Study of high speed fluid

Report Number: R18EU0902
Subject Category: Space and Astronautical Science
URL: https://www.jss.jaxa.jp/en/ar/e2018/9178/

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Abstract

We conduct fundamental research on aerodynamics such as aerodynamic acoustic noise generated by supersonic jet and aerodynamic design of Mars aircraft.

Reasons for using JSS2

Large eddy simulation is required for analysis of aeroacoustics generated from a supersonic jet. Aerodynamic design of Mars airplane requires several hundred cases of CFD computation. Therefore, a supercomputer is necessary.

Achievements of the Year

This year, we studied aerodynamics of Mars airplane and freestream turbulence effects.

As for Mars airplane, we obtained aerodynamic characteristics of the high-altitude flight model of Mars airplane (Fig. 1, Fig. 2). we also investitaged Mach number effect in low Reynolds number condition.

As for freestream turbulence effects, we studied freestream turbulence effects on laminar separation bubbles in low-Reynolds-number flow over a flat plate using large eddy simulations Fig. 3). The results have shown that the freestream turbulence accelerates the laminar-turbulent transition and the length of the separation bubble decreases (Fig. 4). Consequently, the pressure distribution of the simulations with the freestream turbulence have shown closer distributions to an experimental result than the simulation without freestream turbulence. Moreover, a parametric study has shown that the length scale of turbulence, as well as the intensity of turbulence, affects the flow reattachment point. This fact may indicate that we have to pay attention to the turbulent length scale in addition to the turbulent intensity on wind tunnel tests.

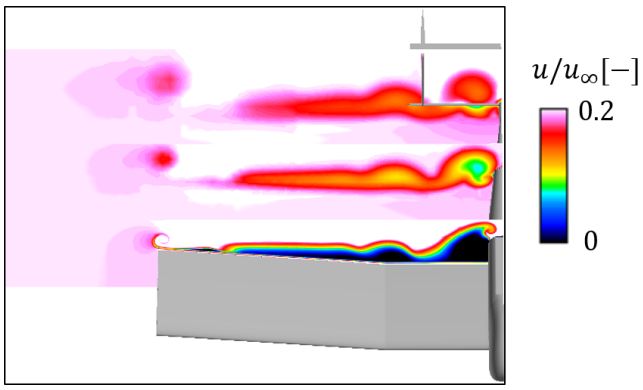

Fig. 1: Flow field behind the main wing of high-altitude flight test model of the Mars airplane.

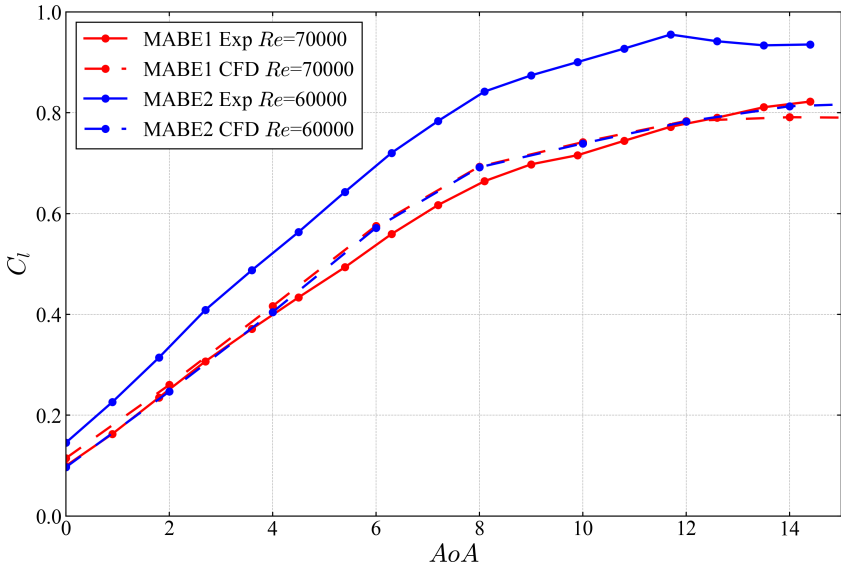

Fig. 2: Lift coefficient evaluation of high-altitude flight test model of the Mars airplane.

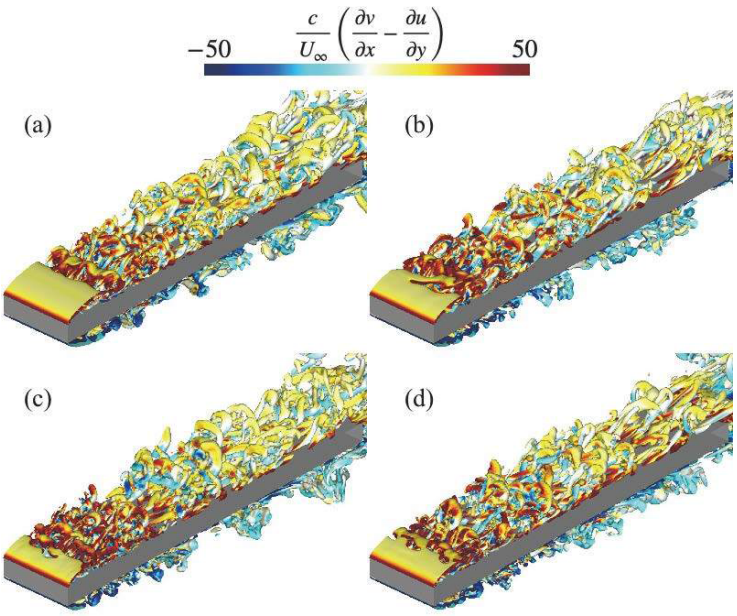

Fig. 3: Instantaneous flow structures at (a) zero freestream turbulence condition, (b) intensity 3%, length scale 0.01 (c) intensity 5%, length scale 0.01, and (d) intensity 3%, length scale 0.03.

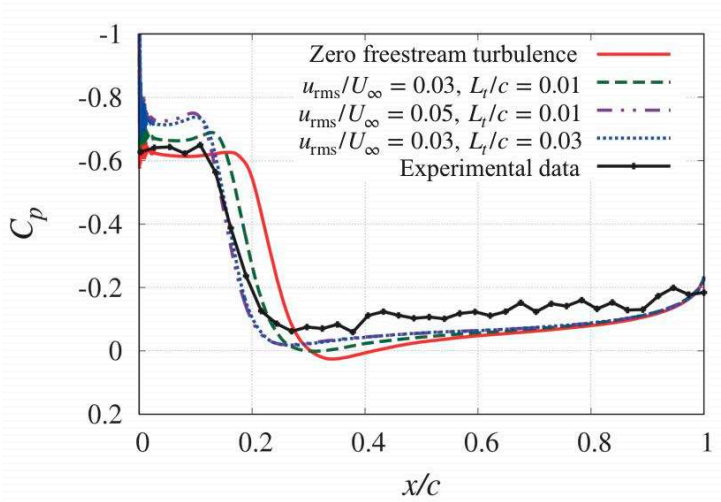

Fig. 4: Surface pressure distributions at different freestream-turbulence conditions.

Publications

- Peer-reviewed papers

1. Taku Nonomura, Hiroaki Nakano, Yuta Ozawa, Daiki Terakado, Makoto Yamamoto, Kozo Fujii, and Akira Oyama, Large-eddy Simulation of Acoustic Waves Generated from a Hot Supersonic Jet, Shock Waves, (accepted).

2. Seiichiro Morizawa, Taku Nonomura, Akira Oyama, Kozo Fujii, and Shigeru Obayashi, Effect of Mach Number on Airfoil Characteristics at Reynolds Number of 3,000, Transactions of JSASS, Vol. 61, Issue 6, pp. 258-267, 2018.

- Oral Presentations

1. Shigetaka Kawai, Keigo Asada and Akira Oyama, Evaluation of Inflow Turbulent Fluctuation Effects on Laminar Separation Bubbles Using Large Eddy Simulations, AIAA SciTech Forum 2019, San Diego, US, January, 2019.

2. Shun Tamura and Akira Oyama, Effect of External Rib Structure on Aerodynamic Performance of Thin Wing in Low Reynolds Number, AIAA-2019-0033, AIAA Scitech 2019 Forum, San Diego, California, January 7-11, 2019.

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	128
Elapsed Time per Case	7 Hour (s)

- **Resources Used**

Fraction of Usage in Total Resources[*1] (%): 1.12

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2] (%)
SORA-MA	10,047,394.86	1.23
SORA-PP	4,066.40	0.03
SORA-LM	104.60	0.05
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2 (%)
/home	1,927.40	1.99
/data	51,475.75	0.91
/ltmp	14,877.80	1.27

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	3.75	0.13

[*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.