Italian Aerospace Research Centre

Carmine Pirozzi

Nanoinnovation conference and exhibition 2016: ALM activities for space and aeronautics at CIRA

Italian Association for Industrial Research Roma, 20-21-22-23 Settembre 2016

OUTLINE

- ***CIRA IN BRIEF***
- ***THE ADDITIVE LAYER MANUFACTURING ACTIVITY AT CIRA***
  - EBM Technology – The CIRA equipment
  - Powder Materials
  - On going Funded Project
- ***QUALITY ASSURANCE***
  - *Process validation tools: process monitoring and control*
  - *EBM Process Parameter Optimization (OPPLA Project)*
  - Product validation
- ***TECHNOLOGICAL CHALLENGES***
  - *Design*
  - *Materials*
  - Machine
  - Post Processing

CIRA IN BRIEF

In 1989, the Italian Government entrusted CIRA the management of the Italian Aerospace Research Program (PRORA). CIRA performs PRORA management under the control of Ministry of Research (MIUR).

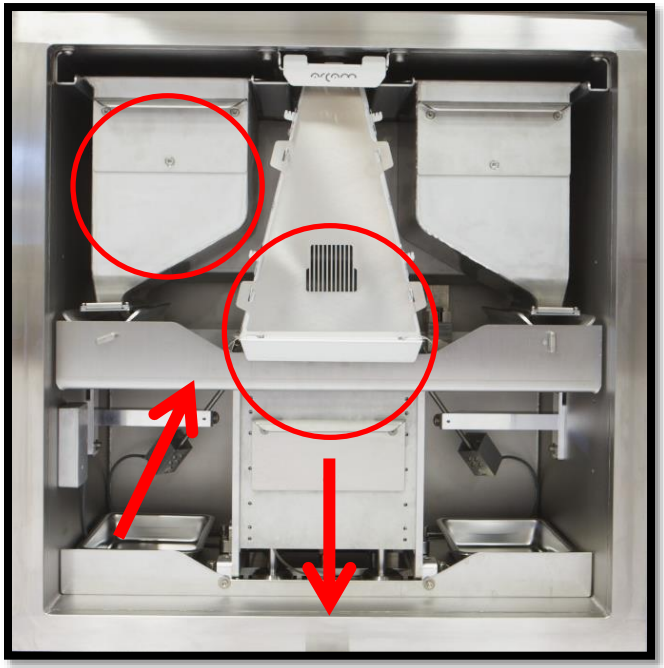
A non-profit public-private partnership among:

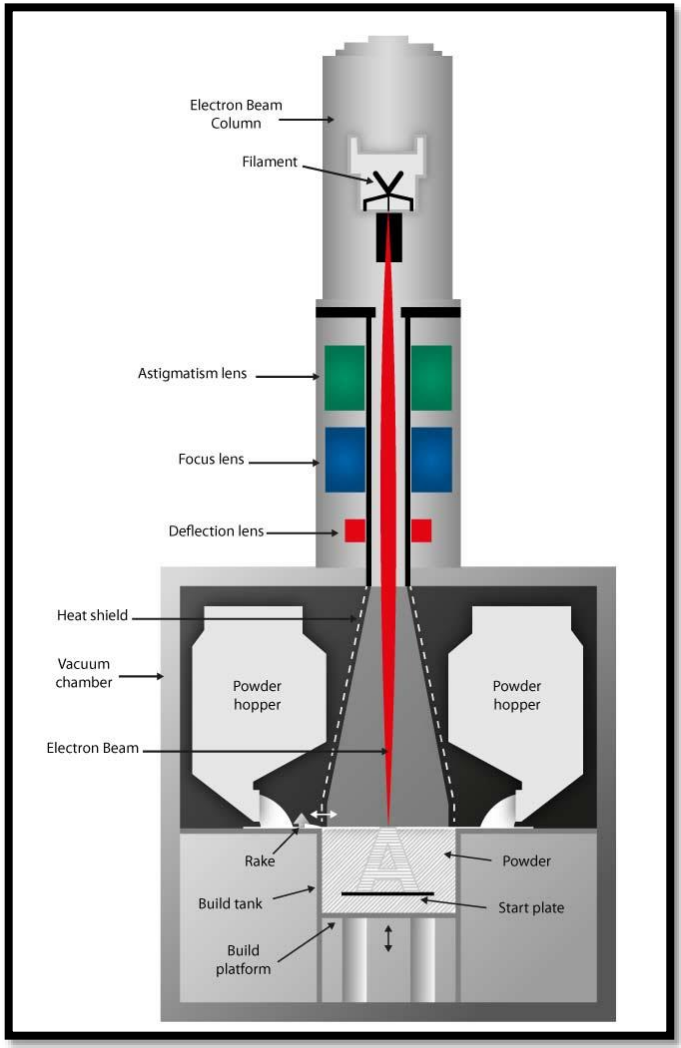
- ASI (Italian Space Agency) - 47%
- CNR (National Council for Research) - 5%
- Campania Region - 16%
- Italian Aerospace Industries - 32%

370 employees
and approx. 50 university students and PhD candidates a year

EBM TECHNOLOGY – THE CIRA EQUIPMENT

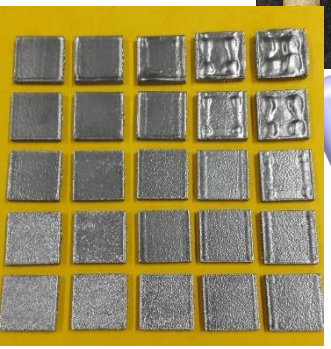
- The CIRA PRMM Lab is equipped with a “large capacity” **EBM machine** (ARCAM A2X)
- **Actual build envelope**: 210 x 210 x 380 mm (W/D/H)
- **Power**: up to 3.500 W
- **Power density**: 106kW/cm^2
- **Vacuum Process Clean & controlled environment** (10^{-4} mbar)
- **Hot Process**: Designed to process titanium alloys as well as materials that require elevated process temperatures





ADDITIVE LAYER MANUFACTURING ACTIVITY AT CIRA

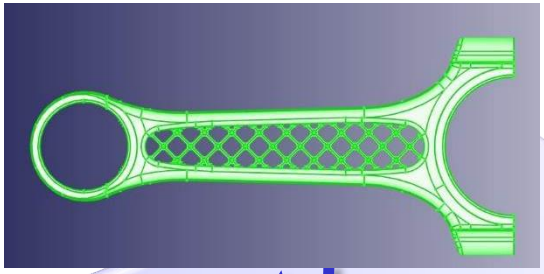
The research activities are focused on **Additive Layer Manufacturing** and in particular to the **EBM technology**



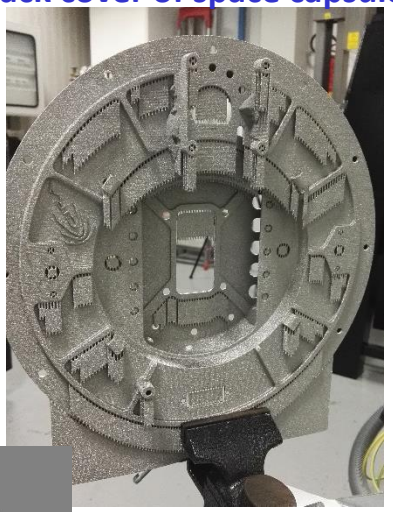
Samples for microstructural and mechanical tests, surface and dimensional characterization.

Injector mock-up

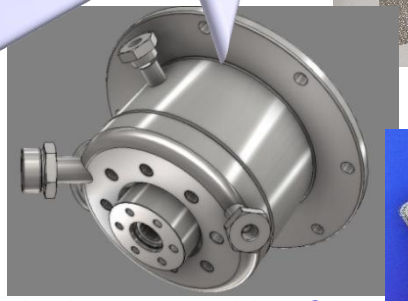
Connecting Rod



Back cover of space capsule



Shape complexity



Back plate assembly of the injection head of space engine

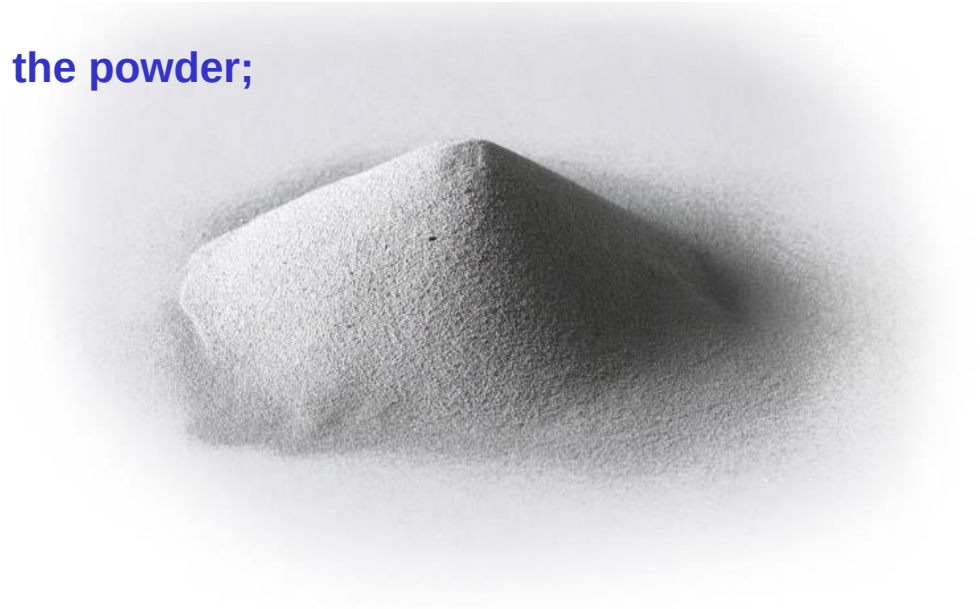
Satellite antenna filter

Convergent-divergent mock up

POWDER MATERIALS

Arcam

- **has developed the process parameters that match the powder;**
- **has qualified and verified the material;**
- **guarantees the powder quality;**
- **has established a validated supply chain.**



Titanium Grade 5 **Ti6Al4V**
Titanium Grade 23 **Ti6Al4V ELI**
Titanium Grade 2 **Pure Titanium**
Cobalt-Chromium **(ASTM F75) - CoCr**

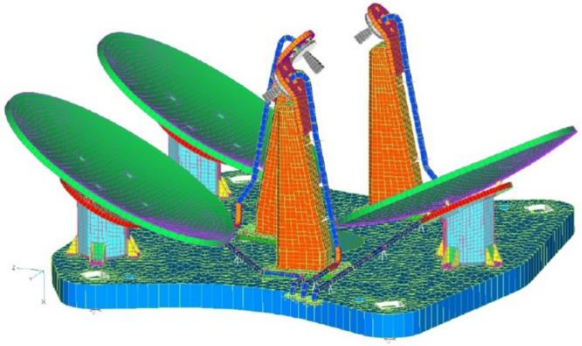
Recently Arcam launched a Nickel Base Superalloy process for Additive Manufacturing with Arcam's EBM systems. The Inconel process is initially available for the Arcam A2X platform (the same as that of CIRA PRMM Lab).

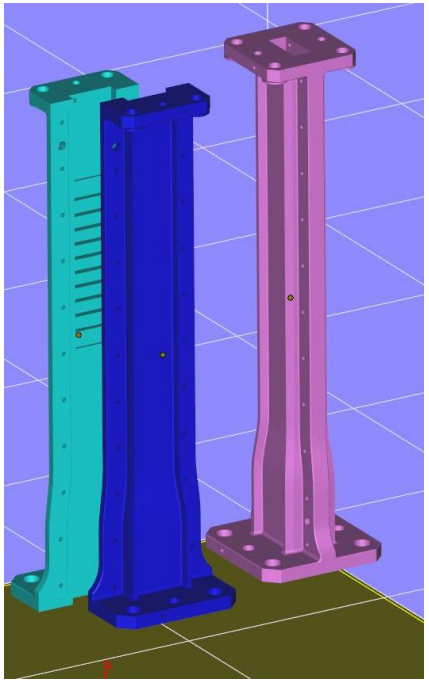
BUT THERE ARE MANY INITIATIVES AROUND THE WORLD AIMING AT NEW MATERIALS TO USE

ON GOING FUNDED PROJECT: THE ISAA PROJECT

The **ISAA Project** is funded by **ESA** (CIRA is a subcontractor of Space Engineering spa)

***ISAA**: **I**maging antenna **S**ystem based on **A**periodic feeding **A**rrays*





OBJECTIVE

The main objective is to demonstrate the performance of an innovative **Imaging Antenna system** for satellite applications including the manufacturing and testing of critical elements (waveguides, horn, etc.).

AM OPPORTUNITIES

- Innovative design reducing assembly;
- reduced manufacturing time;
- less post-processing.

Half shell to be assembled

Monolithic waveguides

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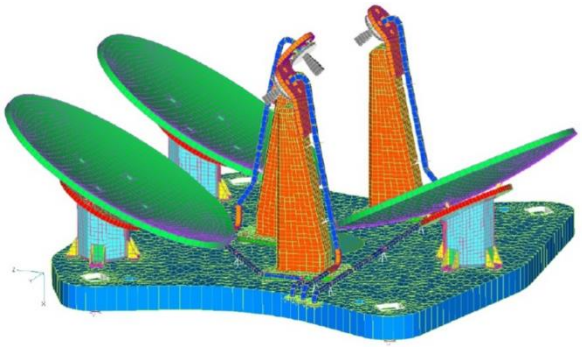

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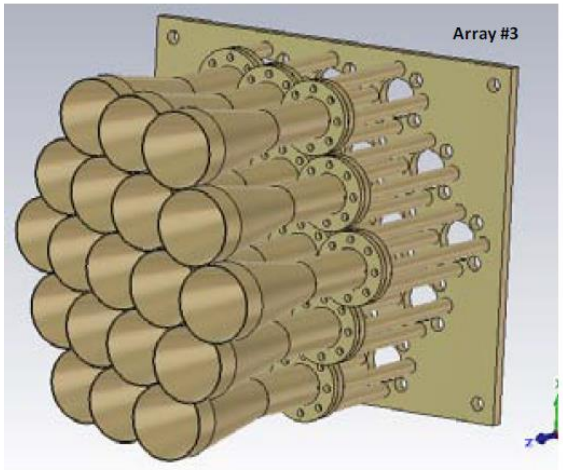
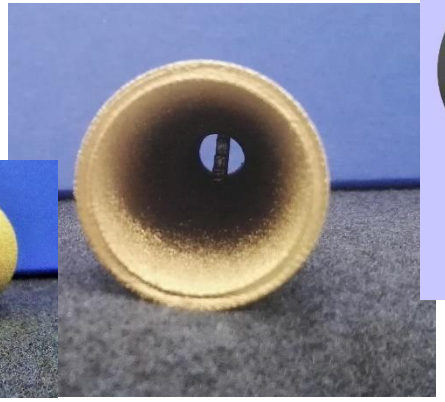
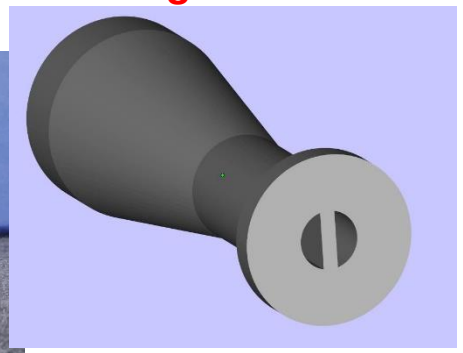
Array configuration



Single horn



Single horn



ON GOING FUNDED PROJECT: THE HYPROB PROJECT

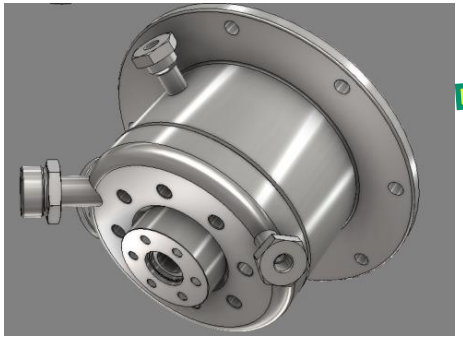
The **HYPROB Project** is funded by **MIUR** through the National Aerospace Research Program (**PRORA**).

OBJECTIVE

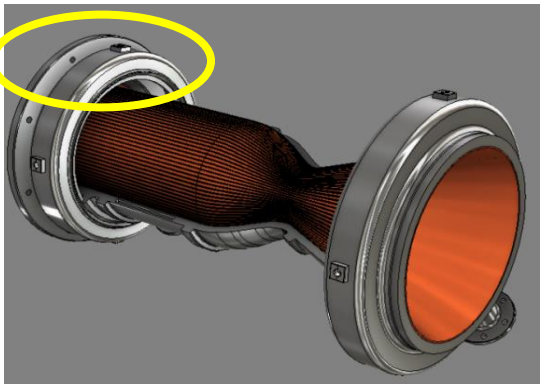
Design, manufacture and testing of ground demonstrator (**L0X/LCH4 engines**) for spatial propulsion system

AM OPPORTUNITIES

- Reducing Manufacturing costs of critical parts (back plate assembly of the injection head)



Back plate assembly of the injection head



Rocket engine demonstrator

CIRA CHALLANGE

Manufacturing of the whole **Regenerative cooled thrust chamber** in Ti6Al4V with a monomaterial and monolithic innovative design (no need for brazing)

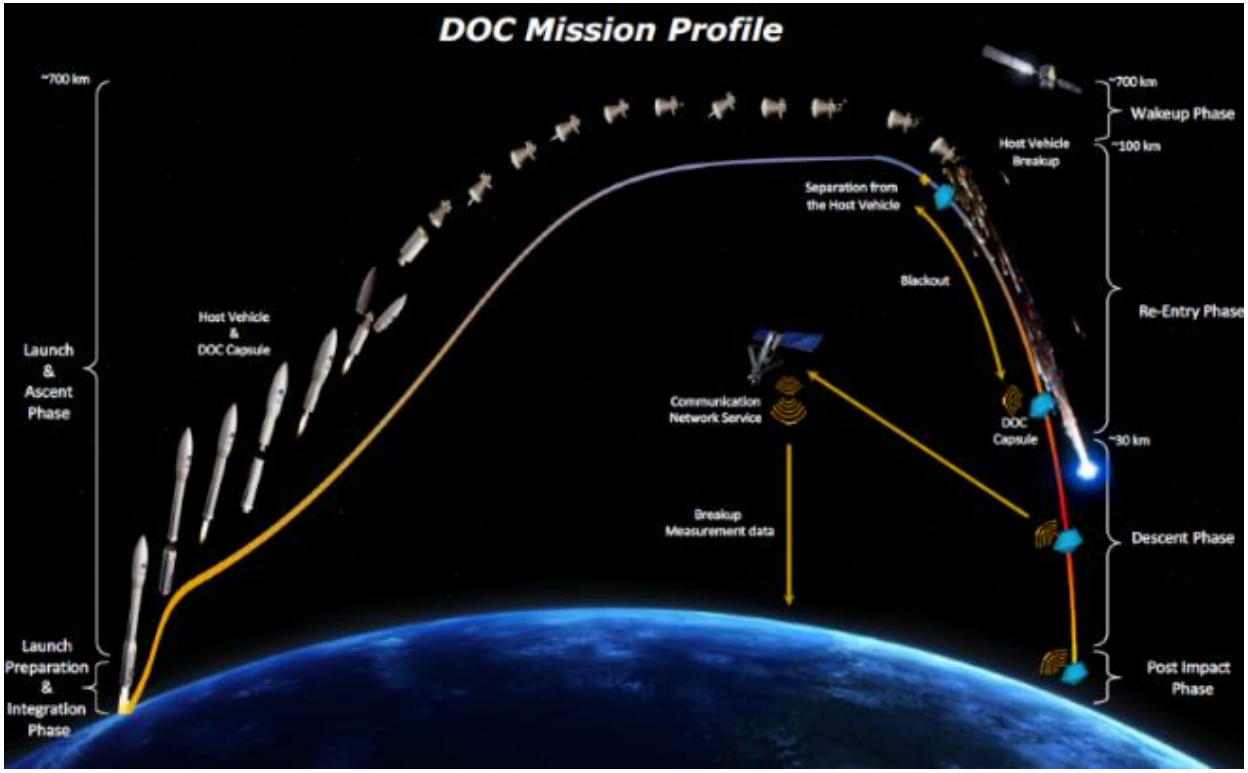
Convergent-divergent mock up

ON GOING FUNDED PROJECT: THE DOC PROJECT

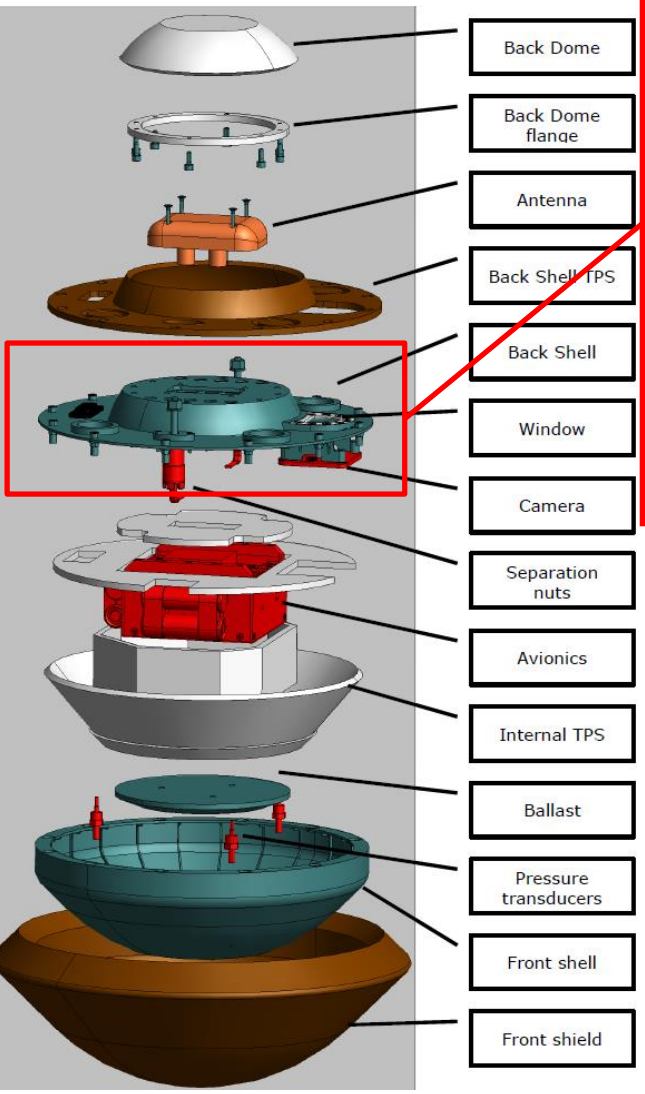
The DOC (Demise Observation Capsule) Project is an ESA Project.

OBJECTIVE

Collect important information about the re-entry process of VEGA launcher stages in order to accurately predict break-up altitudes, debris trajectories and ground impact footprint.



ON GOING FUNDED PROJECT: THE DOC PROJECT



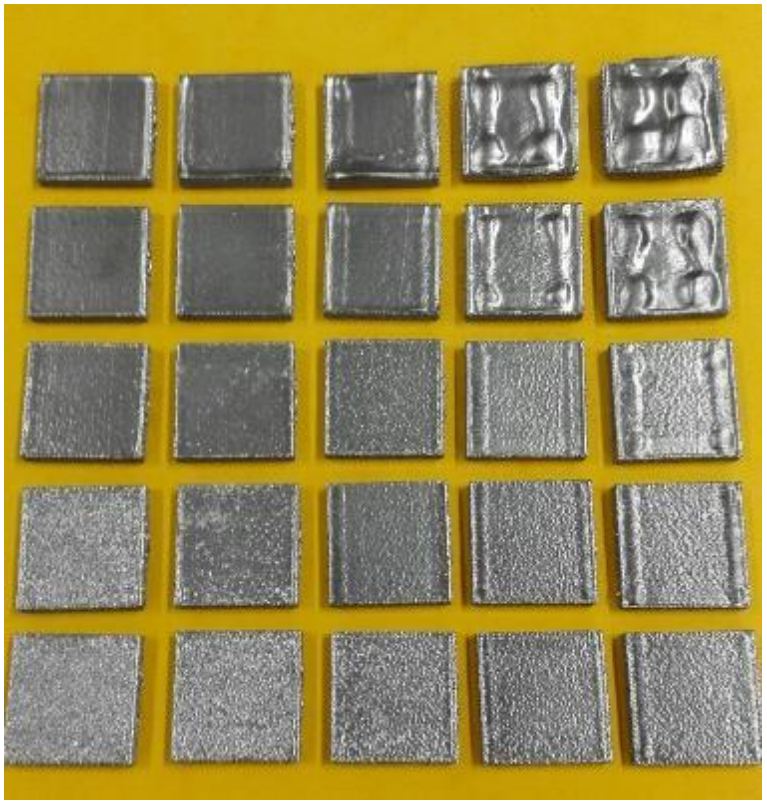
AM OPPORTUNITIES

- Design and manufacture the **Back cone of the space capsule** in Ti6Al4V. It is the most important structural part. It connects the host vehicle to the frontal shield and to the avionics.
- **Reduce the amount of parts** (simpler integration, less FEM modelling uncertainties, more complex shape)
- **Less machining post-processing** (Use of threaded inserts, Design hexagonal receptacles in the body parts)
- **Increase efficiency** (Extensive use of rounding, whatever radius, add stiffeners just where needed)

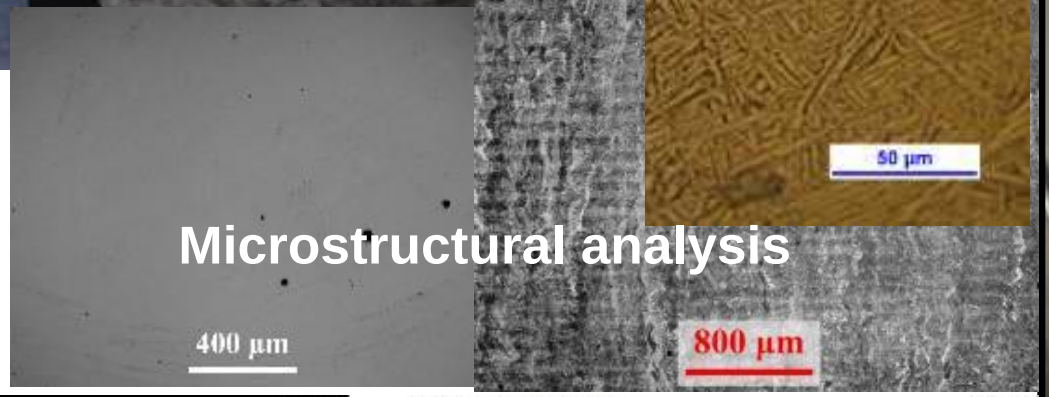
EBM Process Parameter Optimization

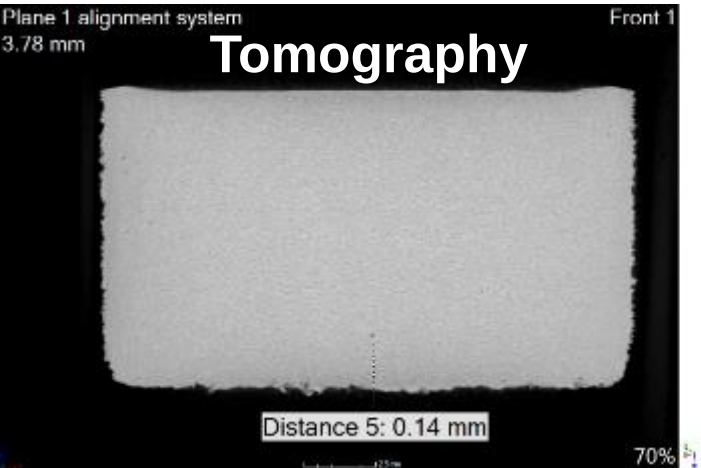
OPPLA (PRORA Project)

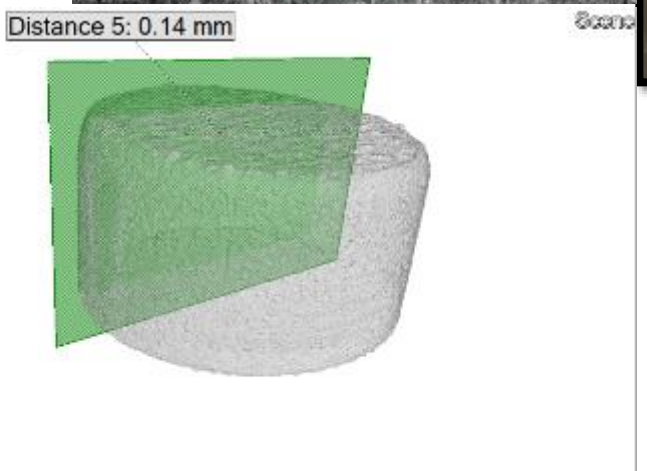
EBM process is a complex procedure depending upon different processing parameters.
The final microstructures of EBM built are the result of complex combination of different processing parameters.
Our goal is to estabilish the process parameters influence on the microstrucutral properties, geometrical and dimensional tolerances and roughness surfaces.

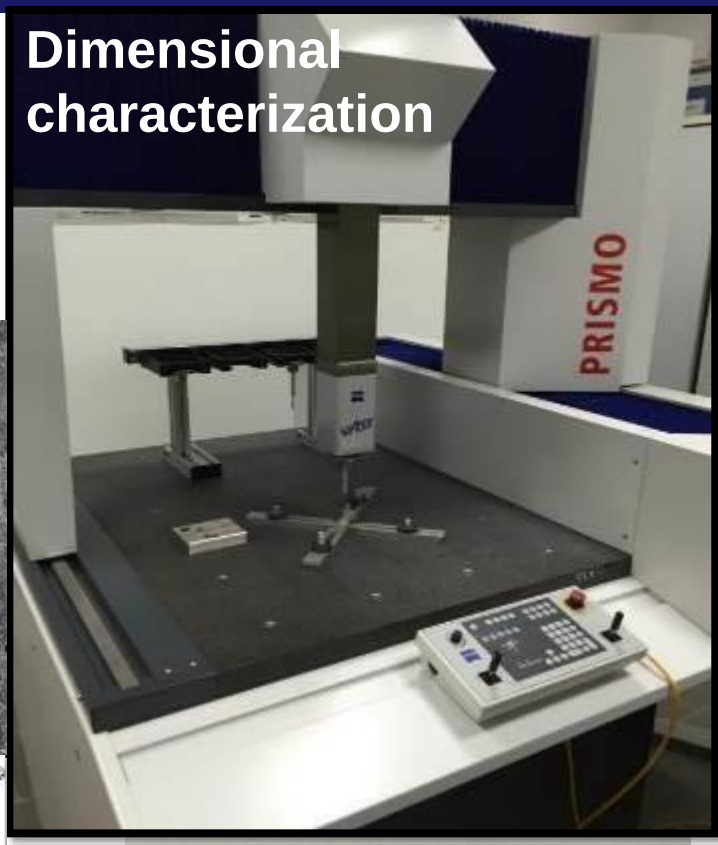


PRODUCT VALIDATION









Arcam LayerQam and Arcam xQam

Arcam LayerQam is a high resolution camera system for powerful defect detection. It tracks porosity layer-by-layer and reports defects in the entire build and individual components.

Frequent high precision calibration is crucial for a robust and predictable operation. **Arcam xQam** is a unique, built-in X-ray detection system, you can rely on quick, high precision autocalibration and system diagnostics that is completely operator independent.

This new functionality will position Arcam xQam for future application possibilities for more robust monitoring and validating processes

TECHNOLOGICAL CHALLENGES

Design | Materials | Machine | Post Processing

AM allows to put material directly in the right place instead of removing it only where possible!

Think additive

Optimization topology

- Weight saving
- Improving performances
- Reducing post processing

TECHNOLOGICAL CHALLENGES

Design | **Materials** | Machine | Post Processing

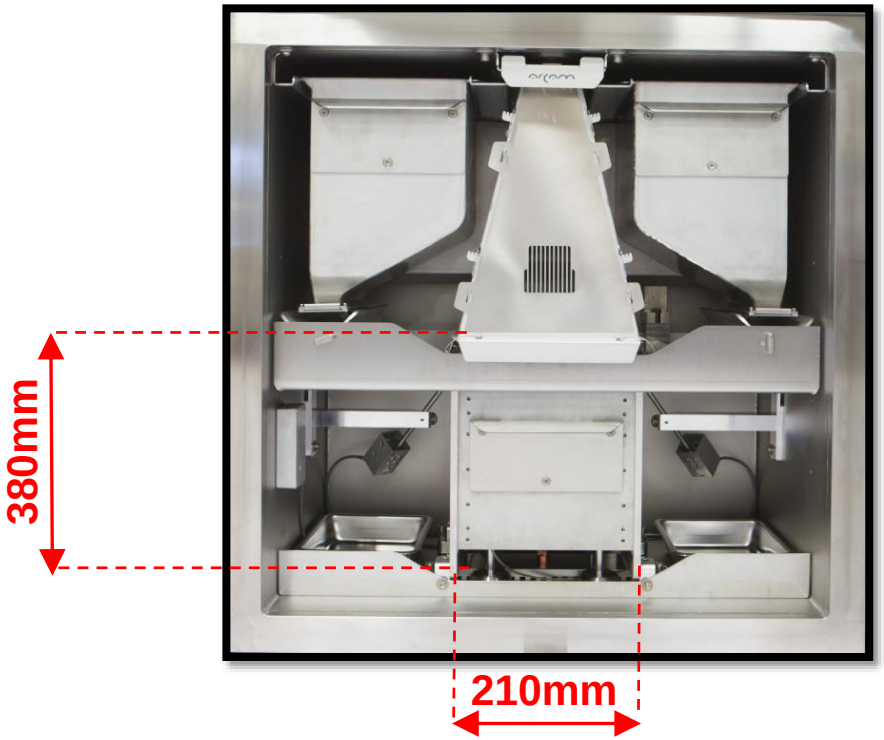
- **Producing machine independent metallic powder in order to reduce feedstock costs.**
- **Orienting the powder metallurgy to optimize the final properties of the alloys used, studying and qualifying new powders ad hoc developed for AM technologies**

TECHNOLOGICAL CHALLENGES

Design | Materials | **Machine** | Post Processing

The maximum **dimensions of printable AM components** produced by Powder Bed Technologies are nowadays limited due to the very small build envelope of modern machine.

Machine with **larger build envelope** need to be designed



TECHNOLOGICAL CHALLENGES

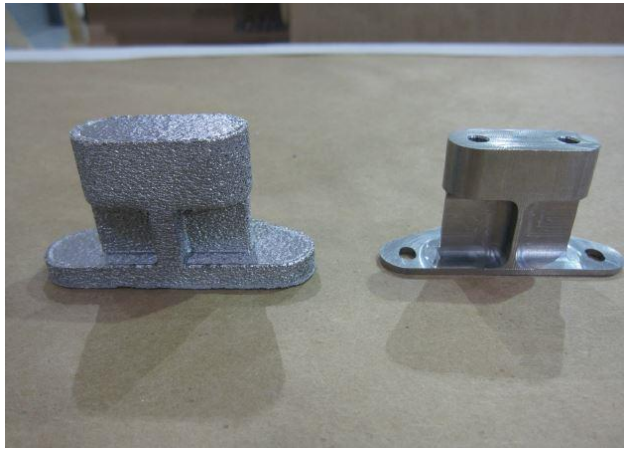
Design → Materials → Machine → **Post Processing**

The maximum dimensions of printable AM components produced by Powder Bed Technologies are nowadays limited due to the very small build envelope of modern machine.

Joining techniques need to be assessed and/or developed

TECHNOLOGICAL CHALLENGES

Design → Materials → Machine → **Post Processing**



Precision engineered parts leave no room for error when it comes to surface treatment. A good finishing state allows to:

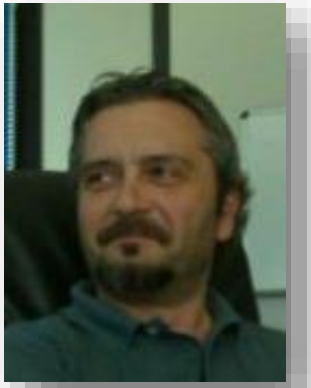
- Increasing resistance to corrosion
- Reducing friction
- Increasing resistance to wear
- Improving aerodynamics

Nowaday **machining** provides the best results in terms of dimensional accuracy and surface roughness. **BUT IT IS NOT STRATEGIC!!!**

INNOVATIVE SURFACE FINISHING AND POWDER REMOVING TECHNIQUES ARE NEEDED

As EBM processed

Thanks for your attention



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