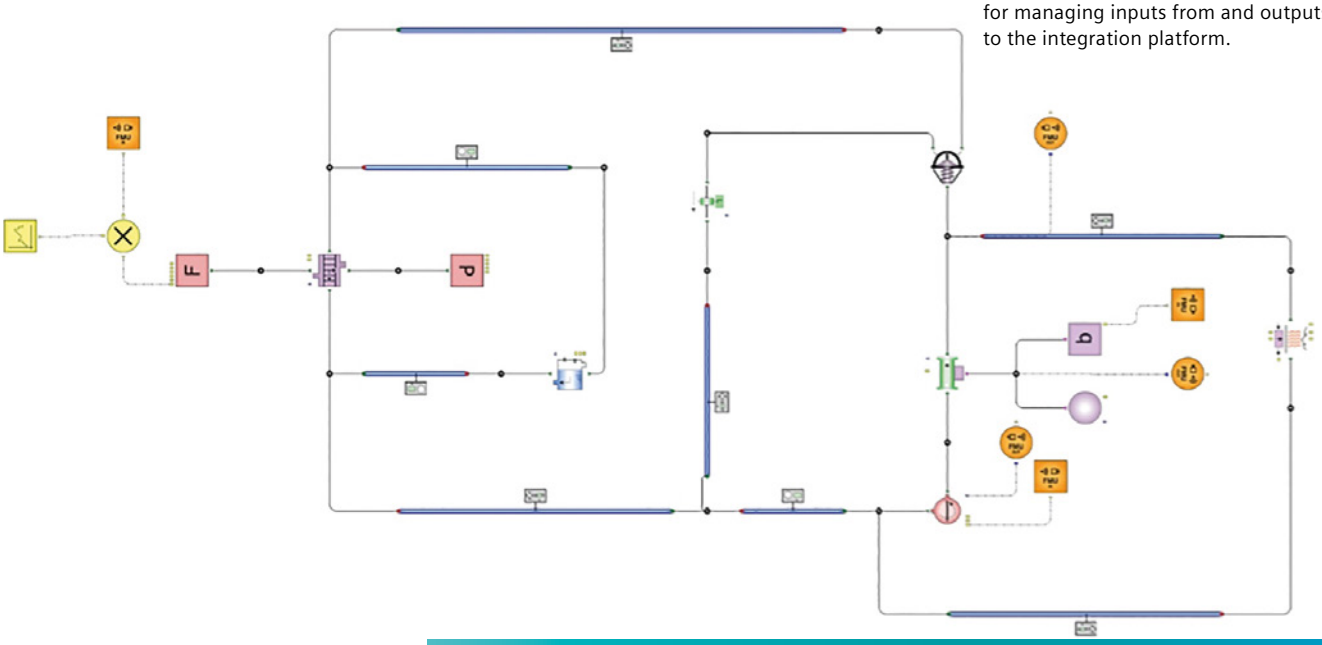

Figure 1: Engine cooling system model in Simcenter Flomaster. Orange components are dedicated controllers for managing inputs from and outputs to the integration platform.

How to...

Model a System-of-Systems through FMI Co-Simulation

By Alberto Deponti, Product Manager, Simcenter Flomaster

Successfully designing complex, sophisticated and efficient systems is not enough to optimize the product. In order to optimize the final product it is necessary to account for system interactions using a System-of-Systems approach early in the design phase and throughout product development. This means that each single system should be modeled using Best-In-Class specialized tools and co-simulation among different tools need to be used to model system interactions.

Functional Mock-up Interface (FMI) is a tool independent standard that specifies an open format for exporting and importing simulation models into a co-simulation framework. FMI is supported by over 100 tools and is used throughout Europe, Asia and North America. An exported model is called Functional Mock-up Unit (FMU). FMU models can be imported in a platform for co-simulation in the wider framework of System-of-Systems analysis where complex system interactions can be properly captured. This opens the door to effective optimization and harmonization of system behaviors. But this is not the only advantage, this approach also allows a consistent reuse of models in different design phases within different company departments which increases the value of model-based design and of the investment in simulation.

Application example

Let us consider for example an internal combustion engine vehicle. To optimize its performance it is necessary to account for the complex interactions of different systems such as the engine and the ECU, the gearbox, the transmission system and the cooling system. This needs to be performed while also considering the vehicle dynamics and a range of different drive cycles.

A comprehensive System-of-System analysis can be set within Simcenter using Simcenter Flomaster™ software and

Simcenter Amesim. Simcenter Flomaster is a vertical solution for accurate modeling of thermo-fluid systems of any size and complexity while Simcenter Amesim is a simulation platform for accurate modeling of mechatronic systems.

The engine cooling system is modeled in Simcenter Flomaster, exported as an FMU and simulated from within Simcenter Amesim, where the interactions among the cooling system, the engine, the ECU, the gearbox and transmission system are accurately modeled.

Preparing an existing Simcenter Flomaster model for export can be achieved in a matter of minutes. Dedicated controllers and gauges are provided for managing inputs from and outputs to the integration platform. Inputs and outputs can vary during a transient co-simulation and effectively account for the complex interactions among the different systems. In addition to this, it is possible to use fixed parameters that will not vary during transient co-simulations but can vary from one simulation to another to account for different operating conditions and/or for different designs.

In this particular case, Simcenter Amesim provides Simcenter Flomaster with computed values of vehicle velocity, engine heat rejection and pump rotational speed. Simcenter Flomaster provides Simcenter Amesim with computed values of engine temperature, fluid temperature downstream of the engine and pump torque.

Importing the FMU into Simcenter Amesim is equally as easy. Once the inputs and outputs of the FMU are connected to the other sub-systems of the Simcenter Amesim model, co-simulations can be run to accurately analyze the interactions among the different sub-systems and to effectively optimize and harmonize system behavior. ■

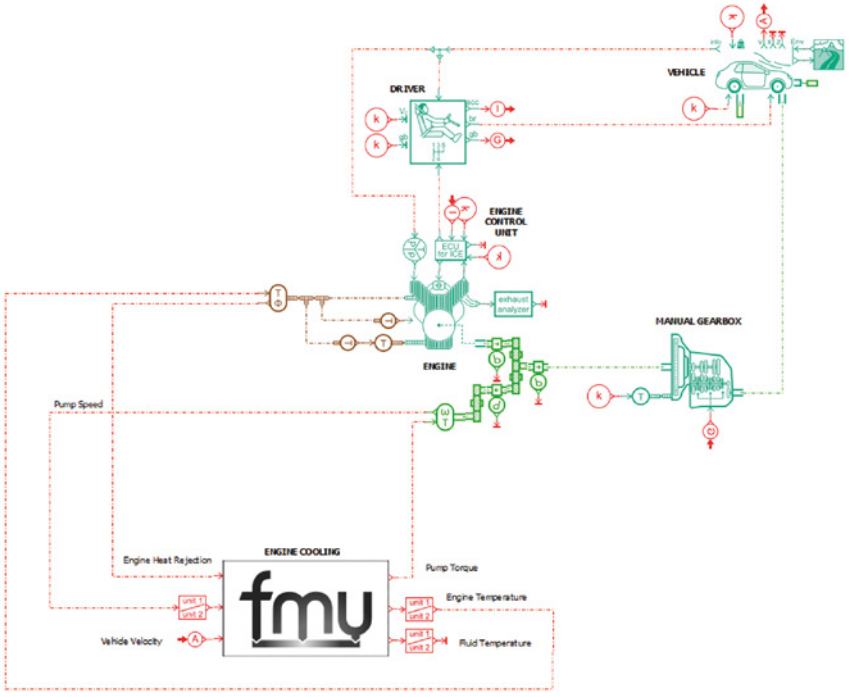

Figure 2: Internal combustion engine vehicle model in Simcenter Amesim. Engine cooling system is modeled with Simcenter Flomaster and integrated into the Amesim model as an FMU.

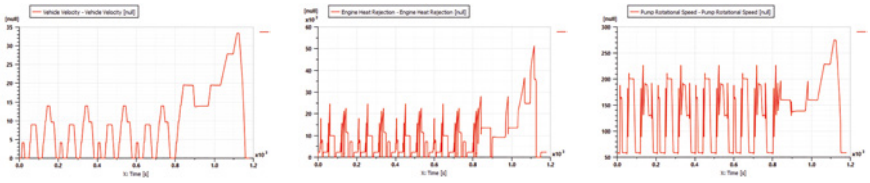

Figure 3: Simcenter Amesim provides Simcenter Flomaster with computed values of vehicle velocity, engine heat rejection and pump rotational speed.

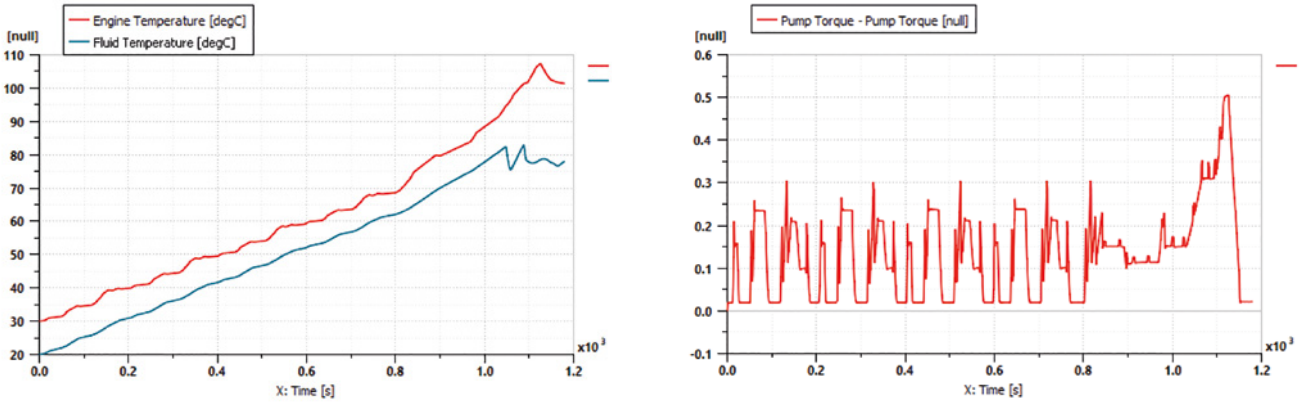

Figure 4: Simcenter Flomaster provides Simcenter Amesim with values of engine temperature, fluid temperature downstream of the engine and pump torque.