Multidisciplinary and Multiscale Co-Simulation - Already widely used but still a Challenge

K. Wolf[1]

[1] Fraunhofer Institute SCAI, Klaus.Wolf@scai.fraunhofer.de

Multiphysics treats simulations that involve multiple physical models or multiple simultaneous physical phenomena. Typical examples are fluid-structure interactions, fluid-thermal-stress calculations, or full system simulations incorporating hydraulics, MBS, control and electric network models.
There is a growing market demand driven by industrial engineers who want to take into account more relevant physical phenomena when they model their processes and products. Based on the company's own long-term experience the engineers want to use the most suitable software tool or solver for each single physical domain. Therefore multiphysic simulation often means a coupling of solvers and simulators coming from different vendors.
Fluid-structure interactions (using a co-simulation of CFD and FEA) are already quite established in industry. Besides such 'standard' FSI applications there are some trends to use more complex co-simulation setups for specific areas:

- to use combination of EMAG, FEA and CFD for plasma simulation - e.g. electric arc simulations in switching devices with moving contacts;
- to couple highly detailed geometries with locally non-matching parts - e.g. thermal and radiation coupling for full car models using millions of cells on each coupling surface;
- to use more than two codes in a single application - e.g. in turbine design engineers use one CFD code for the main turbine flow, another CFD for the internal cooling flows, plus a FEA tool for the thermal stress analysis;
- to do transient studies incorporating flutter analysis and moving reference frames - e.g. start-up procedures of turbines or clutches;
- to do (moderate) multiscale multiphysic modeling combining system codes and detailed CFD or FEA - e.g. HVAC cooling flow circuits coupled to detailed 3D CFD models of aircraft cabins.

However, there are still a lot of challenges open which need to be worked on:

- missing or incompatible programming interfaces in the codes which limit the multiphysic co-simulation capabilities,
- incompatible proprietary cosimulation platforms from different software vendors,
- robust and accurate coupling algorithms for FSI, FMU cosimulations, etc
- integrating black-box models into complex system setups,
- and many other issues.

This talk will present some aspects of multiphysics simulations from a viewpoint of an independent provider of a neutral code coupling software environment.