

## **AEROPTIMUM – Aeronautics Knowledge-based Production Optimisation. High Density and Multi-Dimensional Digital Representation and Simulation of Composite Parts, Processes and Activities in Aeronautics**

### **Concept**

Commercial passenger planes consume an extraordinary amount of jet fuel. The aircraft manufacturing sector is heading towards bigger and more efficient airplanes, which require a higher quality control and more critical components. Composite materials in the aerospace market are forecast to grow by more than 10% annually from 2005 to 2010. During that period, it is estimated that the global aerospace industry will use about €2.5 billion worth of composite materials. The global end product market for composites is estimated at €17 billion by 2010.

Following such a trend, the use of composites over the last three decades has evolved from less than 5% in the Boeing 737 and 747, to over 17 % in the Airbus A320. The A320, launched in 1990, uses about 17% composites and 66% aluminium. The Airbus A380 uses more than 20% more fuel efficient than similar-sized planes, thanks to advancements in composite materials technology.

Traditional manufacturing process for composite components is mainly handcraft, and demands a high accuracy in terms of quality of the produced components. Such manufacturing process undergoes an impact on both costs and delivery time of the components. As the competitiveness between the main industries using nowadays composite materials increases, the pressure for enhanced automation in the production line also increases. The final aim is to lower the production price and offer higher mass production with high quality for a broader spectrum of users.

The performance of the global manufacturing process layout (composed of different and consecutive activities) for composite components is highly dependent on factors such as:

- Availability of the different optimum activities
- Selection of the most suitable activity
- A tailored use of the features leveraged by each activity design

Whilst designers and manufacturers have made significant advances in the development of processes and activities with high-tech properties for manual and semi-automatic use, similar advances in the exploitation of the knowledge accumulated have not been observed. Processes and activities are designed under worst case conditions with offline and static information, which is both time-consuming and in-effective.

The aeronautical manufacturing industry can no longer remain focused only on the process and activity itself. There is a clear need for this industry to develop the means to exploit process knowledge beyond the process. AEROPTIMUM project aims at developing this new platform that the aeronautics industry needs to allow for next generation services, exploiting the human and knowledge capital developed during the engineering phase, which is a direct consequence of R&D activities and expert knowledge of the quadruplet tool-material-machine-process. This new scenario, proposed by the AEROPTIMUM project, will strengthen the European aeronautic industry's quest to maintain its position as a world leading manufacturing agent and permit global exploitation of expert knowledge through advanced services aimed at zero production errors due to process and activity under-performance.

Composite materials have increased their importance in structural and mechanical engineering, although there is still a lack of knowledge regarding certain aspects of their mechanical behaviour

in production. In fact, this is encouraging demand from industry for technologies and systems that can ensure that materials meet all of the specifications required by the most important clients.

Composites in aeronautics is an area with significant business potential due to the inherent problems that appear in the manufacturing process and that require expert knowledge about the material, the concrete manufacturing activities that the material goes through, and the behaviours and errors appeared. Improved alignment of this knowledge will result in better engineering, reduced costs, tailored manufacturing processes and better efficiency.

Some of the needs of the aeronautics sector within the composite-related manufacturing process are clear – for instance precision and surface finishing that is compatible with cost and productivity goals. However, such performance heavily depends on many factors that can not be fully addressed during design of the different activities involved in the whole manufacturing process. They can only be partially handled, as the most appropriate design, use and configuration of a particular process activity cannot be easily anticipated, and this is one of the key aspects in obtaining zero process and activity failure. Moreover, as more complex multifunction manufacturing activities are envisaged there is also a knock-on increase, in relative terms, in the time needed to produce the suitable and optimum activity.

## Overall objectives

**The challenge of this proposal is to design a new knowledge-based method for activities design and process control to improve the manufacturing of composite materials in terms of: accuracy, surface finish, productivity and cost performance.**

The main goals of the project are:

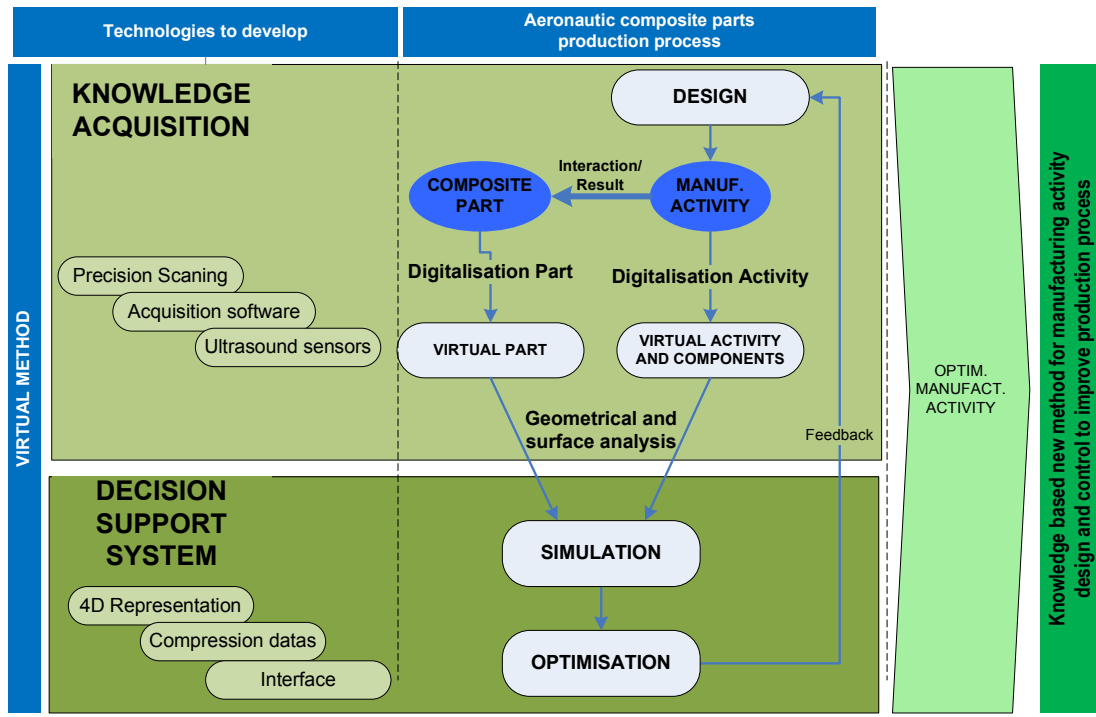
- To develop a **holistic method for manufacturing activity design** that integrates information from the whole manufacturing process lifecycle. The developed method will be implemented within a **DECISION SUPPORT SYSTEM** that will action existing knowledge existing in the aeronautic engineering and manufacturing industry for the benefit of complex component productivity and efficiency.
- **Enhancement of VIRTUAL CONCEPT based simulation.** The development and improvement of digital information gathering from the production lines enables virtual work to be carried out. Simulations fed with on-line data are key to feed the Manufacturing Activity Knowledge Database. The information gathered from optical, visual non-contact and ultrasonic sensors assessing and predicting for instance an specific tool or machine wear-out due to specific use will permit through simulation and expert knowledge prevent manufacturing errors and to support in better process matching based on material properties, available time for the operations and observed performance.

To achieve these overall objectives, we are targeting advances on the state of the art in the following fields:

- **Activity State & Use Characterisation.** Through Visual Image Processing the particular state of the activity components (tools, machines...) would be characterised, as well as the temperature observed during operation.
- **Activity Performance Characterisation.** The performance of the results obtained in the activity would be dimensionally characterised externally and internally through 3D optical and ultra-sonic sensors.
- **Activity Engineering Information Data Acquisition.** The performance of the activity will be simulated based on the expert knowledge incorporated into the simulation environment

- Production Decision Support Systems. Human and Expert Database support will be provided to the final user in terms of optimum configuration, optimum process adaptation...

The overall system performance is described in the Figure below. The manufacturing activity is initially designed based on existing requirements. The activity and its components dynamics – wear-out, temperature behaviour - are characterised during process set up. The performance of the activity and its components on the composite material is characterised through part scanning and ultrasonic measurements. The process is real-time supported by off-line simulation results and expert advice in activity and components use and configuration to optimise production cycle and automation.



**Scientific and technological objectives**

*KNOWLEDGE ACQUISITION*

- Information and Knowledge Acquisition
- Precision Scanning
- Ultrasound Sensors

*DECISION SUPPORT SYSTEM*

- Virtual Service Composition
- 4D Representation
- Storage, Data Compression
- Interface oriented to the process

**Work plan**

WP	Title	Objectives in short
0	Project Management	<ul style="list-style-type: none"> <li>▪ Overall administrative, technical, financial and quality project management</li> <li>▪ Maintain close contact with the EC throughout the project</li> <li>▪ Establish and support a fluid communication and information exchange process within the project</li> <li>▪ Ensure that the work and delivery of the project meet its objectives in a cost and time effective manner and with the quality demanded</li> </ul>
1	AEROPTIMUM concept and specifications	<ul style="list-style-type: none"> <li>▪ Extensive state of the art investigation, targeting both scientific literature and patent databases</li> <li>▪ Specification of the new virtual part representation and management solution</li> <li>▪ Specification of materials and manufacturing process and activities</li> </ul>
2	Activity State & Use CHARACTERISATION	<ul style="list-style-type: none"> <li>▪ Research full representation needs.</li> <li>▪ Define virtualisation strategy</li> <li>▪ Develop representation technologies: Full digital and virtual representation.</li> <li>▪ Precision Scanning: develop a system capable of scanning a large object with a high resolution and high accuracy</li> </ul>
3	Activity Performance CHARACTERISATION	<ul style="list-style-type: none"> <li>▪ Research and develop ultrasound sensors, detailed and truthful representation of the superficial and internal material characteristics</li> </ul>
4	SIMULATION Decision Support system	<ul style="list-style-type: none"> <li>▪ Research multi-scale, multi-resolution 4D open representation of high density 3D objects</li> <li>▪ Develop a simulation software</li> <li>▪ H-M Interface</li> <li>▪ Study new method compression data</li> </ul>
5	OPTIMISATION Decision Support system	<ul style="list-style-type: none"> <li>▪ Feedback results</li> <li>▪ Best practice recommendation</li> </ul>
6	Proof of concept and evaluation	<ul style="list-style-type: none"> <li>▪ Define and run a proof of concept in real shop-floor conditions</li> </ul>
7	Dissemination	<ul style="list-style-type: none"> <li>▪ Promotion and dissemination of AEROPTIMUM results during and at the end of the project.</li> </ul>

**PROPOSAL TO BE SUBMITTED TO CALL FP7-AAT-2010-RTD-1**

**ACTIVITY 7.1.4. IMPROVING COST EFFICIENCY**

**AREA 7.1.4.1. Aircraft development cost**

**AAT.2010.4.1-5. Production**

Development of advanced ‘intelligent’ knowledge-based manufacturing and assembly processes and technologies with increased degree of automation; advanced manufacturing methods to reduce both recurring and non-recurring costs across the whole production cycle from single component manufacturing process to final assembly including techniques to repair and re-use key components and for reduction of waste and consumables; development of techniques for increased flexible tooling; advanced in-process inspection and quality control, including knowledge-based diagnosis and prognosis and damage tolerance.