Educational Series & Academy

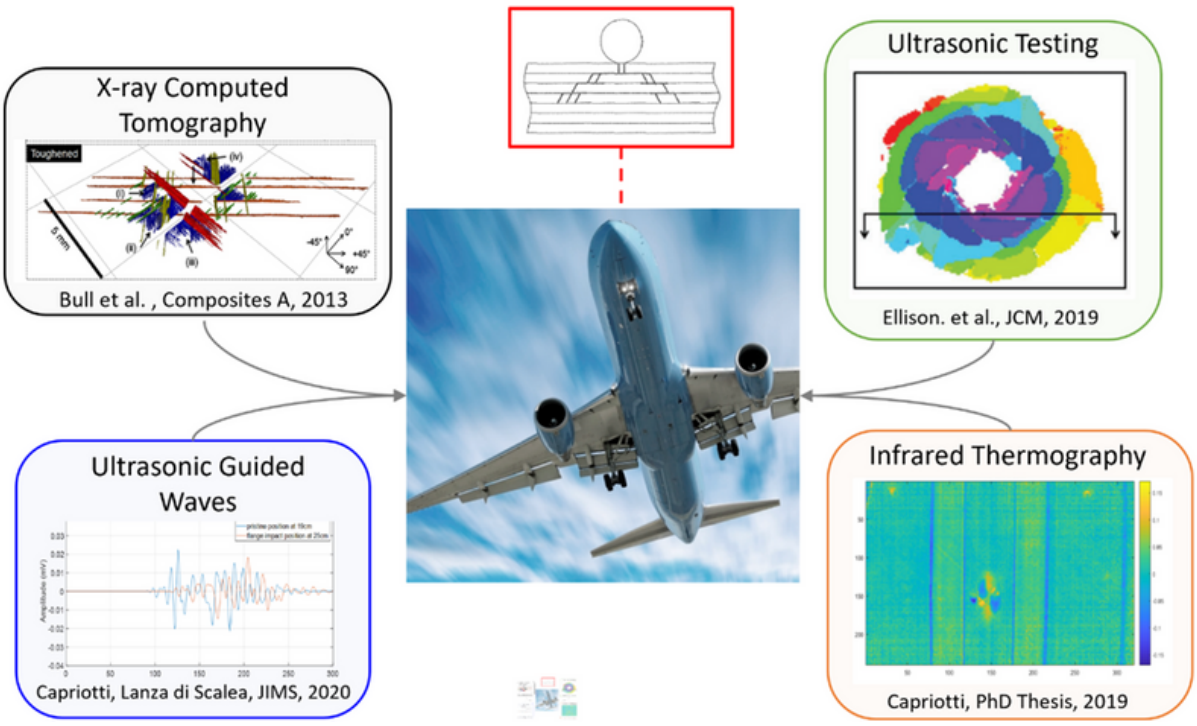
IDENTIFICATION AND NON-DESTRUCTIVE CHARACTERIZATION OF DEFECTS AND DAMAGE IN AEROSPACE COMPOSITE STRUCTURES

Fiber-reinforced polymeric (FRP) composites are high-performance materials used in the aerospace industry due to their excellent fatigue resistance, durability, and high stiffness- and strength- to weight ratios. Composites allow the design of lightweight structures with tailorable properties that minimize energy usage and contaminant emissions. These materials are currently utilized in fuselages, wings, tails, doors, and interiors of modern aerospace structures.

Despite the excellent mechanical properties, adoption and certification of composite aerospace structures is a challenge primarily due to (1) the current knowledge gap in the technology, manufacturing, process-induced defects, maintenance and repair methods for aerospace-grade FRP composites, and (2) the complex and highly varying behavior and damage formation/evolution of these materials.

This course discusses some of the main challenges for the use of composite materials in aerospace applications, emphasizing four main aspects: manufacturing defects and signatures, identification of defects via non-destructive evaluation (NDE) methods, effect of defects on the mechanical performance, and NDE for assessment of structural integrity.

The current manufacturing techniques for fabricating aerospace-grade FRP composite structures are discussed. The common defects associated with these methods (e.g., fiber and ply waviness, voids/porosity, inclusions, resin-rich regions) are reviewed, and the effect of these manufacturing defects on the strength and life of composite structures is analyzed. The state-of-the art techniques for identifying and characterizing defects in aerospace structural components using NDE methods are discussed, giving particular attention to ultrasonic testing, guided waves, infrared thermography and X-Ray computed tomography. Finally, the current challenges for assessing structural integrity of aerospace composite structures via NDE techniques are presented and the main areas of opportunity in this field are highlighted.



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MODULE 1 – Manufacturing Defects and Signatures (90 minutes)
1. Overview of composite materials systems used in the aerospace industry.
2. Manufacturing processes for aerospace composite materials.
3. Defects developed during the manufacturing processes.

MODULE 2 – Non-destructive Evaluation Methods (90 minutes)
1. Non-destructive evaluation (NDE) techniques for the detection and characterization of defects in the aerospace industry.

MODULE 3 – Effect of Defects (90 minutes)
1. Experimental and modeling approaches for predicting the effect of defects on the damage modes and mechanical performance of composites.

MODULE 4 – Structural Integrity Assessment using NDE Methods (90 minutes)
1. Damage developed in composites during operational life.
2. NDE methods for assessment of structural integrity of composite structures.

Learning objectives

At the end of this course, the attendees should be able to:
1. Explain the difference between thermoplastic and thermoset polymer systems, in terms of the microstructure and mechanical properties.
2. List the main applications of carbon fiber reinforced polymeric (CFRP) composites in aerospace structural components.
3. Explain the different manufacturing methods for fabricating aerospace-grade composite materials, and identify the advantages and disadvantages of each of these techniques.
4. Describe the common defects in CFRP composites developed during the manufacturing.
5. Describe the needs, constraints and outcomes of NDE inspections in the aerospace field.
6. Understand the physical principles and basic implementation of the presented NDE techniques (i.e., ultrasonic testing, ultrasonic guided waves, infrared thermography, X-ray computed tomography).
7. Assess the effect of manufacturing defects on the mechanical properties, strength and life of composite structures.
8. Describe damage formation and/or evolution in CFRP due to fatigue, impacts and environmental conditions.
9. Assess advantages and limitations of NDE techniques with respect to specific defects and damages in the aerospace field.

Target audience: This webinar is addressed to undergraduate, graduate and doctoral students, academic and non-academic professionals. CTNA-Cluster Exploore Marche members.

Dates and time: 23/25 January 2024, 15:00-18:00 CET

REGISTRATION AND CONTACTS

Course Code: 20241012325

This course is part of the 2023 institutional activity for AIDAA members. The registration requires the purchase of one of the packages described here https://www.aidaa.it/package-list/, and the completion of the online form available on AIDAA webpage.

Course platform: Webex, a link will be sent via email as the registration is complete.
At the end of each course, **attendance certificates** will be sent to participants via email.

For further info, please, contact **academy@aidaa.it**

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SPEAKERS

Margherita Capriotti, Ph.D., is currently an Assistant Professor in the Department of Aerospace Engineering at San Diego State University. She focuses on Non-Destructive Evaluation (NDE) and wave propagation and is currently setting up her NDE Research Clinic at SDSU.
Dr. Capriotti's research investigates ultrasonic guided wave propagation and scattering in complex materials and geometries through global-local and semi-analytical finite element approaches, and non-contact/hybrid testing. She also studies heat diffusion and defect interaction, by using infrared thermography through thermal signal reconstruction for quantitative NDE in aerospace structures. Her research aims at developing noninvasive techniques for defect detection, material characterization and structural assessment of composite aerospace structures and complex media, using wave propagation and scattering, and heat diffusion. She is also interested in noninvasive techniques for biomedical applications, specifically shear wave elastography.
Dr. Capriotti's research and education strategies relies on multi-disciplinarity and diversity, where different methodologies, skills and backgrounds are integrated towards advancing science and broadening participation. She is a member of the Women in Engineering, Chair of the Diversity, Equity and Inclusion Committee in the Aerospace Engineering Department and co-advisor of the Women of Aeronautics and Astronautics, at SDSU. She enjoys and is active in international collaborations and is also the point of contact at SDSU for the Cluster Aerospace Exploore Marche.
Dr. Capriotti received her Ph.D. in Structural Engineering from University of California San Diego in 2019, pursuing research in the Experimental Mechanics, NDE & SHM Lab. She previously graduated with her B.S. and M.S. in Mechanical Engineering at the University of Parma (Italy). She has been a Graduate Research Trainee in the Mechanical Engineering Department at McGill University (Canada) and a postdoctoral Research Fellow at Mayo Clinic in the Department of Radiology, within the Ultrasound Research Lab.

Paulina Díaz-Montiel, PhD, is an Assistant Professor of Mechanical Engineering at the University of San Diego. Dr. Díaz-Montiel's expertise is in structural mechanics and composite materials. Her work combines manufacturing, testing, experimental mechanics, and computational methods for studying the progressive failure of materials and structures at different scales and loading conditions.
Dr. Díaz-Montiel's scholarship aims to develop engineering solutions for advancing the manufacturing of composites that can be employed in various applications: from efficient vehicles to innovative infrastructure. She is particularly interested in understanding the influence of manufacturing-induced defects on the strength and life of composites and exploring the sustainability and recyclability of these materials.
Dr. Díaz-Montiel is passionate about teaching and mentoring young professionals from multiple backgrounds and diversifying the STEM workforce. In the past, Dr. Díaz-Montiel has established local and international partnerships to investigate damage accumulation in composites using NDE methods and has mentored students across the California/Mexico border.
Dr. Díaz-Montiel received her PhD in Structural Engineering from the University of California San Diego - San Diego State University joint doctoral program. She holds an MS in Aerospace Engineering from San Diego State University and a BS in Mechanical Engineering from CETYS University (Mexicali, México). She is currently an active member of the American Society for Composites, the American Institute of Aeronautics and Astronautics, and the American Society of Mechanical Engineers.