

## Study of high speed fluid dynamics

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### ● Abstract

We conduct fundamental research on aerodynamics such as aerodynamic design of Mars aircraft.

Ref. URL: <https://ladse.eng.isas.jaxa.jp/>

### ● Reasons and benefits of using JAXA Supercomputer System

Large eddy simulation is required for analysis of Mars airplane .

### ● Achievements of the Year

Numerical analysis to design electric aircraft considering interaction between propeller and main wing. All simulations are conducted by FaSTAR move, which is developed by JAXA. We conducted numerical simulation of main wing, nacelle and propeller. The effect of propeller mounting position is investigated. An example of the results are shown in Fig.1. Numerical results and wind tunnel experiments show agreements for flow field features such as suppression of separation due to propeller wake and main wing surface flow. Both results also show agreement for the aerodynamic characteristic coefficients.

As for Mars airplane design, aerodynamic performance evaluation of optimized airfoil with external rib structure using LES. Under its cruise condition, the external ribs don't inhibit the formation of vortices on suction side and therefore don't degrade the aerodynamic performance. Also, it is implied that the rib structure promotes the reattachment of the separated flow at high angle of attack. These findings indicate that the optimized airfoil with external rib structure is useful as the main wing of Mars airplane.

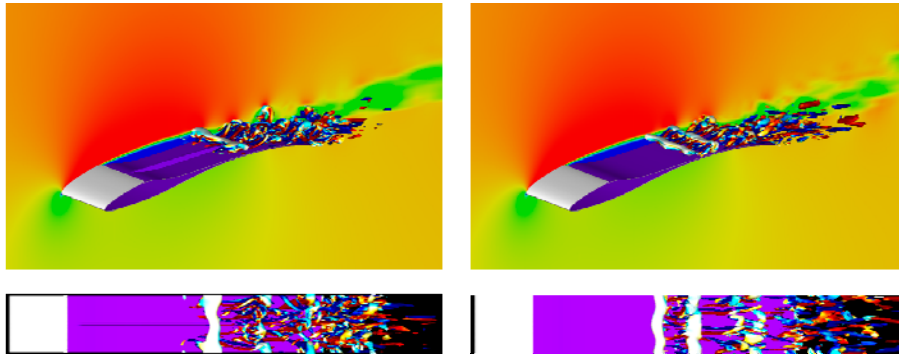


Fig. 1: Main wing's surface streamline and iso surface of Q criterion

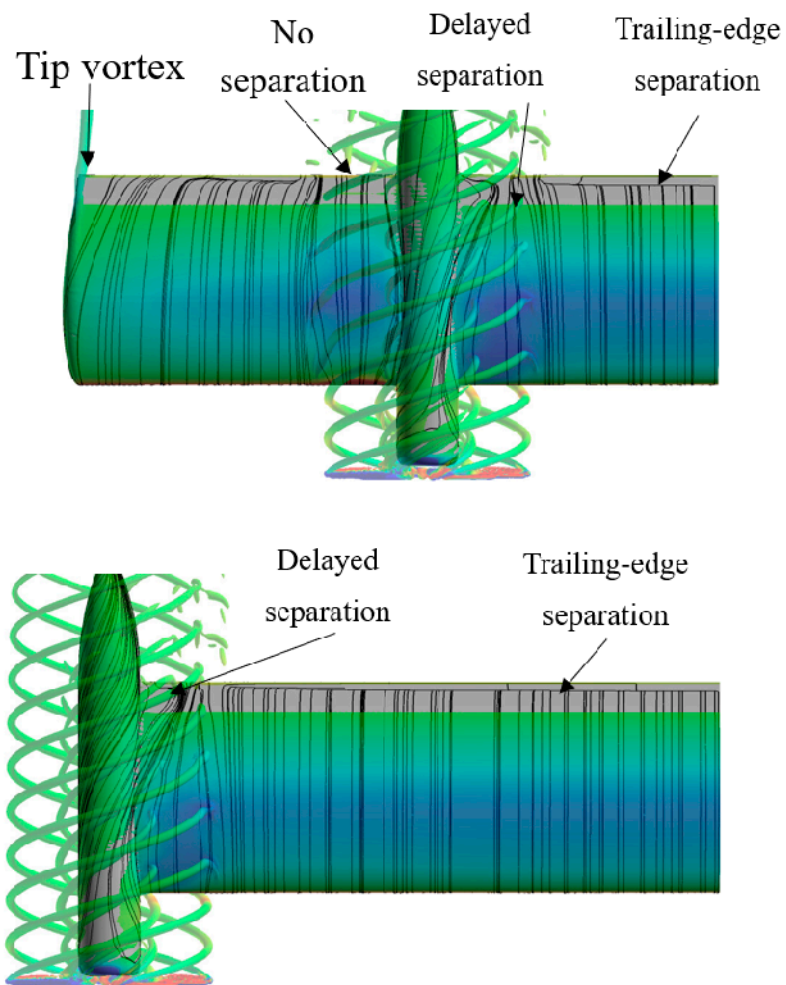


Fig. 2: Visualization of velocity field with vortices (top) and vortices on suction side(bottom). (Left: with external rib structure, Right: without rib structure)

## ● Publications

- Peer-reviewed papers

Shigetaka Kawai and Akira Oyama, Uncertainty Quantification and Global Sensitivity Analysis of Low-Reynolds-Number Airfoil for Future Mars Airplane, Transactions of the Japan society for aeronautical and space sciences, Vol. 63, No. 4, pp. 172-184, 2020.

- Oral Presentations

Naruhiko Nimura, Shun Tamura, and Akira Oyama, High Angle-of-Attack Aerodynamic Characteristics of Thin-Trailing-Edge Airfoil with External Ribs, AIAA SCITECH, Virtual Event, 11-15 January 2021.

Shigetaka Kawai, Wataru Yamazaki, Akira Oyama, Uncertainty Quantification of Supersonic Biplane Airfoil by Multi-Element Polynomial Chaos Based on Edge, AIAA SCITECH, Virtual Event, 11-15 January 2021.

## ● Usage of JSS

### ● Computational Information

|                                 |             |
|---------------------------------|-------------|
| Process Parallelization Methods | MPI         |
| Thread Parallelization Methods  | OpenMP      |
| Number of Processes             | 12 - 37     |
| Elapsed Time per Case           | 350 Hour(s) |

### ● Resources Used(JSS2)

Fraction of Usage in Total Resources<sup>\*1</sup>(%): 1.25

Details

| Computational Resources |                                       |                                     |
|-------------------------|---------------------------------------|-------------------------------------|
| System Name             | Amount of Core Time<br>(core x hours) | Fraction of Usage <sup>*2</sup> (%) |
| SORA-MA                 | 7,221,557.14                          | 1.37                                |
| SORA-PP                 | 66,099.88                             | 0.52                                |
| SORA-LM                 | 1,130.02                              | 0.66                                |
| SORA-TPP                | 0.00                                  | 0.00                                |

| File System Resources |                        |                                     |
|-----------------------|------------------------|-------------------------------------|
| File System Name      | Storage Assigned (GiB) | Fraction of Usage <sup>*2</sup> (%) |
| /home                 | 1,677.15               | 1.54                                |
| /data                 | 36,484.79              | 0.70                                |
| /ltmp                 | 11,791.49              | 1.00                                |

| Archiver Resources |                    |                                     |
|--------------------|--------------------|-------------------------------------|
| Archiver Name      | Storage Used (TiB) | Fraction of Usage <sup>*2</sup> (%) |
| J-SPACE            | 11.99              | 0.40                                |

\*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.

● **Resources Used(JSS3)**

Fraction of Usage in Total Resources<sup>\*1</sup>(%): 1.20

Details

| Computational Resources |                                       |                                     |
|-------------------------|---------------------------------------|-------------------------------------|
| System Name             | Amount of Core Time<br>(core x hours) | Fraction of Usage <sup>*2</sup> (%) |
| TOKI-SORA               | 5,719,077.00                          | 1.23                                |
| TOKI-RURI               | 135,055.12                            | 0.77                                |
| TOKI-TRURI              | 0.00                                  | 0.00                                |

| File System Resources |                        |                                     |
|-----------------------|------------------------|-------------------------------------|
| File System Name      | Storage Assigned (GiB) | Fraction of Usage <sup>*2</sup> (%) |
| /home                 | 3,213.14               | 2.20                                |
| /data                 | 87,286.67              | 1.46                                |
| /ssd                  | 5,635.69               | 2.94                                |

| Archiver Resources |                    |                                     |
|--------------------|--------------------|-------------------------------------|
| Archiver Name      | Storage Used (TiB) | Fraction of Usage <sup>*2</sup> (%) |
| J-SPACE            | 11.99              | 0.40                                |

\*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.