# BRIDGING PHYSICS AND DATA: PREDICTIVE ANALYTICS FOR NEXT-GENERATION ADDITIVE MANUFACTURING

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## ABSTRACT

Additive Manufacturing (AM) is increasingly driven by advances in sensing, data analytics,machine learning, and digital engineering. Modern AM systems generate large volumes of process and quality data, creating new opportunities for predictive modelling, adaptive process control, and accelerated qualification. However, the complexity of AM processes, spanning multiple spatial and temporal scales, requires modelling approaches that combine predictive accuracy, physical consistency, and computational efficiency.

This session focuses on data-driven, physics-informed, and hybrid modelling approaches that enable real-time prediction and decision-making in additive manufacturing. Contributions are invited on machine learning, reduced-order modelling, digital twins, sensor fusion, uncertainty quantification, symbolic and explainable artificial intelligence, and data-centric process optimization.

Recent research [1] has demonstrated how reduced-order and hybrid physics-based models can provide real-time predictions suitable for process control and digital twin applications. Similarly, works on symbolic [2] and explainable AI show the potential for deriving interpretable process-structure-property relationships in manufacturing systems. These developments complement broader advances in AM digitalization, including digital twin frameworks, physics-informed machine learning, ICME-based materials modelling, and in-situ monitoring and qualification strategies for metal AM.

The session welcomes contributions on machine learning for AM, real-time process

modelling, digital twins, reduced-order modelling, symbolic and explainable AI, physics-informed learning, defect prediction, process monitoring, uncertainty-aware modelling, and industrial deployment of intelligent manufacturing systems. By bringing together experts from additive manufacturing, materials science, computational engineering, and artificial intelligence, the session aims to advance trustworthy, scalable, and interpretable predictive technologies for the next generation of autonomous and data-driven AM production systems.

## REFERENCES

[1] Horr, A.M., Hovden, S. & Kronsteiner, J. Application of real-time models for multi-scale predictions during material processes. *Int J Adv Manuf Technol* 140, 5189–5205 (2025). https://doi.org/10.1007/s00170-025-16575-8

[2] Kabliman, E., & Kronberger, G. Identification of Empirical Constitutive Models for Age-Hardenable Aluminium Alloy and High-Chromium Martensitic Steel Using Symbolic Regression. *Phil. Trans. R. Soc. A* 384, 20240587 (2026). https://doi.org/10.1098/rsta.2024.0587.