

# 4D HYBRID



Newsletter n°1



[www.4Dhybrid.eu](http://www.4Dhybrid.eu)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723795



## Project summary

The 4D Hybrid project has to deal from aeronautics to oil & gas complex metal parts and it embraces major challenges across their lifecycles from the green field intensive manufacturing to the numerous maintenance and repairing operations worldwide distributed.

The project exploits the synergic combination of additive and subtractive processes conceived not only as a simple succession of steps but as an hybridization of the processes. 'Plug and produce' modular approach is a key factor to success for such hybridization.

In this scenario, 4D Hybrid will deliver 4 disruptive breakthroughs:

- A set of four elementary modules specifically designed for AM that embed the control and monitoring systems which can be integrated on new or existing concepts of machines and robots to realize different processes ranging from the Direct Energy Deposition (powder and wire) to ablation and cold spray;
- A new concept of CNC, constituting a high level SW layer which can be integrated on the top of commercial CNCs, and it is conceived as open to embed portions of the 4DHybrid modules control;
- A validated process model to fully exploit the synergistic interactions among elementary processes;
- A dedicated 4DHybrid Engineering CAD/CAE/CAM Platform, which covers the lifecycle of the reference product family where multiple processes and hybrid resources are integrated for the (re) manufacturing stage.

Innovation will be physically demonstrated at three possible levels of hybridization: the modules, where small hybrid modules are integrated on new special machines, focusing on portable units for certified in-situ repair operations; the Hybrid Machines, where there is the Hybridization on existing robots and machines; Production lines, the Hybridization of a flexible production line focusing on new concepts for AM mass production.

### End use cases definition

The first period of the 4D Hybrid project was dedicated to the definition of the components and requirements of the use cases used to demonstrate the 4D Hybrid concept.

GLOBOTICS is active in the field of oil & gas industry. Such as the pilot case of 4D Hybrid will involve maintenance and repair of oil & gas-related structures. A multitude of such parts has been identified, including storage tanks for gases and liquids, as well as large sized pipes used for transportation of petrochemicals.

SIEMENS has provided a case that involves maintenance and repair of gas turbine blades, as used in electric power generators installed in power generation plants. Parts are usually from medium to large scale, subjected to high heat loads. Materials involve Ni-based alloys (IN718, cupronickel) but may also involve carbon steels.

## User experience mapping

Based on the above generic descriptions, and during the first 6 months of the project, LMS, Keen Bull and SUPSI have collectively worked and collaborated with both technology providers and end users to gather and formalise the information related to all end use cases.

Information included not only parts geometry and variants, but also materials, current manufacturing and repair processes, as well as process chains. This information was formalised in user experience maps (one for each end use case), which were subsequently validated with the end users and shared with the 4D Hybrid consortium to serve as the basis on which 4DHybrid developments would have been built upon. In addition, through these references baseline scenarios, a list of opportunities have been arising from utilising identified and validated 4D technologies. Through these opportunities, new maps will emerge depicting the same Maintenance-Repairing-Operation (MRO) process after implementing the 4D Hybrid results, highlighting the impact of the project

### Round robin parts design

Based on the user experience maps as well as CAD files, images and drawings of the end use cases, their distinctive features and characteristic dimensions were extracted and formalised in a designed matrix, in the way to be able to generate a large family of Round Robin parts. Using these design matrices as a basis, parametric CAD files of the Round Robin family of parts were generated. These parts will be used throughout the 4D Hybrid project to test the functionalities of associated technologies and equipment.

### Engineering Platform specifications

The Engineering Platform will form the "software backbone" of the 4D Hybrid project and will be designed as a responsive solution supporting multiple devices. It will be conceived to be utilized by all players of the manufacturing value chain and, consequently it will ensure the persistent translations between various CAD and CAM software without losing any information.

It will serve three major goals:

- Provide a design environment merging standard information categories (parametric solid geometry, stress-strain, functionalities, use modes) with other information which can be modelled in the form of objects classes
- Design customization, by assisting the user to assess if the nominal CAD model will fit the actual operating environment and execute minor modifications of the main CAD file.
- Repairing stage, by assisting the user to elaborate the status of the monitored existing part and match it against the nominal CAD file.

Following the work executed in T2.1 as it regards the user experience mapping, the teams' know how was used to create a generic MRO meta-map for the 4D engineering platform. This meta-map describes

a generic MRO process, allowing in this way an exchange of information from all end use cases to be efficiently handled by the platform and ensuring transferability to future MRO processes. The meta-map and generated opportunities will be validated and will serve as a basis to develop the Engineering Platform specifications.





### General information

PRIMA ELECTRO is an Italian leader in electronic control and power solutions. Today the company designs, produces and sales dedicated industrial electronics and it is part of the group PRIMA INDUSTRIE, a worldwide leader in the field of the laser machinery for the metal sheet applications. Prima Electro experience started in 1978 when Prima Electronics has been founded as a satellite company of Prima Progetti, a Society specialized in the design of industrial automation, with a strong propensity to integrate mechanics, electronics and software. Prima Electro begun producing electronics as a pioneer of mechatronic. In the early months of 2007, it completed the acquisition of MLTA, a company specialized in power electronics and transport applications. Always in the same year, in July it became the 100% owner of OSAI Company, the historic CNC brand and world leader in the market for wood, glass and marble applications, allowing to conquer the leadership in the CNC production in Italy and become the first Italian manufacturer of numerical control. Today, Prima Electro has a wide broad and diversified portfolio of prestigious clients. Prima Electro is active in the market with two brands: DOTS e OSAI. The DOTS electronics is located in the market area between the commercial electronics COTS (Commercial Off-The-Shelf) and the “custom” one. Being a pioneer in this market area, Prima Electro offers dedicated solutions for specific applications with a high level of industrialization and high competitive costs and time-to-market. The OSAI brand is today leader in the wood, glass and marble working and in the competitive costs and time-to-market. The offer of OSAI products is composed of Numerical Controls, Motors and Servo-drives. The acquisition of Convergent Lasers in 2010 made Prima Electro the main character of the Industrial laser market with more than 6.000 installations all over the world. Prima Electro company works as a customer-specific electronics manufacturer, who designs and industrializes the customer’s idea by offering a service for different application markets.

Today Prima Electro commitment is to provide, develop, produce and test high tech electronic equipment, numerical control and laser sources, leading industry players. Proven experience, advanced research and technological solutions inspired by different markets, are the key factors that makes it one of the leading and most trusted electronics manufacturer on the market. Today it is also the first Italian manufacturer of numerical controls and offers also dedicated solutions for specific applications with a high level of industrialization and costs and time-to-market very competitive.

### Role in 4D Hybrid

Prima Electro is the Project coordinator of 4DHybrid. Its commitment in research and technology innovation, together with Prima Industrie group, allows Prima Electro to be proactive in European research and boost new solution for the advanced manufacturing processes.

The experience of prima Electro, will be exploited in 4DHybrid also in different technical activities mainly related to the control, modelling, simulation and process design. The contribution is in the design and development of the 4D control architecture, organized for logic control and CNC system, collaboration in defining CAM solution (Post processor from CAD to CNC) and at the CAx chain. Prima Electro is also joining the other partners to test the robots that will be used to manufacture (Full scale industrial pilots).

### General information

The University of Applied Sciences of Southern Switzerland (SUPSI) is one of the 7 UAS in Switzerland. It has a university statute focused on applied research.

The Laboratory of Automation, Robotics and Machines led by Anna Valente is part of the ISTEPS (Institute of Systems and Technologies for Sustainable Production) with the Department of Innovative Technologies DTI.

Key research areas are: Automation and Control, Mechatronic, Reconfigurable Robotics, Artificial Vision Systems, Industrial Technologies for Additive Manufacturing. Specific research activities are:

- \* Design of reconfigurable robots and mechatronic equipment for multi-metal material AM technologies for aerospace and medtech industries;
- \* Design and development of innovative machining and high precision manufacturing systems based on flexibility and reconfigurability principles, of their data models and data flow management;
- \* Design and development of new automation solutions integrating advanced industrial technologies and robots;
- \* Integration of 2D/3D vision systems for image acquisition and processing in new automatic processes ;
- \* CAD-CAM-CAPP integrated chains based on STEP-NC;
- \* Design and development of embedded applications for real-time processing of digital signals and data streams, and of parallel and distributed applications for heterogeneous platforms;
- \* Design, simulation and optimization of manufacturing path planning and process planning;
- \* Process control and adaptation based on a closed loop monitoring system to select best available processing strategies and machine settings;
- \* Analysis and application of new methods, reference models and architectures for designing, configuring and optimizing high performing control and scheduling applications for distributed adaptive automation systems.

ARM Lab counts 15 people and a long-term experience in the applied research. In fact it has developed in the last twenty years, in national and international projects, a strong experience on applying advanced industrial technologies for developing new manufacturing concepts based on the combination of automated modules made of mechatronic elements that can be configured according to the production requirements, allowing to move away from manual operations to high-accuracy automated methods.

### Role in 4D Hybrid

Anna Valente is the Scientific and Technical coordinator of the project.

ARM Lab is responsible for the design, engineering and development of new concepts of hybrid additive manufacturing solutions based on the modular integration of compact, low cost modules including laser source, deposition head, sensors and control. Applications in the aerospace, oil & gas, and power generation equipment. Such modules will be integrated in shop-floor and off-shore operating environments.





### General information

The Laboratory for Manufacturing Systems & Automation (LMS) of the University of Patras has been founded in 1994 and is oriented on research and development in cutting edge scientific and technological fields. LMS is involved in a number of research projects funded by the CEU and European industrial partners. Particular emphasis is given to the co-operation with the European industry as well as with a number of “hi-tech” firms. LMS is under the direction and technical coordination of Professor George Chrysosouris. It is organized in three different groups:

- Manufacturing Processes Modelling and Energy Efficiency
- Robots, Automation and Virtual Reality in Manufacturing
- Manufacturing Systems

Specifically in the field of Innovative Manufacturing Processes, LMS is active in various aspects including experimentation, process modelling and simulation, process monitoring and control as well as life cycle assessment.

In collaboration with European industrial partners, LMS has produced a large number of research results. Especially in the field of Additive Manufacturing, LMS has to demonstrate a significant range of research results and participation in a number of relevant projects since 1997. Focused research has been conducted on the development of process models and simulation tools, ranging from capturing thermal field history and predicting thermo-mechanical behaviour to build time models for a variety of AM processes. Furthermore, coupled (thermal-fluid) models for the investigation of the melt-pool dynamic phenomena have been developed, and several experimental studies have been conducted by LMS. From a digital design perspective, special focus has been given on the investigation of re/designed structural parts considering process's capabilities and implementing topology optimization algorithms.

Finally, LMS is also well known in the manufacturing community for its contribution to the science of manufacturing via a rich collection of scientific and technical papers produced. More than 500 (five hundred) publications in international refereed scientific journals and conferences have been authored by LMS, earning international acclaim and attracting thousands of citations.

### Role in 4D Hybrid

LMS as a research partner is involved in a number of activities in the 4D Hybrid project, mainly related to modelling, simulation and process design, as well as scientific dissemination.

More specifically, LMS has cooperated with 4D stakeholders to define the process requirements as well as the Round Robin parts that will be used for 4D technologies validation and evaluation. Moreover, aiding the process design, LMS will be involved in modelling and simulation of the involved processes. In addition, LMS is in charge of the integrated modelling of processes and 4D modules, as well as for the process chain optimization.

Finally, LMS together with MCI is collaboratively developing the dissemination plan and coordinates the scientific dissemination activities.

# Keen Bull

### General information

Keen Bull is a Swiss Certified B Corp that operates as an organizational design and development company. We apply Agile and Lean methodologies to design business models, impact models, products, services, organizational structures and software tools following a Human-Centered Design proprietary process. We provide requirements and recommendations for Human-Centred Design principles and activities throughout the lifecycle of digital interactive systems. Our main competences are related to managing design processes, and are focussing on enabling hardware and software components of interactive systems to enhance human-system interaction.

In 4D Hybrid project, Keen Bull has the role of designing a multi-device product recognition and analysis software infrastructure.

Keen Bull is responsible of the following activities, in the 4D Hybrid consortium:

### Research and Analysis

Analysing current MMO/MRO inspection processes (Aerospace and Oil&Gas sectors) from a Human-Centered Design perspective in order to understand and individuate areas of improvement and successful features from different points of view (e.g. user interfaces, technologies, process handling, cognitive load, roles, information flows, feedback, etc).

By interviewing and researching the End-Users' Maintenance and Repairing Operation we contribute to discover, clarify and formalize the processes at the origin of the entire project. We drive the knowledge co-creation by participative design approaches where all the stakeholders are involved in providing their knowledge. We act as process facilitators and designers with the final goal of enabling the definition of research scenario where the 4D Hybrid project can actually develop its scientific and engineering nature.

### Engineering Platform Design

Designing and developing the interfaces for an Internet-based multi-device collaborative platform. The platform will use a big-data acquisition approach, standardization and analysis procedures and software tools to allow stakeholders involved in the repairing process to work remotely and efficiently with an accessible and usable WYSIWYG interfaces.

By iterating the refinement of lo-to-hi fidelity prototypes and mock-ups we grow an accessible and usable User Experience satisfying the collectively gathered technical, business and scientific requirements. We tailor the final User Interface on actual End User needs by testing and assessing their usability following a Human-Centered Design approach.

### Scanning Device Design

Designing and developing the User Interface and the User Experience for sensors-enabled hand-held scanners and other tools involved in collecting information.

We integrate the findings of the research and analysis phases with the research scenarios and the results of the User Interface design and testing in order to produce an efficient and effective End-User Experience.



Project Coordinator



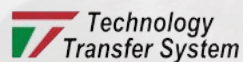
Technical Coordinator

**SUPSI**

Project Partners



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