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The Executable Digital Twin: digital models creating value in the physical world

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Résumé — The digital twin has become an intrinsic part of the product creation process. Basically, it is a virtual image of a real asset, integrating all data, models and other structured digital information of a product, a plant, an infrastructure system, or a production process. Digital twin data are generated during the design, engineering, manufacturing, commissioning and operation and evolve over the product lifecycle. While the digital twin can have multiple appearances, its objective is always to have a digital representation suited to the purpose in terms of level of detail, completeness, accuracy, and execution speed.

The true power of the digital twin lies in its relationship with its physical counterpart. Data acquired on the physical asset can validate, update and enrich the digital twin and provide use information to improve the design. Inversely, the knowledge contained in the digital representation can bring value to the physical asset itself. Dedicated encapsulations can be extracted from the digital twin to model a specific set of behaviors in a specific context, delivering a stand-alone executable representation. Such instantiated, self-contained and encapsulated, model can be referred to as the Executable Digital Twin.

Examples of such usage are embedded models for virtual sensing, model-based control, performance monitoring or X-in-the-loop hybrid testing applications. But also, the use as a companion model to the physical asset through its lifecycle for performance assessment or decision support applications.

Key enabling technologies to create the Executable Digital Twin are fast simulation methods, Model Order Reduction, state estimation and standard model delivery (e.g. as FMU). Machine Learning methods allow compact models of complex non-linear systems over wide operational range. Open platforms accepting external models with their execution engines, linking these in a hybrid co-simulation environment are key.

Several case studies are discussed including virtual sensing and hybrid (XiL) testing in the automotive and aerospace domain as well as decision support and process monitoring applications in the manufacturing and process industry. The related value propositions include data augmentation, reducing sensor cost, speeding up system validation and optimizing operational performance and asset availability.