Research and development of fluid analysis tools using GPU

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Abstract

FaSTAR's default routine calculations were accelerated with OpenACC. We analyze High-Lift configuration of the NASA CRM aircraft (CRM-HL) at low-speed stall conditions using GPU-based FaSTAR. For buffet analysis, we performed GPU-based calculations using the OpenSBLI code.

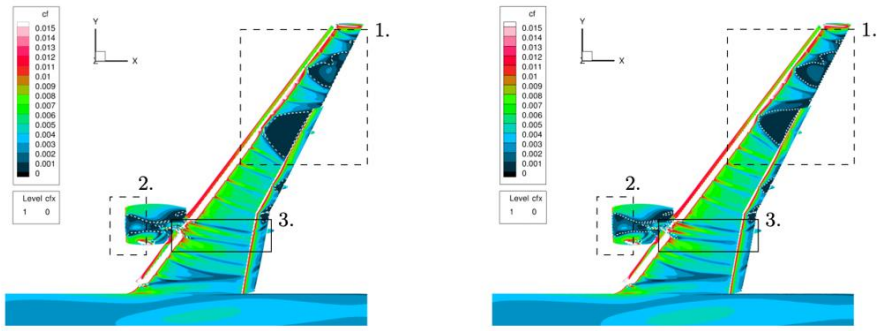
Reasons and benefits of using JAXA Supercomputer System

To develop a GPU version of CFD solvers, the GPU nodes available on JSS3 can be used to verify the code and run large scale simulations

Achievements of the Year

About FaSTAR-GPU: Acceleration and optimizion of FaSTAR on GPU using OpenACC. The results of the multi-GPU version of the code and those of the multi-CPU version of the code are in excellent agreement (figure 1). For a typical setup, the multi-GPU version of the code allows a speedup of 2.

About OpenSBLI: OpenSBLI has been developed and used for wide-span transonic buffet simulations on up to 10 billion mesh points. World first scale-resolving high-fidelity simulations of wide-span buffet were performed up to aspect ratio of AR=3 (Figure 2). These simulations were awarded the Numerical Simulation Grand Prize at ANSS conference 2023 [Grand Prize (Aerospace Numerical Simulation Technology Category) Issued by 41st Aerospace Numerical Simulation Technology Symposium]



(a) GPU. (b) CPU.

Fig. 1: Comparison between FaSTAR-GPU and FaSTAR-CPU results on the NASA CRM-HL full-aircraft configuration.

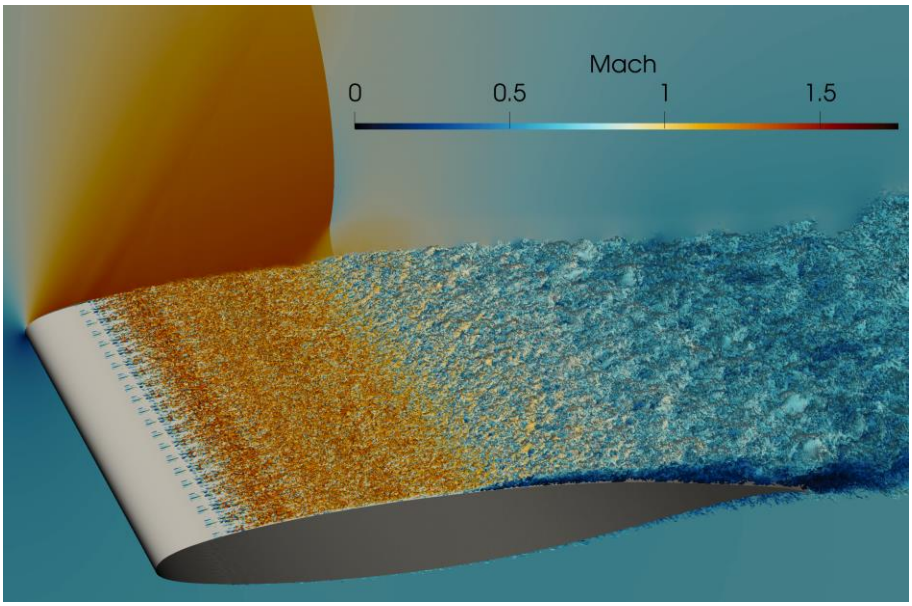


Fig. 2: Transonic Buffett OpenSBLI simulation for NASA-CRM wing on JSS3 TOKI-RURI GPU nodes.

Publications

- Peer-reviewed papers

[1] DJ Lusher, A Sansica, A Hashimoto. Effect of Tripping and Domain-Width on Transonic Buffet on Periodic NASA-CRM Airfoils. arXiv preprint arXiv:2401.14793. AIAA-J (Under review, 2024).

[2] David J. Lusher, Andrea Sansica, Neil D. Sandham, Jiangping Meng, Atsushi Hashimoto. OpenSBLI v3.0: High-Fidelity Multi-Block Transonic Aerofoil CFD Simulations using Domain Specific Languages on GPUs. Computer Physics Communications (Under review, 2024).

- Non peer-reviewed papers

[1] P. Zehner, A. Sansica, A. Hashimoto. Investigation of the Mesh and Flow Influence on GPU Performance of Time Integration Methods for an Unstructured CFD Solver. ANSS Conference Tokyo, 2023.

[2] P. Zehner, A. Sansica, A. Hashimoto. Contribution of JAXA to APC-9 using GPU-accelerated FaSTAR: free-

air and in-tunnel RANS calculations for CLmax prediction on the CRM high-lift configuration. ANSS Conference Tokyo, 2023.

[3] D.J Lusher, A. Sansica, M.Zauner, A. Hashimoto. High-fidelity simulations of transonic buffet on wide-span airfoils in the OpenSBLI automatic code-generation framework on GPUs. ANSS Conference Tokyo, 2023.

[4] A. Sansica, D.J Lusher, A. Hashimoto. Mach Evolution of the Cylinder Wake Flow Bifurcations. International Symposium on Shockwaves ISSW34. Daegu, Korea, 2023.

- Invited Presentations

[1] D.J. Lusher, N.D. Sandham. OpenSBLI/OPS workshop Training course: OpenSBLI automatic code-generation framework. UK Turbulence Consortium, Oxford. United Kingdom 2023.

- Oral Presentations

[1] P. Zehner, A. Sansica, A. Hashimoto. Investigation of the Mesh and Flow Influence on GPU Performance of Time Integration Methods for an Unstructured CFD Solver. ANSS Conference Tokyo, 2023.

[2] P. Zehner, A. Sansica, A. Hashimoto. Contribution of JAXA to APC-9 using GPU-accelerated FaSTAR: free-air and in-tunnel RANS calculations for CLmax prediction on the CRM high-lift configuration. ANSS Conference Tokyo, 2023.

[3] D.J Lusher, A. Sansica, M.Zauner, A. Hashimoto. High-fidelity simulations of transonic buffet on wide-span airfoils in the OpenSBLI automatic code-generation framework on GPUs. ANSS Conference Tokyo, 2023.

[4] A. Sansica, D.J Lusher, A. Hashimoto. Mach Evolution of the Cylinder Wake Flow Bifurcations. International Symposium on Shockwaves ISSW34. Daegu, Korea, 2023.

[5] D.J Lusher, A. Sansica, A. Hashimoto. High-fidelity simulations of wide- span transonic airfoil buffet on multi-GPUs using automatic code-generation. JSFM, CFD37 Symposium Nagoya, 2023.

Usage of JSS

Computational Information

Process Parallelization Methods	GPU
Thread Parallelization Methods	N/A
Number of Processes	128
Elapsed Time per Case	100 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 4.12

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	1,364,131.95	0.06
TOKI-ST	4,655.28	0.01
TOKI-GP	7,374,608.25	95.86
TOKI-XM	0.00	0.00
TOKI-LM	8,364.68	0.64
TOKI-TST	0.00	0.00
TOKI-TGP	0.00	0.00
TOKI-TLM	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage[*2] (%)
/home	1,200.11	1.00
/data and /data2	122,015.56	0.75
/ssd	32,114.44	3.03

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage[*2] (%)
J-SPACE	7.06	0.03

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage[*2] (%)
ISV Software Licenses (Total)	43.99	0.02

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.