Deutsches Zentrum
für Luft- und Raumfahrt
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Excellerat Success Story: Transparent Integration of Emerging HPC Technologies into the Computational Fluid Dynamics Software CODA

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Industry sector: Aerospace
Key codes used: CODA, Spliss

Organisations and Codes Involved:

The German Aerospace Center (DLR) is the Federal Republic of Germany's research center for aeronautics and space. DLR conducts research and development activities in the fields of aeronautics, space, energy, transport, security, and digitalization. The German Space Agency at DLR plans and implements the national space programme on behalf of the federal government. DLR employs approximately 10.000 people at 30 locations in Germany.

CODA is a Computational Fluid Dynamics (CFD) solver for the simulation of aircraft aerodynamics and is developed in a joint effort between the German Aerospace Center (DLR), the French Aerospace Lab (ONERA), and Airbus.

Technical and Scientific Challenge:

Providing high-fidelity aerodynamics simulations requires enormous computational resources. High Performance Computing (HPC) systems aim to meet these increasing demands. However, the increasing performance comes with an increasing complexity with current leading-edge HPC systems consisting of millions of heterogeneous processing elements including hardware accelerators such as GPUs. To harness the full potential of current and upcoming HPC systems, CFD software such as CODA require not only the efficient utilization of the Central Processing Unit (CPU) but must also support emerging technologies such as Graphics Processing Units (GPUs).

Solution:

An integral part of CODA is the Sparse Linear Systems Solver (Spliss) that is used for solving linear equation systems for implicit time integration methods. Spliss is a linear solver library that, on the one hand, is tailored to the requirements of CFD applications such as CODA but, on the other hand, independent of the particular CFD solver. Focusing on the specific task of solving linear equation systems allows for integrating more advanced, but also more complex, hardware-specific optimizations, while at the same time hiding this complexity from the CFD solver.

One example is the usage of GPUs: within EXCELLERAT, the capabilities of Spliss have been extended to GPUs. Furthermore, the performance of Spliss on GPUs has been analysed and optimized allowing the efficient and transparent usage of GPUs for linear systems solving within CODA.

Scientific impact of this result/solution:

CODA will be the successor to DLR's TAU CFD solver, which has been in production in the European aircraft industry, research organizations, and academia for more than 15 years. TAU was, for instance, used for the Airbus A380 and A350 wing design. To be a full replacement, CODA must not only match and exceed TAU's numerical capabilities, but must addresses the efficient utilization of current and upcoming HPC systems as well as emerging technologies such as GPUs.

With the help of EXCELLERAT, significant improvements have been made in improving HPC capabilities and performance. With the added support for GPUs, CODA increases its readiness for future HPC systems; including exascale systems. In addition, the performance optimizations made on GPUs allow to fully harness their computational resources.

The adaption to future systems and their efficient usage allows for larger, more accurate simulations of aircraft aerodynamics in the design process of future aircraft, which in return play a pivotal role on the path to climate-neutral aviation.

Benefits for further research:

- Simulation of aircraft aerodynamics with shorter time to solution
- Simulation of aircraft aerodynamics with higher resolution and higher-quality results
- Readiness for current and future HPC systems including hardware accelerators

Simulation of external aircraft aerodynamics. Credit: DLR (CC BY-NC-ND 3.0)

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EXCELLERAT Success Stories - Scientific achievements

The EXCELLERAT project is a single point of access for expertise on how data management, data analytics, visualisation, simulation-driven design and Co-design with high-performance computing (HPC) can benefit engineering, especially in the aeronautics, automotive, energy and manufacturing sectors. The goal of EXCELLERAT is to enable the European engineering industry to advance towards Exascale technologies and to create a single-entry point to services and knowledge for all stakeholders of HPC for engineering.

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