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DIGI 3D

Trainers Guide

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MOTIVATION

In the rapidly evolving landscape of modern manufacturing, 3D printing has emerged as a transformative innovation, redefining design, production, and supply chain paradigms across industries. Its capacity to enable lightweight structures, complex geometries, and rapid prototyping has positioned it as a cornerstone technology in the digital manufacturing revolution. Recognizing the urgent need for engineers proficient in this emerging domain, the DIGI3D project was conceived as a strategic initiative aimed at cultivating a digitally skilled, industry-ready workforce for the aerospace sector.

At its core, the DIGI3D project represents a forward-looking commitment to bridging the gap between academic training and industrial demand. It introduces a comprehensive curriculum framework anchored by a specialized course entitled "Digitalization in 3D Printing," designed to equip students with the knowledge and technical competencies essential for the aerospace industry's ongoing digital transformation. The course emphasizes not only the fundamentals of additive manufacturing but also the integration of digital design, simulation, and production workflows aligned with Industry 4.0 principles.

The DIGI3D initiative is built around five key pillars:

- *Introducing Novel Technology:*

As a cutting-edge manufacturing technology, 3D printing has become indispensable in the aerospace industry, demanding a new generation of skilled engineers. DIGI3D introduces students to the principles and applications of additive manufacturing, empowering them to innovate and adapt within this technologically dynamic environment.

- *Industry Alignment:*

In direct response to the rapid expansion of the aerospace sector, DIGI3D seeks to address the existing skills gap by producing engineers who are not only theoretically proficient but also practically capable of implementing advanced digital manufacturing solutions.

- *Practical Application:*

Traditional engineering education often emphasizes theoretical foundations over hands-on experience. DIGI3D bridges this gap by incorporating experiential learning, enabling students to apply design and manufacturing concepts in real-world aerospace scenarios through laboratory sessions and industry collaborations.

- *Adapting to the Digital Age:*

As the aerospace industry increasingly embraces digital tools, data-driven decision-making, and automated production systems, DIGI3D prepares students to operate effectively within these environments. The program provides comprehensive training in digital design, simulation-based validation, and cyber-physical manufacturing systems.

- *Environmental Advocacy:*

In an era defined by sustainability challenges and resource constraints, DIGI3D promotes an ethos of environmental responsibility. The program integrates awareness of eco-efficient manufacturing processes, material sustainability, and life-cycle assessment into its educational framework, encouraging students to adopt green manufacturing practices.

This guide provides an outline for trainers by giving a detailed information about training course in the DIGI3D project. The first part explains the course details while the second part gives an overview of the modules.

COURSE DESCRIPTION

Introduction

The course program on 3D printing applications in the aerospace industry has been developed within the framework of the Erasmus+ DIGI3D project. The primary objective of this project is to design and implement an innovative curriculum for engineering departments, addressing the growing need for digitalization in 3D printing applications. The aerospace sector, recognized as a global leader in adopting advanced manufacturing and digital technologies, serves as the target domain for this initiative. The course content has been collaboratively developed by partner institutions from Turkey, Portugal, and Lithuania, integrating multidisciplinary expertise to ensure both academic rigor and industrial relevance.

Short description

This course, developed under the DIGI3D project, focuses on 3D printing applications in the aerospace industry. It aims to establish an innovative, digitally oriented curriculum encompassing key topics such as Digital Manufacturing and 3D Printing, Materials in 3D Printing for Aerospace Applications, 3D Printing Processes in Aerospace Components and Maintenance, and Case Studies from Aerospace Applications. The program combines academic excellence with industrial relevance, equipping students with the knowledge and skills required to meet the evolving demands of the aerospace manufacturing sector.

Target groups

The main target group comprises students from the Aeronautical, Aerospace, Mechanical, and Materials Engineering departments, while research staff and industry professionals will also benefit from the project outcomes.

Objectives

The DIGI3D aims to develop a comprehensive curriculum, textbook, and educational materials. The project promotes the digital tools in 3D printing, fostering a deeper understanding of sustainable manufacturing practices. Another key objective is to enhance applied engineering education, enabling students to engage directly with industry-relevant applications. Lastly, DIGI3D seeks to establish a strong consortium uniting academic and industrial partners, thereby strengthening collaboration in the 3D printing technologies.

Methodology

The developed course supports both online and onsite learning, ensuring flexibility and accessibility. A textbook serves as the main reference, forming the basis for video lectures, reviews, practical assignments, and quizzes. All materials are freely available on an e-learning platform, providing easy access for the target groups. To enhance visibility, dissemination activities such as stakeholder visits, participation in events, and presentations at conferences are conducted by project partners to reach a broad audience and maximize impact.

Thematic modules

Module-1: Digital Manufacturing and 3D Printing

Module-2: Materials in 3D Printing for Aerospace Applications

Module-3: 3D Printing Processes in Aerospace Components and Maintenance

Module-4: Case Studies from Aerospace Applications

Key learning outcomes

Upon completion of the training course, participants will be able to:

● Understand the principles of digitalization in 3D printing applications

● Identify and describe aerospace materials used in 3D printing processes

● Explain 3D printing applications in the production and maintenance of aerospace components

● Recognize and evaluate practical 3D printing applications within the aerospace sector

Assessment methods

The course modules include a self-assessment methodology using quizzes, designed to help participants consolidate their knowledge and build confidence in their skills.

COURSE CONTENT OVERVIEW

The course consists of four modules, with an overview of each module provided on the following pages.

MODULE-1: Digital Manufacturing and 3D Printing

Short Description

This module introduces the fundamentals of digital manufacturing and 3D printing, with a focus on applications in the aerospace sector. It addresses the principles of process digitalization, main software tools used in additive manufacturing workflows, process modelling and simulation, and design methodologies specific to 3D printing (e.g., Design for Additive Manufacturing – DfAM). The module also explores the integration of additive manufacturing into digitally driven and sustainable production systems, preparing learners to meet the challenges posed by digital transformation in additive manufacturing for aerospace applications. The content of the module is given below.

- Introduction
- Digital Tools for Additive Manufacturing
- Modelling, Simulation, and Print Preparation
- Digital Design Methodologies
- Integration of 3D Printing in Digital Production Systems
- Conclusions

Learning Objectives

Upon completion of this module, attendees will be able to:
- Understand the fundamental concepts of digital manufacturing and 3D printing.
- Recognize and apply digital tools (CAD/CAM/CAE) in additive manufacturing workflows.
- Recognize digital design strategies to optimize 3D printed components.
- Understand the influence of process parameters and their control on the printing quality of components for the aerospace industry.
- Understand the complete digital workflow required to prepare parts for additive manufacturing.
- Understand the integration of 3D printing into digitally enabled and sustainable production systems in the context of aerospace applications.

Learning Resources

- Scientific articles
- Industrial reports
- Books
- Thesis
- Tutorials
- Instructional videos

MODULE-2: Materials in 3D Printing for Aerospace Applications

Short Description

This module focuses on material selection and utilization in additive manufacturing processes. It provides an overview of current material technologies used in additive manufacturing, with particular emphasis on aerospace applications. The module explores the structure–property–process relationships of materials, and emerging trends in material development. The content of the module is outlined below.

- Introduction
- Material Requirements for Aerospace Components
- Polymeric and Composite Materials for 3D Printing
- Metallic Materials for 3D Printing
- Ceramic and Hybrid Materials for 3D Printing
- Conclusions

Learning Objectives

Upon completion of this module, participants will be able to:

- Identify the material requirements specific to aerospace components.
- Explain current material technologies used in 3D printing.
- Classify materials suitable for 3D printing based on their properties and applications.
- Select appropriate 3D printing processes for aerospace-grade materials.

Learning Resources

- Scientific articles
- Industrial reports
- Books
- Thesis

MODULE-3: 3D Printing Processes in Aerospace Components and Maintenance

Short Description
This module explores specific 3D printing processes, challenges, and opportunities in aerospace component production and maintenance. It introduces the fundamentals of 3D printing technologies and their applications in aerospace. It will explain the types of technologies and materials used, discuss the limitations and typical defects in 3D-printed parts, present experimental research methodologies, and highlight key performance characteristics such as mechanical resistance and aerodynamic behavior in boundary layers. The module is divided into six units: • Technologies • Materials • Limitations of Technologies and Common Defects in Products • Research Methodology • Mechanical Strength and Performance Characteristics • Boundary Layer and Specific Aerodynamics

Learning Objectives
Upon completion of this module, attendants will be able to: • Identify the main 3D printing technologies applicable to UAV structure manufacturing. • Select materials for 3D printing based on mechanical, thermal, and weight requirements. • Recognize the limitations of different additive manufacturing methods and identify typical defects in 3D-printed parts. • Apply fundamental research methodologies to evaluate the performance and quality of 3D-printed UAV components. • Assess the mechanical strength, impact resistance, and structural integrity of 3D-printed UAV components. • Understand how surface texture, material structure, and print quality affect boundary layer behavior and aerodynamic performance. • Integrate knowledge of materials, printing methods, and design constraints to develop optimized UAV components for real-world applications.

Learning Resources
• UAV Laboratory • Construction laboratory • University Airfield Kyviškės • Scientific articles

MODULE-4: Case Studies from Aerospace Applications

Short Description
This module focuses on 3D printing case studies involving both polymeric and metallic materials used in aerospace applications. The polymer-based case study addresses the manufacturing of airframe structures for drones, while the metallic material case study centers on the production of aero-engine components. The module discusses appropriate manufacturing methods based on the type of material and provides a step-by-step algorithm outlining the entire process. The content of the module is outlined below. • Introduction • Case Study-1: 3D Printing of a Polymeric Material for Airframe Structures • Case Study-2: 3D Printing of a Metallic Material for Aero-engine Components • Conclusions

Learning Objectives
Upon completion of this module, participants will be able to: • Identify process requirements specific to aerospace materials. • Select appropriate process parameters for 3D printing operations. • Design and sequence process steps involved in 3D printing workflows. • Understand and apply digital tools used in 3D printing processes.

Learning Resources
• Scientific articles • Industrial reports • Books • Thesis • Tutorials • Application videos