. *Sensor Fusion for Shape Sensing: Theory and Numerical Results*. 2016. Proceedigs of the International Conference on Adaptive Structure and Technologies.
16. Sodja, J., et al. *Experimental Evaluation of the Morphing Leading Edge concept*. in *23rd AIAA/AHS Adaptive Structures Conference*. 2015. Kissimmee, FL, USA.
17. Sodja, J., et al., *Experimental Evaluation of the Morphing Leading Edge concept.* Journal of Intelligent Material Systems and Structures, 2019.
18. Wickramasinghe, V., et al., *Design and verification of a smart wing for an extreme-agility micro-air-vehicle*. Smart Materials and Structures, 2011. **20**(12).
19. Rocha, B., et al. *Evaluation of Load and Structural Health Monitoring Sensors and Systems for Future Implementation on Aircraft*. in *Conference Proceedings 2013*. 2013.
20. Rocha, B., et al. *Global Framework for the Assessment, Development and Demonstration of Structural Health and Load Monitoring Systems*. in *CASI Conference Proceedings*. 2013.