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Aeronautics Large-scale Pilot in the EU-funded LEXIS project: context, objectives and first outcomes

Playing in the aeronautical market, the demand for reduced fuel consumption is leading to new engine architectures, oriented towards an even higher propulsive efficiency. Nowadays, there are significant efforts to get increasingly reliable performance prediction, searching for more realistic solutions and using multi-physics simulation approaches able to anticipate problems, typically encountered in the detailed design phases. This implies the adoption of CPU-demanding, data-intensive and time-consuming CAE simulations based on sophisticated numerical solvers. The synergy among next-generation HPC/Cloud/Big Data management technologies are opening new scenarios for the aircraft engines' design and optimization, enabling innovative and faster investigation strategies and providing unprecedented levels of accuracy and detail.

Through the Aeronautics Large-scale Pilot in the EU-funded LEXIS project (Grant Agreement ID: 825532), Avio Aero has launched a challenging research activity focused on significantly improving the feasibility and exploitation of advanced numerical modeling capabilities for aircraft engines' critical components. From both a digital technology and business perspective, Avio Aero intends to obtain a marked step change: less time-consuming computational analyses that exploit newly designed, improved and/or tightly coupled HW/SW components opening the doors to the "real time" design approach. To meet this ambitious objective, the industrial applicability of last generation HPC/Cloud/BD platforms is under investigation through two aeronautical engineering case studies, a turbomachinery application and a mechanical rotating parts' one.

More specifically, referring to the Turbomachinery use case, the improvement of TRAF, a CFD code developed by the University of Florence, is currently ongoing to drastically reduce the execution time of fluid dynamics analyses on low pressure turbines. Specifically designed for turbomachinery designers, the code solves steady/unsteady 3D, Reynolds-averaged Navier-Stokes equations in the finite volume formulation on multi-block structured grids. The last TRAF version, that relies on a hybrid OpenMP/MPI code architecture and runs on solely CPU-based HPC resources, has been profiled to evaluate its scalability, to detect any bottlenecks and to identify some actions for optimizing the running time. Moreover, the development of a newly designed GPU-enabled release of this code is currently underway with promising results in terms of speed up.

As regards the Rotating parts use case, the numerical investigations aim to assess NanofluidX capabilities in simulating the multiphase flow inside a high-speed gearbox cooled with an oil-jet system. Conceived and optimized for use on clusters of GPUs, NanoFluidX, by Altair Engineering, is a smoothed particle-based hydrodynamics simulation tool to predict multi-phase flows around complex geometries under complicated motion, which are difficult to handle using CFD approaches based on Finite Volume Methods. In order to investigate the discretization level suited for well reproducing both the liquid and gas phase motion, this code has been tested in some simplified cases, consisting of an oil-jet directed towards a single wheel. Results have been compared with both experimental data and CFD simulations based on the Finite Volume numerical method. The next steps will be aimed at studying more complex rotating parts configurations hardly to solve with the classical Finite Volume codes.