# FMI Co-simulation 1D-3D SIMSEN-CFX

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**Abstract.** Hydraulic systems can be subjected to excitations induced by complex flow structure developed in any system's component. The interaction between the hydraulic system and the excitation source can be predicted by performing a co-simulation between two independent simulation codes. One is resolving the fluid pipe system with a one-dimensional compressible code whereas the other one computes the three-dimensional flow in a given hydraulic system's component which is the source of excitation. In the field of hydroelectric power plants, the one-dimensional SIMSEN software is widely used to compute transient dynamic response of the hydraulic system. The need to couple this tool with a 3D finite volume method of computational fluid dynamics is growing. The aim is to predict resonance or instability phenomena between hydraulic machines and piping systems. To reach this purpose, the FMI co-simulation feature has been implemented in SIMSEN as a part of the FMI library which is considered as a standard communication protocol between two simulation codes solving a set of ordinary differential equations. This protocol has been used to couple SIMSEN software with the Ansys CFX solution. The implementation has been validated with simulations of two test cases involving different physics of interest occurring in hydroelectric power plants: the pressure wave propagation in the piping system and the mass oscillation phenomenon in a surge tank.

## 1. Introduction

To characterize the hydraulic system's dynamic behaviour of a given power plant, a 1D modelling of the system is carried out. However, 1D modelling of excitations induced by complex flow structure developed in any system's component, is not representative or even not feasible. Hence, a 3D numerical model is required to predict accurately the excitation and the interaction between the hydraulic system and the excitation source can be predicted by performing a co-simulation between two independent simulation codes. One is resolving the fluid hydraulic system with a one-dimensional compressible code whereas the other one computes the three-dimensional flow in a given hydraulic system's component which is the source of excitation. In the hydroelectricity field, the excitation induced by the unsteady flow field in the hydraulic machines is of interest for many authors. Cavitation vortex rope developed in the draft tube[ 1 ]-[ 8 ], rotating stall or pressure fluctuations in the S-Shape region [ 9 ]-[ 12 ] are phenomenon for which 1D-3D coupling is of interest. The coupling strategy between the two independent simulation codes is decisive for prediction accuracy and numerical stability. The nature of the exchanged data and the way to exchange data during the time step are of importance. In this paper, the FMI co-simulation feature has been implemented in SIMSEN as a part of the FMI library which is considered as a standard communication protocol between two simulation codes solving a set of ordinary differential equations. With this protocol, the coupling strategy is explicit since data are exchanged at the beginning of time step and kept constant during internal iteration loop of the 3D simulation code. This coupling strategy is used for simulation of pressure wave propagation in piping system and simulation of the mass oscillation phenomenon in a surge tank.