DESIGN FOR ADDITIVE LAYER MANUFACTURING

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Introduction

This project is part of the SILOET programme and aims to improve the design process for Additive Layer Manufacturing (ALM).
Additive layered manufacturing (ALM) is a group of manufacture techniques able to build 3D parts layer-by-layer directly from a CAD file, by cutting the CAD geometry into 2D slices.
While there are currently over 20 different ALM methods that exist, most of them can be grouped into three main categories as shown in Figure 1.

Process type	Materials	Typical markets	Relevance for metal
Powder bed	Metals, polymers	Prototyping, direct part	●
Laser/welding deposition	Metals	Direct part, repair	◑
Material extrusion	Polymers	Prototyping	◔

Figure 1: The three main types of ALM methods, their material capabilities, typical markets and suitability (and maturity) for metal components.[1]

This project is focused on metallic powder-bed methods such as Direct Laser Deposition (DLD) and Electron Beam Melting (EBM), as these are currently the most mature and most suitable methods for production parts in aerospace.

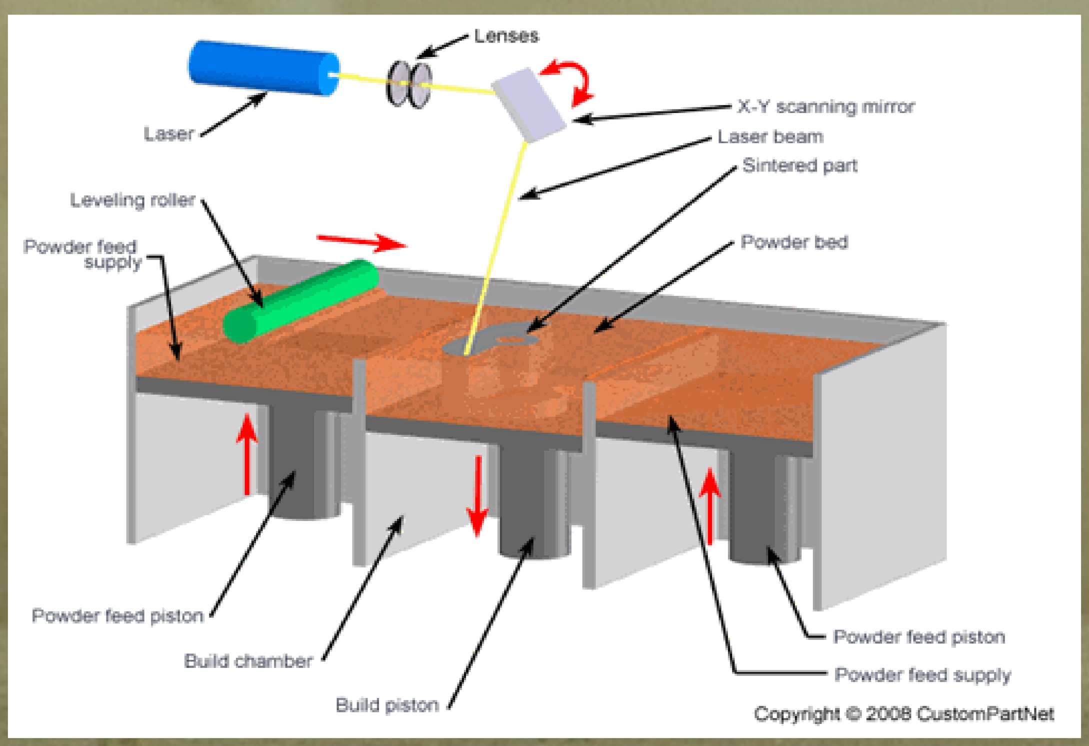

Figure 2: Diagram outlining the Direct Laser Deposition process [2].
The principle for Electron Beam Melting is very similar, with the main difference being the vacuum build environment which is required to prevent air particles from interfering with the electron beam reaching the powder-bed.

Problem Outline

Current design methods and tools are aimed at traditional manufacture techniques such as casting and machining. Due to the relative lack of experience and tools in designing parts for ALM, the current design procedure involves a lot of manual intervention making it labour-intensive, time-consuming and subjective to individual designers' logic. Furthermore, the design rationale and production process of ALM parts are not properly recorded, adding to the problem of inefficiency and lack of understanding.

Therefore, the top-level aims this project are to:

1. Formalise the design process to improve workflow and create reproducible parts, as well as to improve knowledge capture for ALM design.
2. Reduce manual intervention and related uncertainties.
3. Maximise ALM benefits by incorporating ALM considerations early in the design process and eliminating redundant geometry constraints imposed by traditional manufacture methods.

Project Progress and Plan

The first 12 months were spent on relevant training and literature review. The following 12 months will be dedicated to industrial research within Rolls Royce and specialist companies in the ALM field. A case study will be carried out within Rolls Royce, focusing on concept and detailed design stages of components for ALM.

The case study will be carried out on a gas turbine sub-system to highlight the benefits of Electron Beam Melting and to create a component design system for this process.
The case study objectives are as follows:
1. Implement, improve and validate a cost comparison model of EBM vs. traditional manufacturing.
2. Derive EBM design rules for component geometry, based on past cases and expert knowledge.
3. Use DOE to optimise geometric features for weight and cost.
4. Validate the proposed system and optimisation criteria using the case study component.

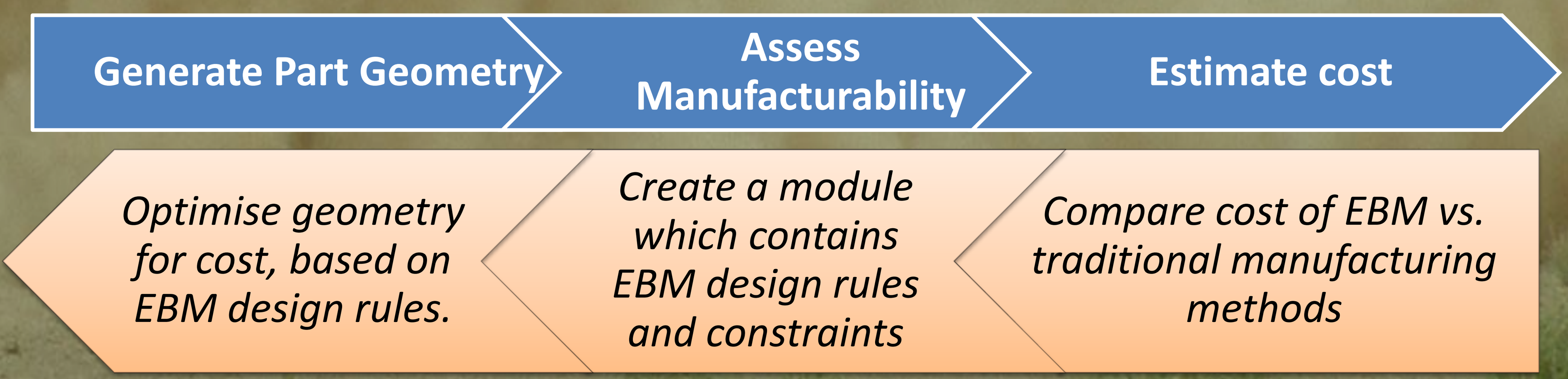

Figure 3: Diagram of simplified design workflow (blue) and case study plan (orange) given in order from right to left.

Conclusion

ALM has traditionally been viewed as only being suitable for rapid prototyping, however, it is now beginning to emerge as a competing end-product manufacturing method. In order to keep up with the ensuing production demands and to fully exploit the benefits offered by ALM a formal framework is required for the design process.
The case study outlined above, aims to provide the required preliminary results to develop such a framework.

[1] "Additive manufacturing: A game changer for the manufacturing industry?," RolandBerger, Munich, 2013.
[2] CustomPart.Net, "Additive Fabrication," 2009. [Online]. Available: http://www.custompartnet.com/wu/additive-fabrication. [Accessed 26 07 2014].

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