# Additive Manufacturing Design Assessment App

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## Abstract

The Manufacturing Technology Centre (MTC) is home to the UK's National Centre for Net Shape and Additive Manufacturing, offering integrated solutions to potential end users, supply chain companies or equipment providers using a three phase approach: discovery, demonstration and pilot production. As such, the MTC has a clear roadmap for the evolution of simulation in additive manufacturing focusing on the maturation of the involved technologies to an industrial standard (Figure 1).

This paper focuses in the additive manufacturing processes of shaped metal deposition (SMD) and selective laser melting (SLM). In SMD, the desired shape is obtained by welding a continuous metal wire onto a substrate; with the advantage of having large deposition rates and the possibility of accepting dissimilar materials through the process, at the disadvantage of having a large heat affected zone. On the contrary, in SLM, parts are built up by locally melting a thin layer of metal powder, achieving high accuracy and a localised heat affected zone, at the cost of a much slower build-up time.

Modelling the SMD process is very similar to simulating a weld, with the added complexity of the progressive addition of material onto the component through the use of complex toolpaths.
Even though SLM can be approached in a similar manner, this often leads to unacceptable simulation time scales in an industrial application, due to the extremely thin layers of melted powder, which are typically on the order of hundreds of microns [2]. The MTC has addressed this issue by creating a new methodology based on the combination of an analytical and numerical analyses, which allows the scaling of the solution to the macro-scale and the subsequent reduction of simulation time [1], as illustrated in Figure 2.

COMSOL Multiphysics® was used to implement this MTC methods, using its standard ODE interfaces as well as its specialist modules for CAD Import, Heat Transfer, Structural Mechanics and Nonlinear Structural Materials. In addition, the MTC had a user focus, aiming to extend the use of this technology beyond the Design & Simulation department. To enable this technology, the use of the COMSOL Server™ has been essential: custom applications have been developed to automate the simulation setup and prepare the geometry and mesh to suit additive manufacturing simulation. This includes the layer slicer and the toolpath generation tool (Figure 3), as well as a simulation application for SMD (Figure 4).

The results show good agreement with experimental data for both SMD and SLM, as well as having reduced the computational time to several hours for industrial scale components. Multiple physical and environmental effects have been studied, such as material non-linearity, a pre-heated furnace and tool operation (e.g. speed, power and path).

## Reference

[1] Afazov, S. & Yaghi, A., 2016. High Value Manufacturing CATAPULT Case Studies: Numerical Modelling of Powder-Bed Additive Layer Manufacturing Technologies. [Online] Available at: https://hvm.catapult.org.uk/wp-content/uploads/2016/04/Case-study-Numerical-Modelling-of-Powder-Bed-Additive-Layer-Manufacturing-Technologies.pdf [Accessed 30 September 2016].
[2] Ding, J., 2012. Thermo-Mechanical Analysis of Wire and Arc Additive Manufacturing Processes, Cranfield: Cranfield University.
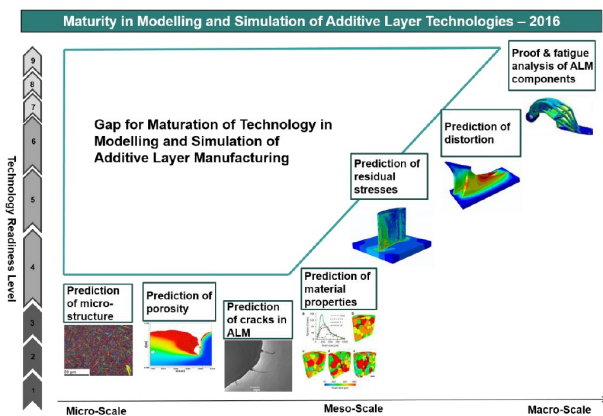
## Figures used in the abstract



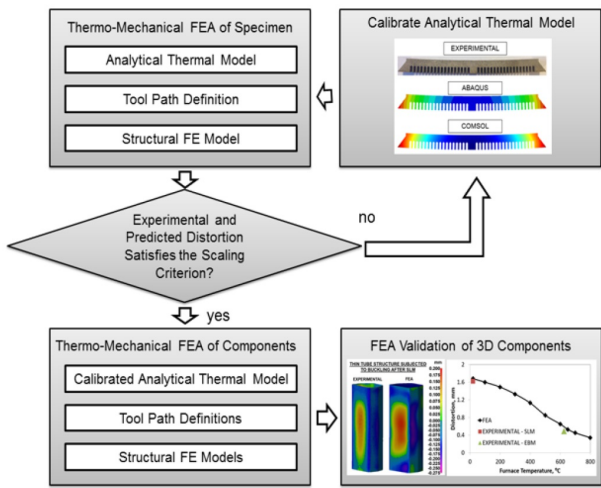Figure 1: Maturity in Modelling and Simulation of Additive Layer Technologies – 2016 [1].

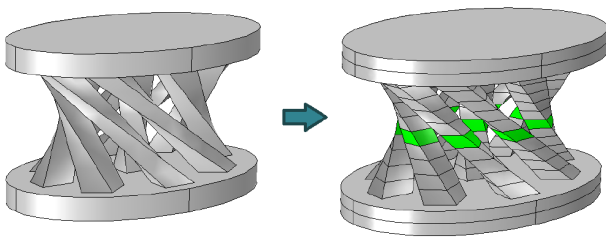**Figure 2**: Rapid ALM Predictive Methodology [1].



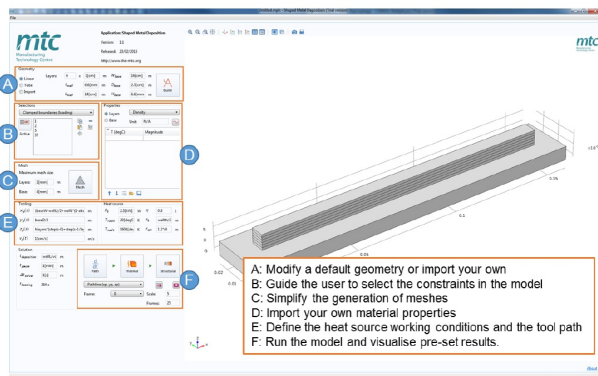**Figure 3**: Geometry sliced using a custom COMSOL app (MTC 2016).



**Figure 4**: Screenshot of the MTC's developed application for shaped metal deposition modelling.