AEROSPACE TECHNOLOGY 2016

ADDITIVE MANUFACTURING IN SWEDEN AND ITS APPLICATION IN THE SPACE INDUSTRY

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PRODUCT INNOVATION
LULEÅ UNIVERSITY OF TECHNOLOGY

LULEÅ UNIVERSITY OF TECHNOLOGY

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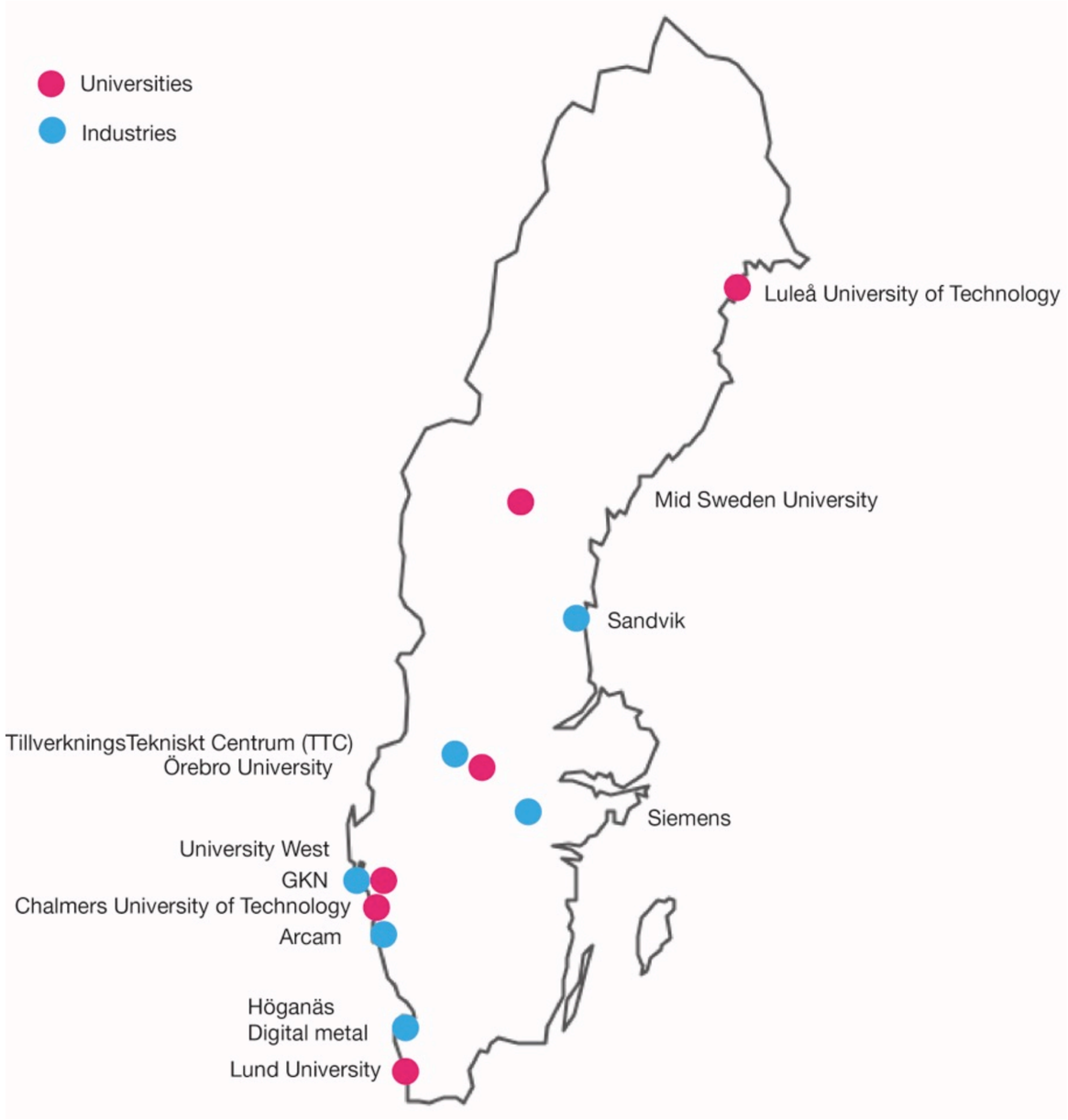
INTRODUCTION

- Additive Manufacturing (AM) is a layer-upon-layer manufacturing method that has evolved from Rapid Prototyping using polymers to an increased use for Rapid Manufacturing (i.e. Direct Part Production) in metals
- The use of metallic AM is increasing in highly regulated industries such as medical and aerospace
- This presentation summarizes the findings from literature reviews, study visits, interviews and workshops
- The purpose has been to understand the Swedish AM capability and set the foundation for future research within the field of AM in space applications

SWEDEN TOUR


Universities
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TillverkningsTekniskt Centrum (TTC)
Örebro University
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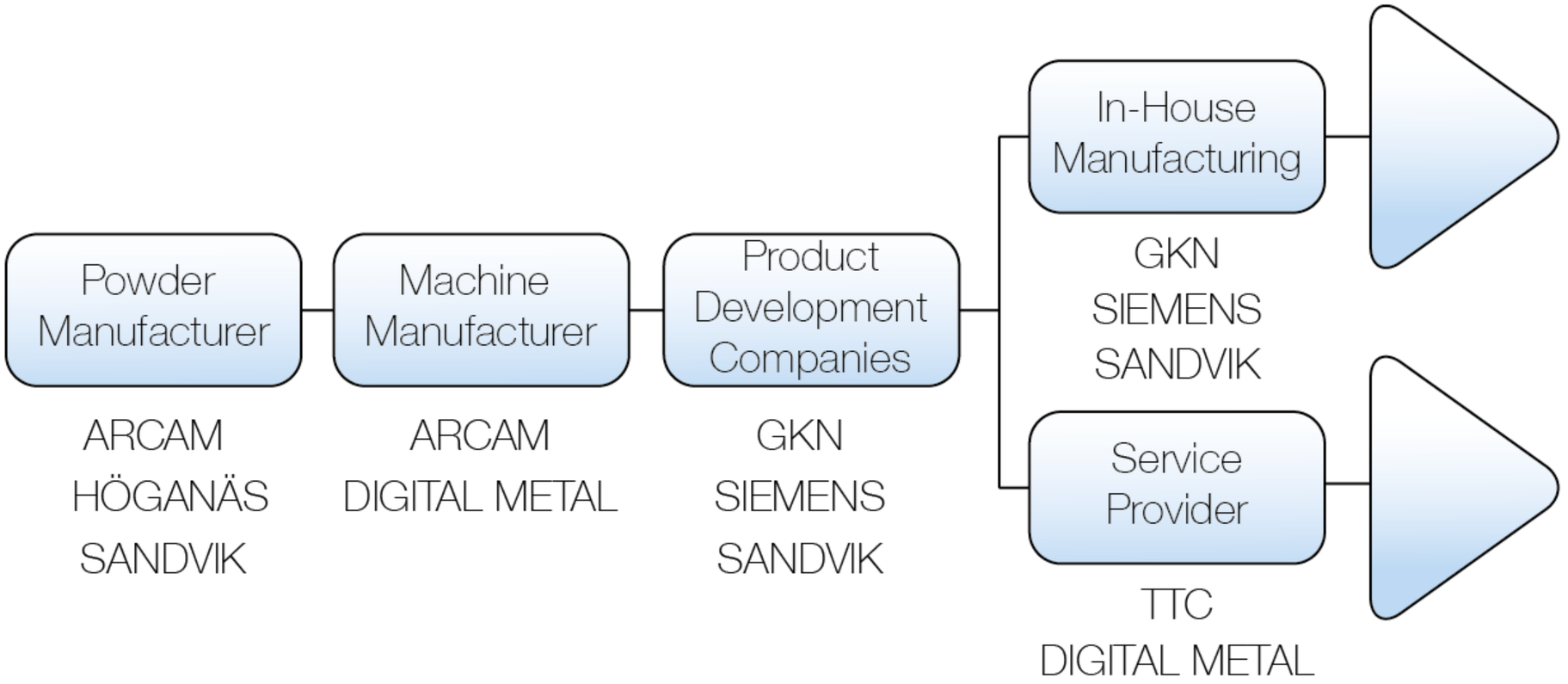
Chalmers University of Technology
Arcam
Höganäs
Digital metal
Lund University

THE SWEDISH ADDITIVE MANUFACTURING INDUSTRY



SPACE INDUSTRY NEEDS

- Move from governmental programs to commercial market has changed the scene for product development
- The focus has shifted from weight and performance to competitiveness in cost

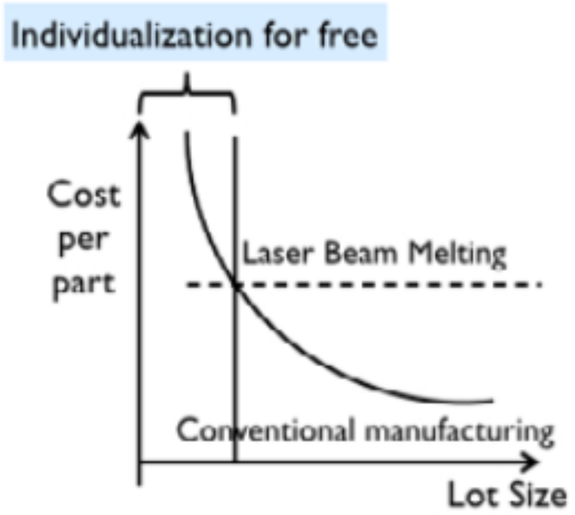
- The space industry is characterized by small production volumes, complex products and costly product development

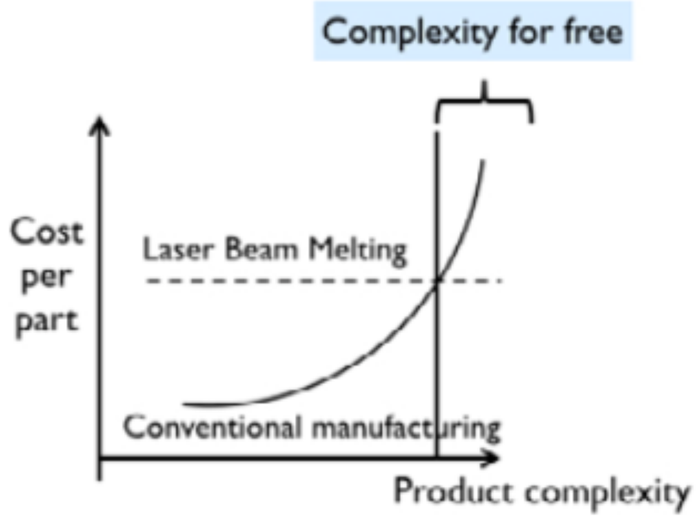
→ Innovation is necessary for cost competitive product development and manufacturing

ADDITIVE MANUFACTURING CHANGES THE SCENE

- **The low volume production is ideal for AM technology, while at the same time it gives the possibility to design with less restrictions**

- **The benefits of AM include:**
  - Part consolidation
  - Increased functionality and performance through optimized or integrated design
  - Weight reduction through mass optimization
  - Efficient product development through design iteration
  - Shorter lead times and supplier independency
  - Material design





(www.epma.com/am, 2015)

→ **The mastering of AM can lead to innovation and cost competitiveness**

Our goal is to contribute to the application of AM in critical space components through studies of the design process to identify and suggest adjustments due to AM

COST REDUCTION POSSIBILITIES IN TURBINE APPLICATION

Turbine Design for Ariane 6 Vulcain Turbopumps Upgrades
Brodin S., Forsberg L., Palmnäs U.
AAAF Space Propulsion 2016, May 2-6

- **Part consolidation**
  - Integration of sub-parts
  - Reduced number of welds
  - Decreased part count
    → less drawings, less administration, easier handling/mounting, …
- **Replace difficult machining**
  - Inlet pipe
- **Reduce amount of machining**
  - Turbine inlet manifold
- **Innovative design solutions**

Next generation turbines for Ariane 6

- Objective: cost reduction, robust design, high reliability
- AM is one strong enabler for cost reduction

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CHALLENGES

Opportunities and Challenges for Additive Manufacturing in Space Applications
Dordlofva C., Lindwall A., Törlind P.
NordDesign 2016, August 10-12

- **Design for Additive Manufacturing**
  - Two approaches for product design: manufacturing or function driven
  - Designers need to adapt to the AM process. There is a need for process understanding to utilize all the potential benefits
  - Design and CAD tools are restricted due to their legacy use with subtractive manufacturing processes

- **Qualification of components**
  - The biggest hurdle for the implementation of AM is process variation and part quality
  - Traditional non-destructive inspection methods cannot be used
  - Traditional material qualification is costly and time consuming
  - Part design impacts material properties

CONCLUSIONS

- The AM community in Sweden is rapidly growing with many different stake holders and a presence throughout the value chain
- Need for increased knowledge of Design for AM (DfAM) within companies
- To be able to implement additive manufacturing as an accepted manufacturing technology in the space industry, there is a strong need for increased process understanding through multidisciplinary research in both academia and industry

- In space applications, there is a gap in the published literature with regard to additive manufacturing when it comes to:
  - The innovation process
  - Established qualification methods