Collaborate project
Project No.636992
Program H2020
FoF.2014-2

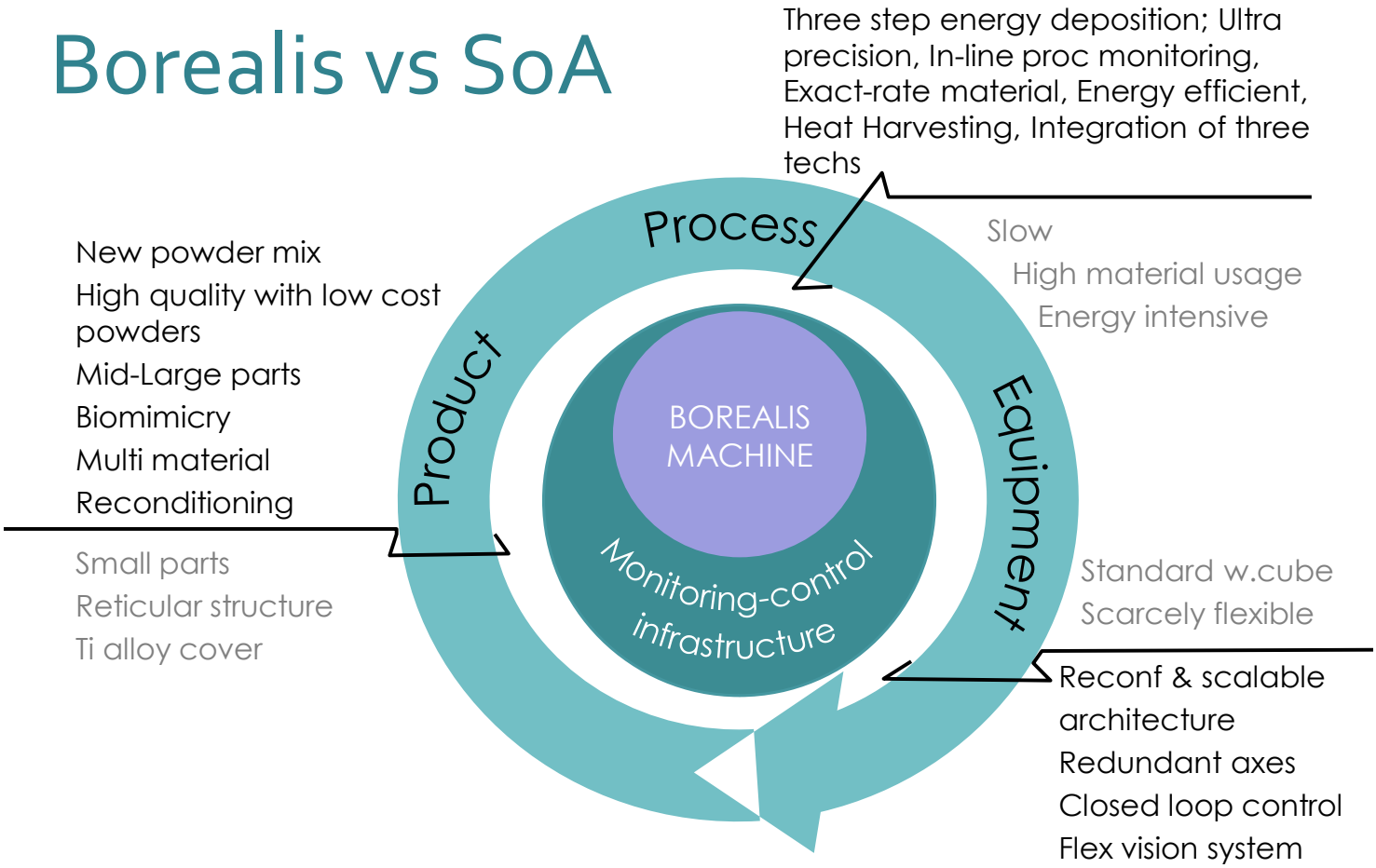
BOREALIS

Enlightening Next Generation of Material

Project brochure

Advanced concept of **flexible machine** for new **Additive Manufacturing** and Subtractive Manufacturing processes on next generation of complex **3D metal parts**.

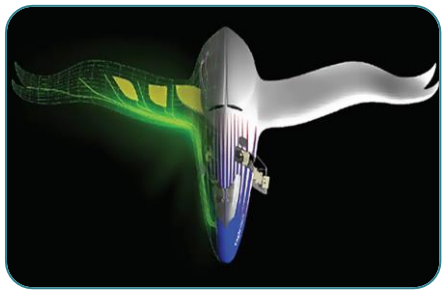
Borealis vs SoA



Applications

Borealis machine is specifically conceived for industrial sectors that suffer extremely high manufacturing costs because of part complexity and low volumes, and the prohibitive cost of raw materials.

As a result, Borealis project focuses on the **medtech, aerospace** and **automotive** sectors as major target.

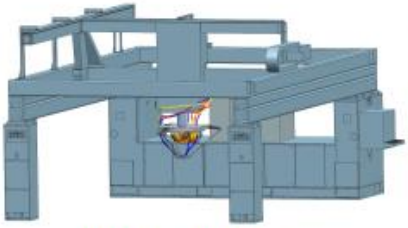


Concept and Approach

Machine Architecture

The Borealis machine will be conceived with a redundant structure integrating a large gantry portal with a processing head constituted by a Parallel Kinematic Machine PKM

Lab scale demo
2015



Full size Prototype
2016

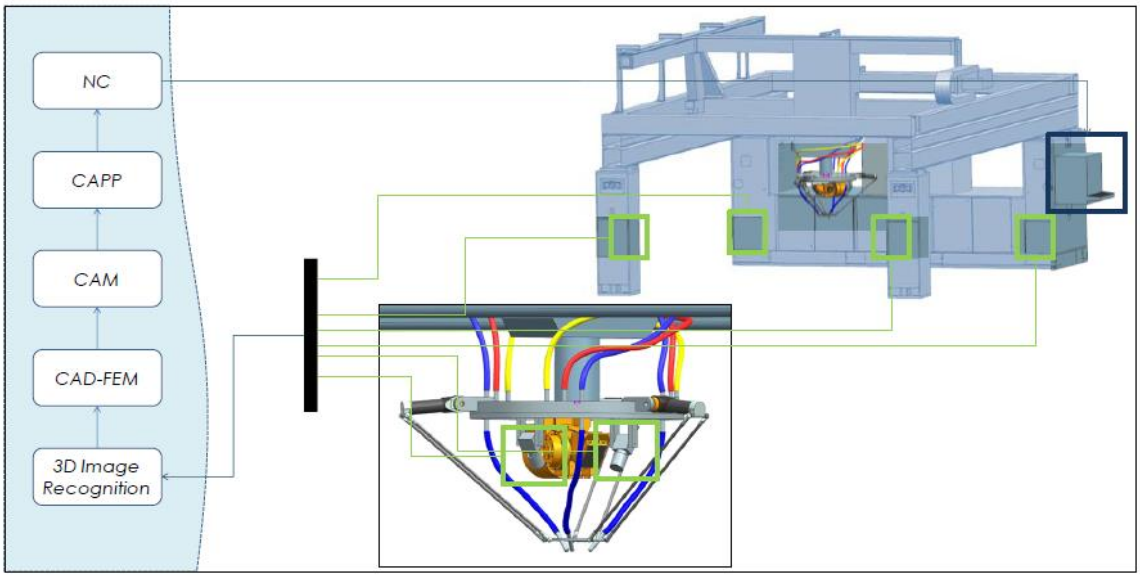
Industrial solution realization
2017-18

Market Catalogue Machine
2019

Integration of Multiple AM Techs and Heterogeneous Powders

Process	Definition	Material
Material Jetting	Plasticized and liquid droplets of build material are selectively deposited	Metal, Metal composites
Binder Jetting	Liquid and/or gas bonding agent is deposited with powder material	Metal, Metal composites
Powder Direct Energy	A thermal energy beam fuses material by melting the material powder as it is being deposited	Metal
Ablation	Material removal by locally melting the metal material	Metal

Software Infrastructure



Objectives

Borealis general objective is to exploit a decade of advanced R&D results in mechatronics and laser processing to demonstrate a novel machine that will produce, at unprecedented throughput and efficiency, in true net shape, with closed loop controlled and certified quality, large and complex products.

BOREALIS technical objectives are grouped into three key innovation actions:

Innovation action for **processes**:

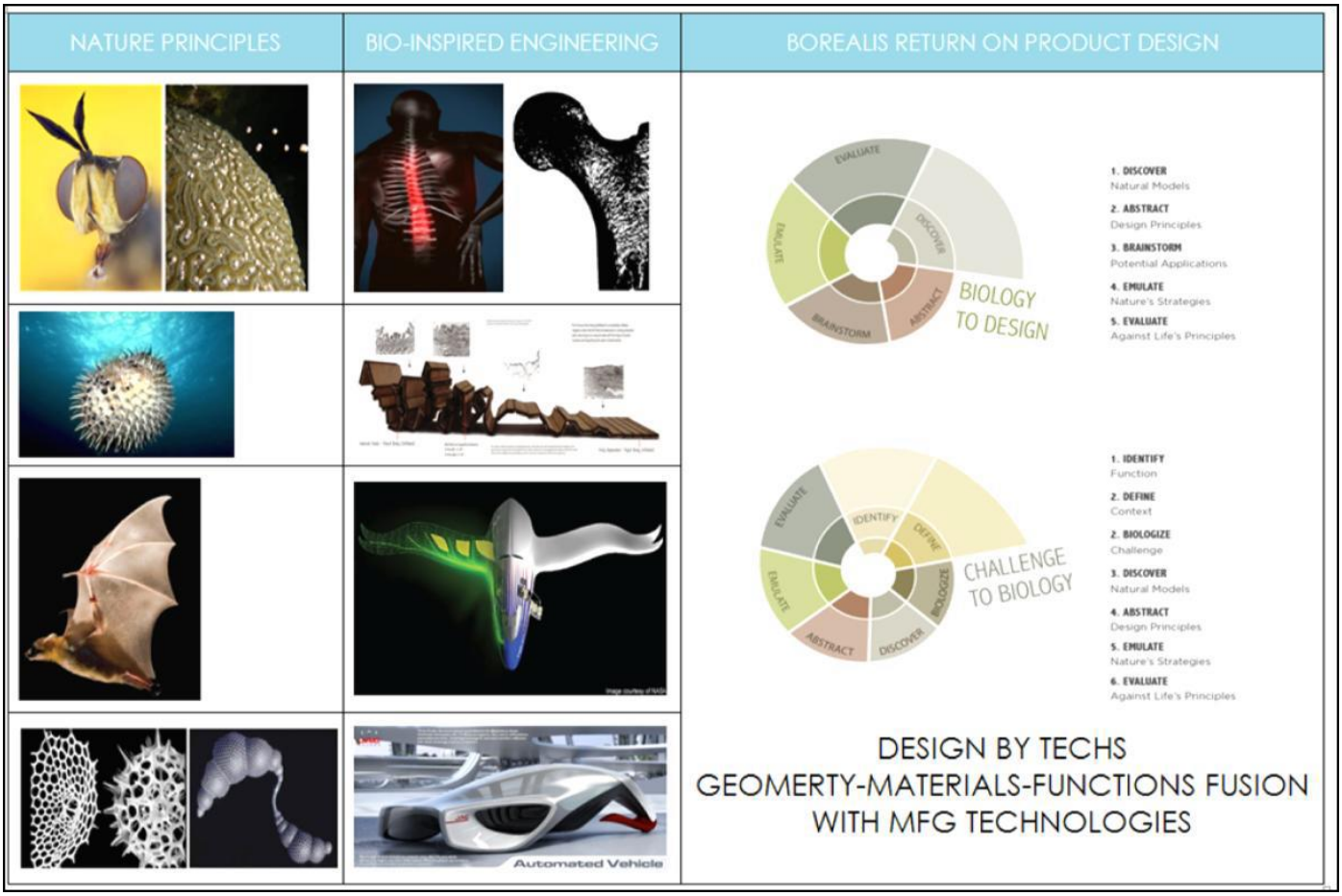
- Borealis will deliver **true-net-shape** products through a **one-step process with -75% material usage and energy efficiency (-40%)**
- For the first time **ablation technology will complement the AM fabrication process**
- Borealis will enable blending **micro and nano powders of different materials**
- Borealis machine and software infrastructure will lead to **zero defect manufacturing**

Innovation action for **equipment:**

- Borealis will be able to accommodate **extremely variable working cubes and deposition areas**
- Borealis will integrate multiple AM technologies to combine the most productive alternative with the most precise one with **zero set-up time** and **zero material waste**.
- Borealis will **minimize powder losses** by guaranteeing a controlled atmosphere
- Borealis will offer the **highest throughput rate (2000 cm3/h) with unprecedented surface quality (submicron rugosity)**

Innovation action for **product:**

- Borealis will make possible the manufacturing of a new generation of products with **complex reticular shapes and multi-material / functionally graded structures in high production rates**.
- Borealis will allow the dynamically reconfigurable blending of powders of metal alloys and metal composites therefore **enabling new functionally graded design concepts**



Borealis product design general principles

Ambition and KPIs

The Borealis projects addresses a number of challenges, the design of the process chain and its realization in Borealis will represent an enormous jump beyond the state of the art under two major perspectives:

- achievement of cutting edge manufacturing thresholds of accuracy, reliability and speed;
- need to dynamically manipulate and shift the technology, process parameters and manufacturing strategy (thus the machine dynamic asset) in real time by inferring the environment and deploying a reasoning process leading to the best configuration solution on-line.

Impact of Borealis on new generation **aerospace, medtech and motorsport** complex products

Category	KPI	Borealis target	SoA Benchmark
	On the matter of machine quality		
Superficial product quality	Superficial roughness	< micron	1-10 micron
Structural performance	Ratio of a specific property (density, fatigue, tensile, etc) / the same property with SoA technology	100%	95 – 100 %
Out of control parts	% faulty parts	0	60%
Time to build	The standard 125 mm cube	12h at 0.05 detail capability	24h at 0.3 detail capability
Buy to fly	Bought material / product weight	Process economically convenient for BTF>3	Process economically convenient for BTF>10
	On the matter of material efficiency		
Material usage	Product weight / material used	95%	5% in powder bed to 70% in material jetting
Powder usage efficiency	melted powders / input powders	90%	<70%
Overall energy consumption in AM	Energy consumption per kg deposited	80 MJ/kg	144 MJ/kg
Overall energy consumption in Ablation	Energy consumption per kg subtracted	60 MJ/kg	144 MJ/kg
Deposition rate	Rate amount of material deposited for unit of time	15 kg/hour	< 5 kg/hour

Ambition and KPIs

Impact of Borealis on efficient **additive manufacturing and laser based subtractive manufacturing** sectors

Category	KPI	Borealis target	SoA Benchmark
On the matter of process efficiency			
Laser efficiency	Wall-plug efficiency	>30%	25%
Beam spot (3kW)	Min max focus spot size	0.02 to 4 mm	0.1 to 3 mm
Laser effectiveness	Optical intensity	10^4 to 10^8 W/cm^2	10^3 to 10^6 W/cm^2

Impact of Borealis on **next generation of machinery**

Category	KPI	Borealis target	SoA Benchmark
On the matter of machine efficiency			
Machine reliability	Downtime per unit of time	1%	5-20%
Machine throughput	N° parts per unit of time	14.25 Kg of processed material per hour	2-5 Kg of processed material per hour
Machine versatility	N° embedded techs	5	< 2
Machine flexibility	Machine working cube	Up to 4,5x2,5x1 m	Up to 0.5x0.5x0.2 m
Machine accuracy	Maximum error machine	0.5 micron	50 micron
Machine set-up times	Time to change from one production batch to the following using a different technology	2 min	20 min
Green labelling	Carbon footprint assessment	Best practice in AM	Does not exist
Monitoring and optimization	Number of reworks after the final production quality check	0	50-80%
Reactivness of Borealis Software Infrastructure	Capability to perform fast and accurate diagnosis of anomalous deposition or ablation of material	CNC cycle time	OFF-line
Self resilience of the machine	Prognosis capabilities of the Borealis software infrastructure	CNC closed loop adaptation	Open loop

Impact

Borealis **Scientific impact**

- Introduction of a **high energy efficient hybrid laser source module**
- Integration of **highly heterogeneous fabrication technologies**
- **Design and Management for Lifecycle resource efficiency**
- **Adaptive monitoring, CAx chain and control**
- **Intelligent behaviour and optimization strategies**.

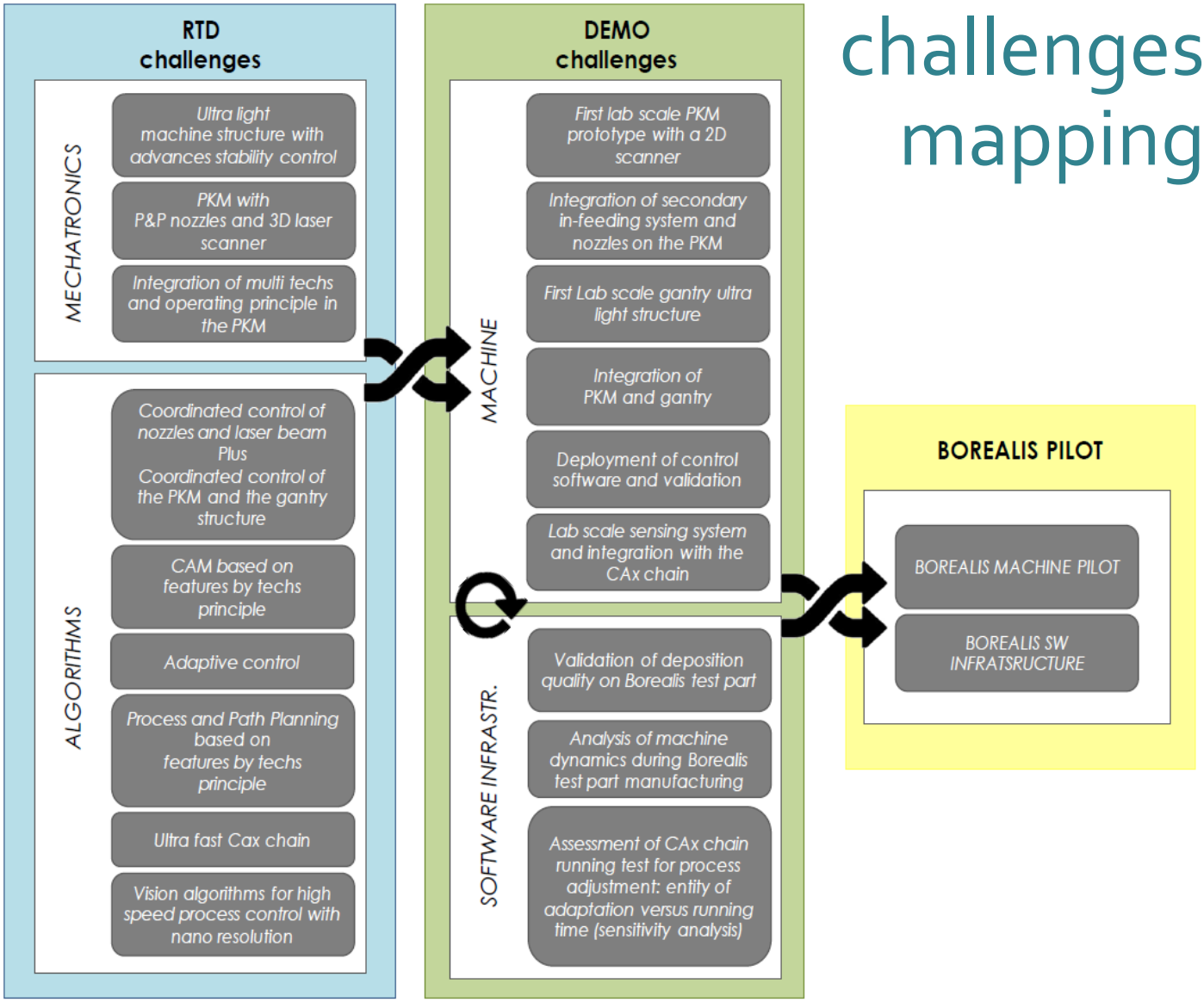
Impact of Borealis on **carbon footprint**

BOREALIS project will be implemented by minimizing all activities which are known to cause direct or indirect emissions of greenhouse gases. A CO_2 emission assessment will be carried out for each activity, form the beginning of the implementation to its end to take into account the CO_2 emitted during the project

Ecolabelling

The Borealis machine is meant to become the **industrial best practice in energy efficient manufacturing of aerospace, medtech and automotive products**.

Borealis challenges mapping



Borealis overall strategic work plan

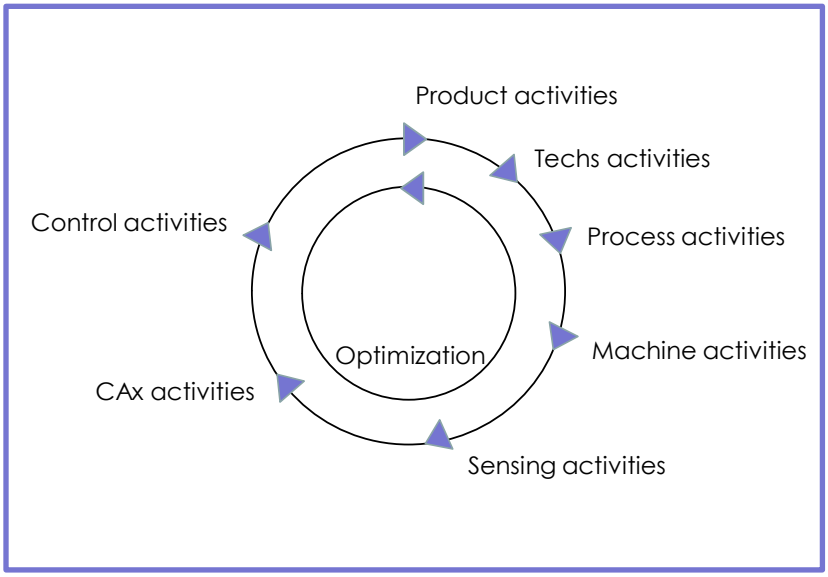
WP 11 DISSEMINATION & EXPLOITATION

WP 1 PROJECT MANAGEMENT

WP 2 PRODUCT-TECHS REQUIREMENTS

WP 8 ADAPTIVE AUTOMATION & NC	WP 3 PROCESS DESIGN & PLANNING
WP 7 INTEROPERABLE CAx CHAIN	WP 4 DESIGN OF LASER SOURCE AND 3D SCANNER
WP 6 RECONFIGURABLE VISION SYSTEM	WP 5 DESIGN OF MACHINE ARCHITECTURE & EFFICIENT MECHATRONICS

WP 9 MONITORING & OPTIMIZATION



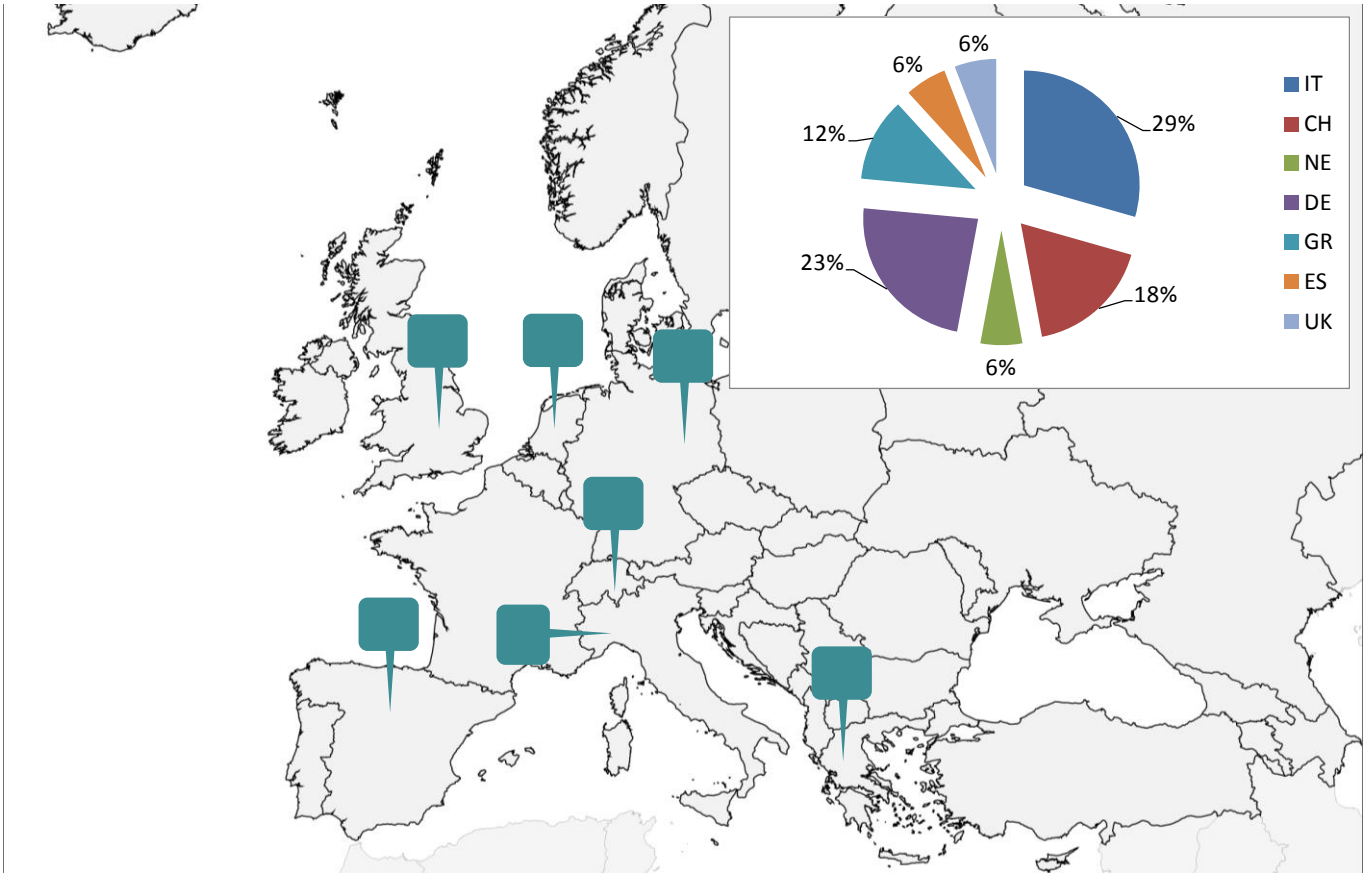
WP 10 DEMONSTRATION MEDTECH-AEROSPACE-AUTOMOTIVE

In order to guarantee the achievement of Borealis objectives and to efficiently manage related project complexity, a coherent work plan, over 3 years, has been developed. It is organized in 11 work packages clustered in *Project Management*, *Scientific and Technical*, *Demonstration* and *Dissemination and Exploitation activities*.
Particularly, the RTD activities will map the Borealis solution development lifecycle from the product and technologies design phases to processes and equipment design phases till the data acquisition, control and optimization phases.
Specifically:

- WP1 aims at managing the overall project activities
- WP2 refers to the study of the next generation of products design and the fusion of manufacturing technologies
- WP3 covers the activity of process design and planning
- WP4 deals with the design and configuration of the laser source and the 3D scanner
- WP5 regards the configuration of the Borealis machine
- WP6 addresses the design of the sensing system
- WP7 outlines the design and development of the first of three step Borealis software infrastructure
- WP8 pertains to the second of the three step Borealis software infrastructure
- WP9 relates with the Borealis solution integration along with the last step of Borealis software infrastructure that is the overall optimization
- WP10 refers respectively to the development of one physical demonstrator and one lab demonstrator for the medtech, aerospace and automotive industries.
- WP11 ascertains an extensive dissemination and exploitation activities with the aim of boosting Borealis industrial solutions in future industrial practice.

Consortium

Excellence in their respective fields of expertise has been the guiding principle in assembling the Borealis team. The high number of challenges dealing with the product design, the process design as well as the Borealis solution development motivates the large consortium constituted by 18 players from different Countries.



SYSTEM INTEGRATOR	• PI will integrate the various modules of the machine
TECHNOLOGY PROVIDERS	• Globotics will provide the PKM structure along with the secondary ejecting system (nozzles) • Irida will provide the image recognition software environment and algorithms • Framos will provide the vision system equipment • PI will provide the 3D scanner head • OPI will provide the ultra-short pulse laser source, will integrate the two laser sources in one advanced combined laser system, and will collaborate to the development of the 3D scanner head. • PE will provide the entire PLM Platform and the CNC development environment along with the control software for redundant control • Synesis will provide the automation platform and the middleware infrastructure
END USERS	• AVIO will support the development of aerospace production scenario by sharing information about specific families of space and aeronautic parts • Sintea will support the development of medtech production scenario by sharing information about specific families of prosthesis • Diad will support the development of automotive production scenario by sharing information about specific families of gear box

CONSORTIUM

Prima Power

TNO innovation for life

Avio

Scuola universitaria professionale della Svizzera italiana
SUPSI

Fraunhofer ILT

LMS Laboratory for Manufacturing Systems & Automation University of Patras

Politecnico di Torino

OPI Photonics

IRIS

Prima Electro

Synesis

DIAD GROUP ES

+sintea SMART
EXPLOITING MATERIALS INTELLIGENCE

IRIDA LABS

FRAMOS

Globotics Industries