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Advances in Modelling and Simulation of Metal Additive Manufacturing at the Part-Scale

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ABSTRACT

Metal Additive Manufacturing (AM) offers considerable opportunities for producing complex components with tailored performance and greater design freedom. Processes including Wire Arc Additive Manufacturing (WAAM), Directed Energy Deposition (DED), and Laser Powder Bed Fusion (LPBF) are governed by interacting thermal, mechanical, and metallurgical phenomena spanning multiple spatial and temporal scales. Predicting and controlling these interactions remains a central challenge for process modelling, optimization, and industrial application.

This Invited Session focuses on recent advances in computational simulation, experimental characterization, and data-driven methods for metal AM. Particular emphasis is placed on predictive modelling at the part and component scales, linking process understanding with improvements in manufacturing reliability and the performance of the resulting structures.

The session will bring together researchers and industry practitioners to discuss accurate and computationally efficient modelling strategies, their experimental assessment, and their integration with process monitoring and control.

Topics of interest include, but are not limited to:

- Advanced computational methods for part-scale AM process modelling.
- Efficient temporal integration and spatial discretization for large-scale simulations.
- Reduced-order models and surrogate modelling strategies.
- Multi-physics and multi-scale approaches to process–structure–property relationships.
- Constitutive modelling of thermo-mechanical behaviour and microstructural evolution.
- Prediction and mitigation of residual stresses, distortion, and manufacturing defects.
- Experimental validation and integration of numerical models with in-situ monitoring.
- Machine learning and data-driven techniques for process optimization and control.
- Design and optimization of scan paths, deposition strategies, and process parameters.

Contributions covering different metal AM technologies, including LPBF, DED, and WAAM, and a broad range of material systems are encouraged. Through the exchange of methodological advances and practical applications, the session will promote collaboration on reliable, high-fidelity simulation tools that support industrial adoption and certification of additively manufactured components.