

# MATHEMATICAL SOULS OF DIGITAL TWINS: THE FRONTIERS OF ADAPTIVE MODELLING FOR VEHICLE DEVELOPMENT, OPERATIONS, AND MAINTENANCE

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## ABSTRACT

Digital twins are widely considered as enablers of groundbreaking changes in the development, operation, and maintenance of novel generation of products. In this context, “a Digital Twin is a set of virtual information constructs that mimics the structure, context, and behavior of an individual/unique physical asset, is dynamically updated with data from its physical twin throughout its lifecycle, and informs decisions that realize value” [1]. While there is a popular – frequently misleading – understanding of digital twins as the highest-fidelity virtual representation of all aspects of the real system of interest, digital twins are rather purpose-driven virtual representations. Therefore, those digital counterparts of an individual real artifact are not unique but would assume different forms depending on the purpose [2]. At the same time, all digital twins share a key property that distinguish them from the parent family of digital models: digital twins are physics based and adaptive in nature, and are conceived to continuously learn from data. As such, digital twins are inevitably characterized by a mathematical soul to combine data streams and physics-based representations in a principled and efficient way.

Methods are rooted at the intersection of scientific computing and machine learning, and span the world of Bayesian frameworks, multi-fidelity and multi-source information fusion or calibration, data assimilation, surrogate and reduced order modelling, uncertainty quantification, to mention a few. Major research open challenges relate to rapidity and reliability of responses and predictions from the digital representations. This Invited Session aims at bringing together researchers and practitioners who develop and apply digital twins across a variety of applications of engineering products and vehicles, focusing on mathematical formulations and/or computational methods to enable their distinguishing adaptivity feature.

## REFERENCES

- [1] AIAA Digital Engineering Integration (DEIC) Committee. *Digital Twin: Definition & Value*, AIAA and AIA Position Paper. AIAA, December 2020. (2020)
- [2] Rasheed, A., San, O. And Kvamsdal, T. Digital Twin: Values, Challenges And Enablers From A Modeling Perspective. *IEEE Access*, 8, (2020) Pp.21980-22012.