Avio Aero
A GE Aviation Business

Ti based powders supply chain for industrial additive manufacture

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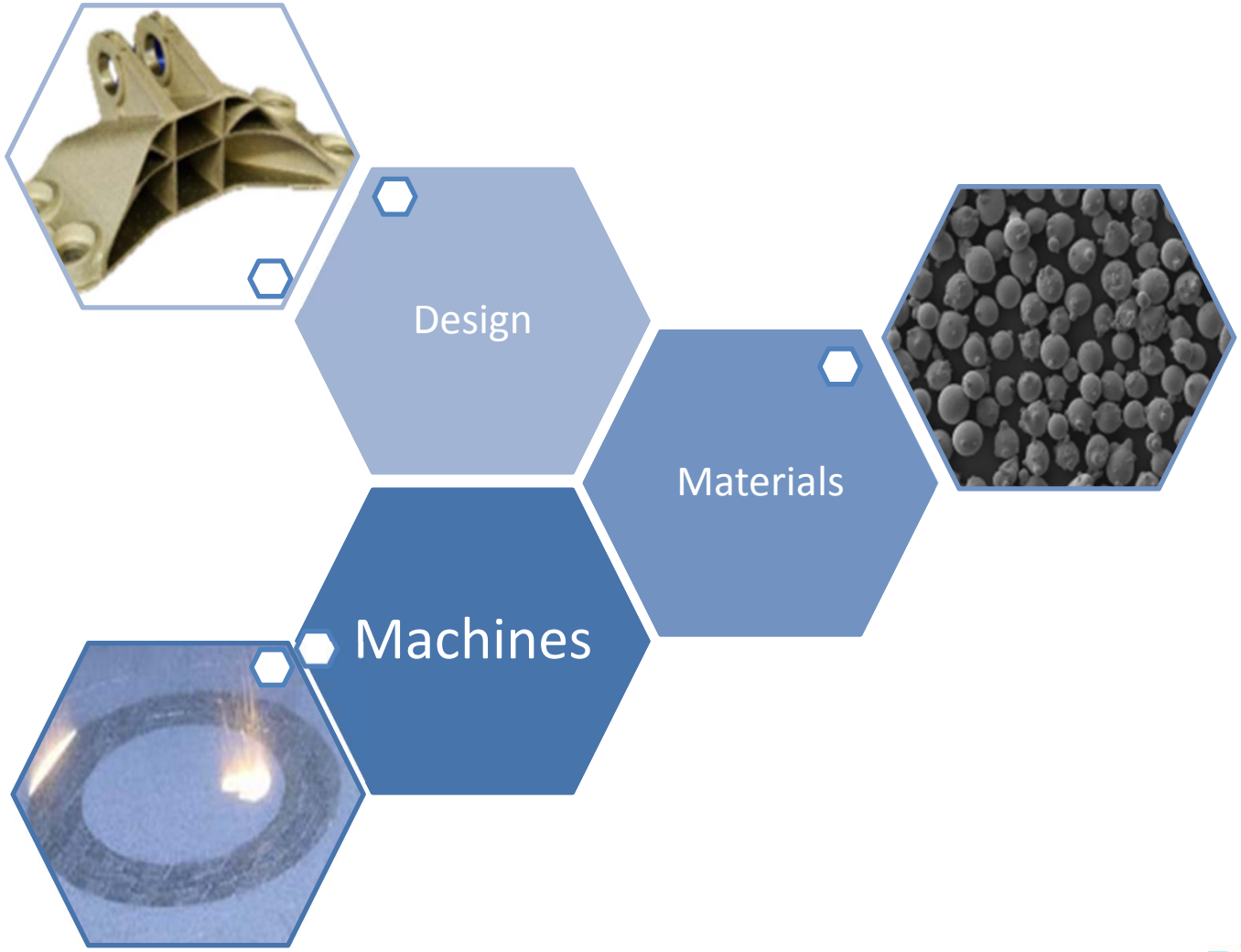
Additive Manufacturing Concept



Design: based on topological optimization

Put material only where it is needed…

- AM allows to put material directly in the right place instead of removing it only where possible
  - no joints, screws and nuts or flanges
  - replacement of 'solid-body' parts with reinforced structures
  - add as many stiffening ribs as required
- Reducing assembly requirements
  - integration of multiple part numbers in one
  - reliability increases: less part count means less unique failure points

Example (GE 3D Printing Design Quest)

Conventional Manufacturing

Original bracket GE asked the GrabCAD Community to redesign via 3D Printing

Weigh: 2,033 grams

Additive Manufacturing

Winner bracket (titanium alloy by EBM process)

Weight: 327 grams (84% reduction)

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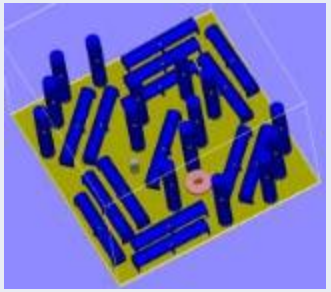
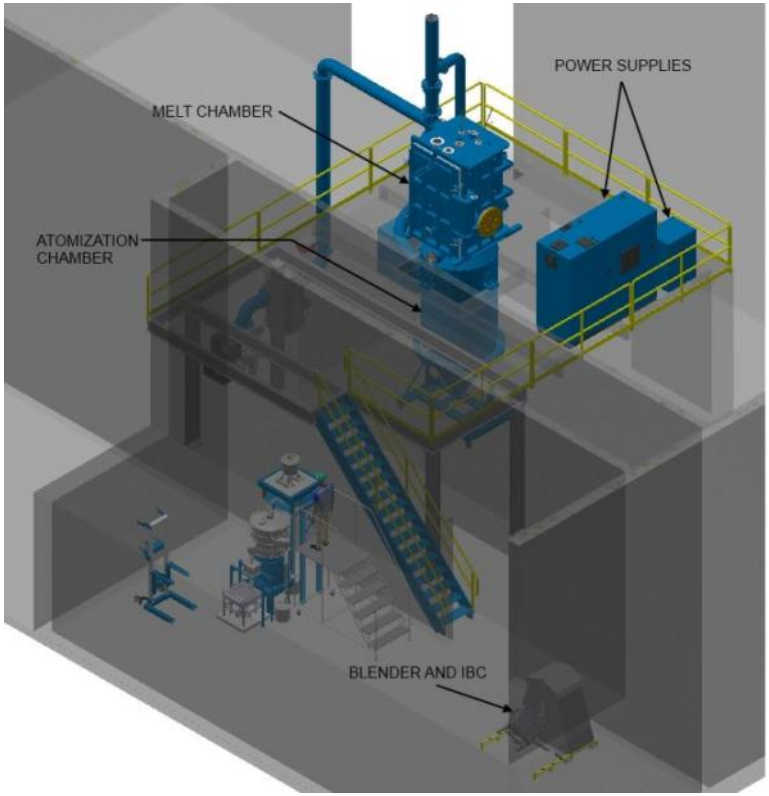
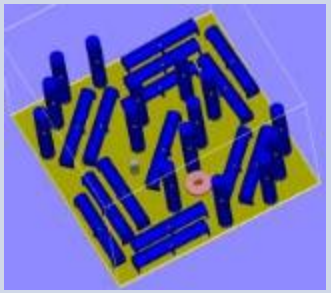
Special process are to be qualified

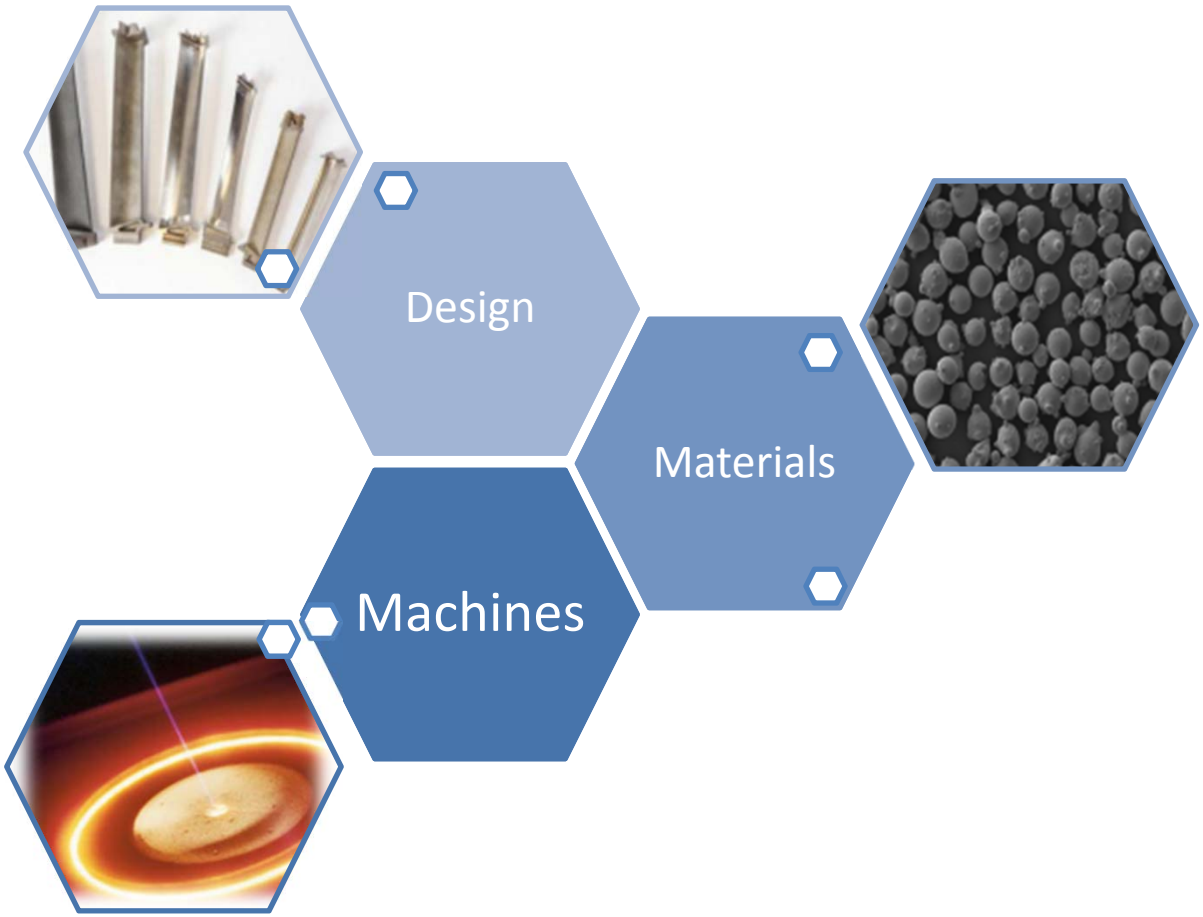
Task	Milestones
1 SYSTEM Qualification	1.1 MATERIALS (powders) 1.2 EQUIPMENT (EBM & DMLS) Calibration 1.3 PERSONNEL Training
2 PROCESS qualification (on specimens)	2.1 MACHINE 2.2 MATERIALS 2.3 PROCESS PARAMETERS 
3 PARTS Qualification (every PN)	3.1 Task 2 + geometry on components and specimen 

Powder atomization to produce powders for AM is a special process to be qualified

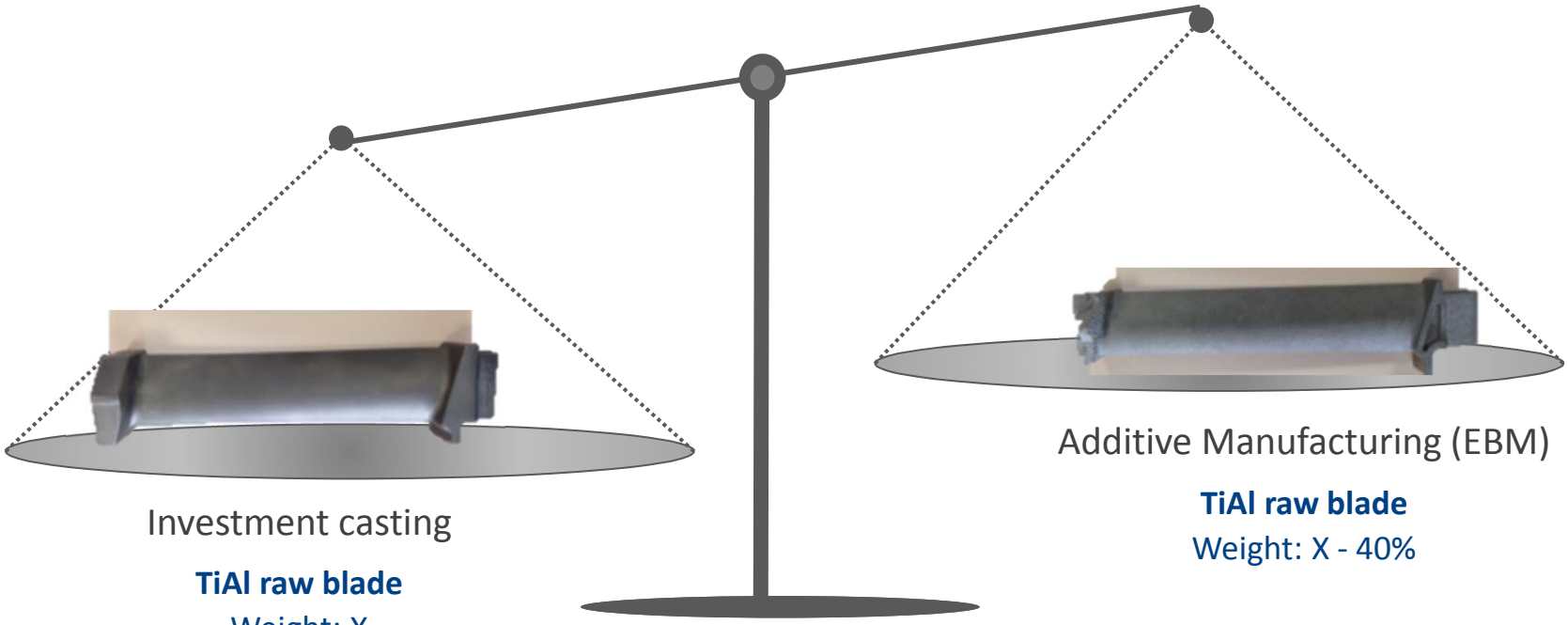


Task	Milestones
1 System	1.1 MATERIALS Suppliers 1.2 SYSTEM Calibration 1.3 SOFTWARE Validation 1.4 PERSONNEL Training
2 Process	2.1 Powder production (procedure in place)
3 Parts	3.1 Specimen production On qualified machines 

Application case: TiAl LPT blades



Application case: TiAl LPT blades: design



Investment casting

TiAl raw blade

Weight: X

Additive Manufacturing (EBM)

TiAl raw blade

Weight: X - 40%

AM allow a drastical reduction on stock material

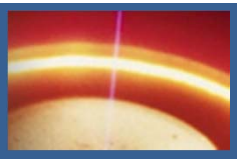
- The row blade cost less
- Machining cost less

Application case: TiAl LPT blades :machines

Avioprop new plant - Cameri (Novara)

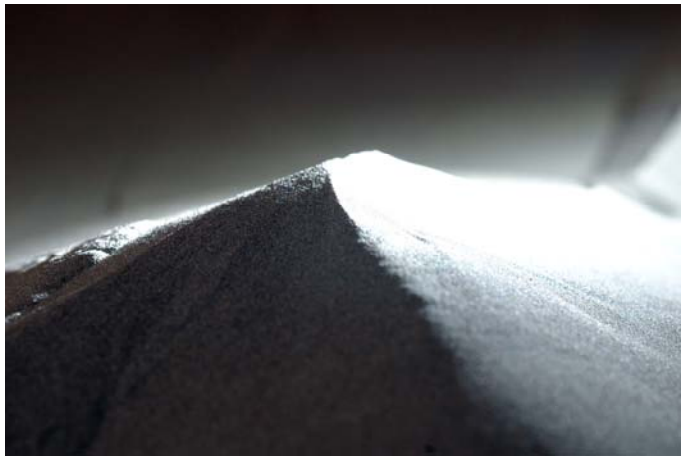
- Built year: 2013
- 12,000 sqft (+ potential 2x)
- Up to 60 AM machines
- AM machines qualified for Aerospace productions
- Lab (chemical, Laser Scan)
- Gas Atomization system

EBM
Electron Beam Melting



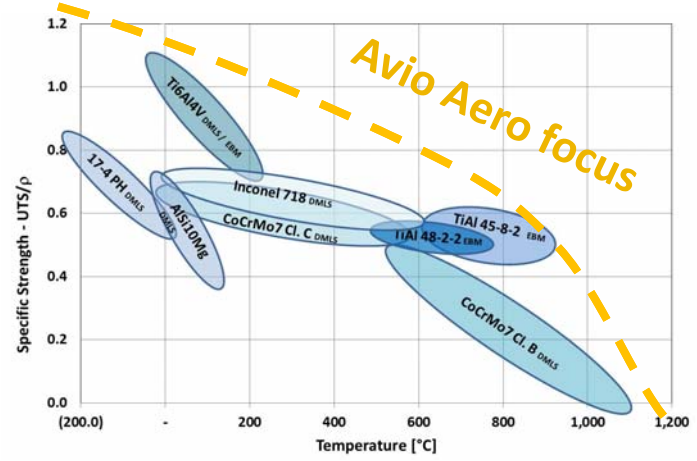
Material choice	• TiAl 48-2-2 • TiAl high Nb
Temperature	Relative hot process (700-1100° C) • Less stress, less distortion • Fine microstructure

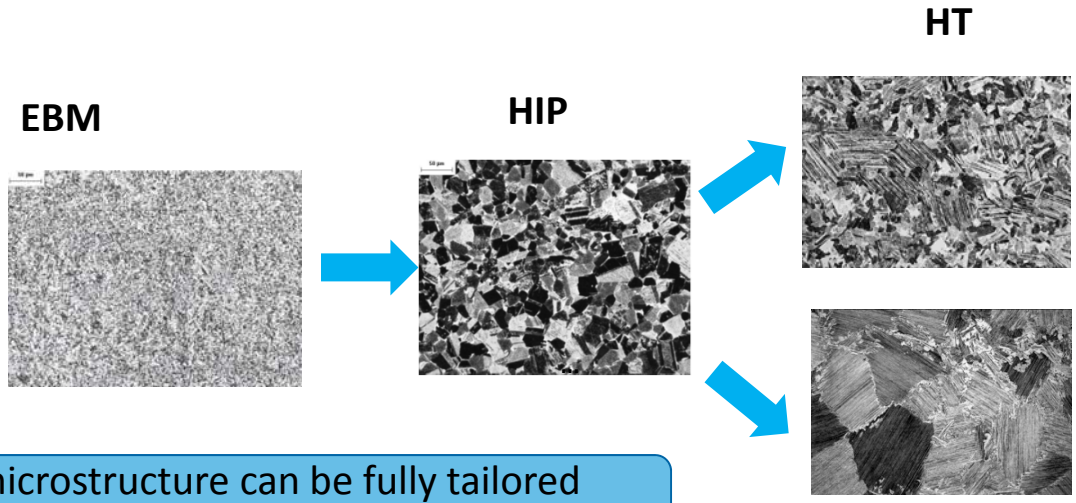
Application case: TiAl LPT blades: material



GAS ATOMIZATION PROCESS for TIAl powder production

- Built year: 2014
- Up to 50 Tons/hear capacity
- Design for reactive materials
- Quality powder lab

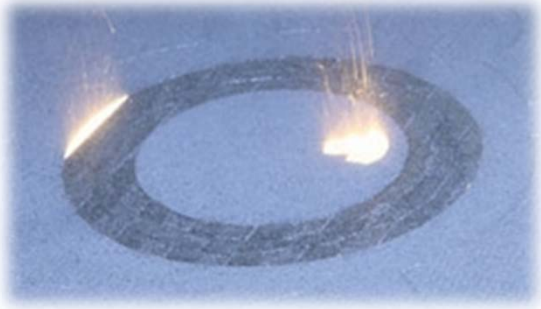




Post-EBM microstructure can be fully tailored through heat treatment, depending on design requirements

Additive Manufacturing

Avio Aero capabilities



Thanks for your attention