Study of high speed fluid dynamics

Report Number: R22EU0902
Subject Category: Space and Astronautical Science
URL: https://www.jss.jaxa.jp/en/ar/e2022/20891/

Responsible Representative

Akira Oyama, Associate Professor, Institute of Space and Astronautical Science, JAXA

Contact Information

oyama@flab.isas.jaxa.jp(oyama@flab.isas.jaxa.jp)

Members

Shota Taniguchi, Naruhiko Nimura, Kento Kaneko, Kei Toko, Hodaka Mori, Sakura Endo, Takeshi Sawada, Atsuhi Shinoduka

Abstract

To conduct fundamental research on high-speed fluid dynamics such as aerodynamic design of Mars drones

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

Reasons and benefits of using JAXA Supercomputer System

High-fidelity flow simulations such as the large eddy simulations are required to analyze Mars drones.

Achievements of the Year

A CFD analysis was performed on the flow around a propeller and fixed-wing to obtain design guidelines for the propeller layout of electric aircraft, such as a Mars exploration aircraft. The height of the propeller mounted on the wingtip of the fixed-wing was shifted up and down by 15% of its diameter to clarify the effect on the aerodynamic characteristics of the fixed-wing (Fig.1). Numerical results show that the upper-mounted propeller configuration has highest cruise aerodynamic characteristics when only considering the aerodynamic characteristics of the fixed-wing (Fig.2).

To study surface riblet processing as a friction reduction technology for space transport vehicles, computational fluid dynamics simulations was also conducted. The result show that the behavior of riblets in laminar flow does not depend qualitatively on the Mach number. On the other hand, the rate of change of the friction coefficient decreased by about 4% in the transonic region compared to the subsonic region. Based on this result, it was found that it is desirable to design appropriately under transonic flow conditions when considering the practical application of surface riblet processing to space transport vehicles in the future.

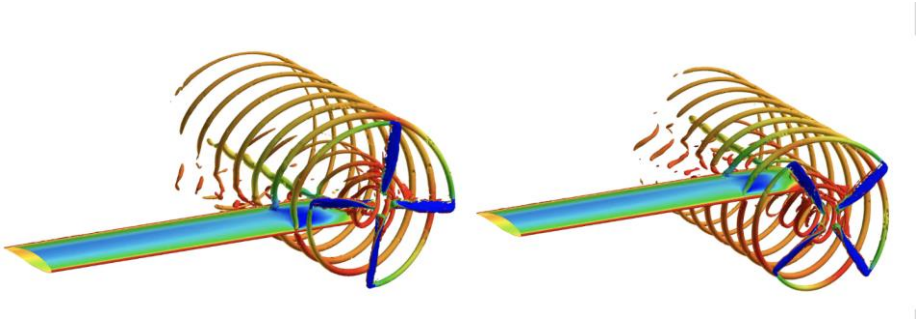

Fig. 1: Flowfield around propeller and fixed-wing

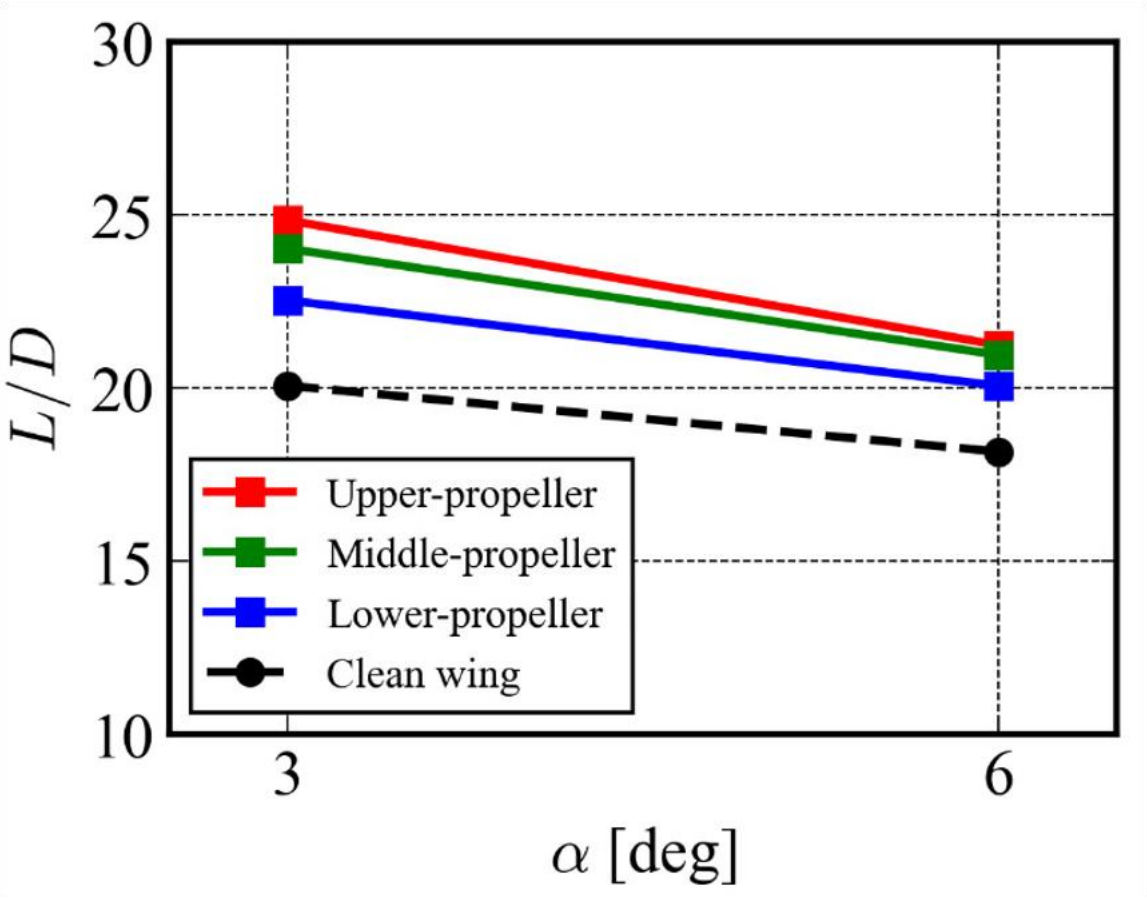

Fig. 2: Propeller vertical position effect on the lift-to-drag ratio of the fixed-wing

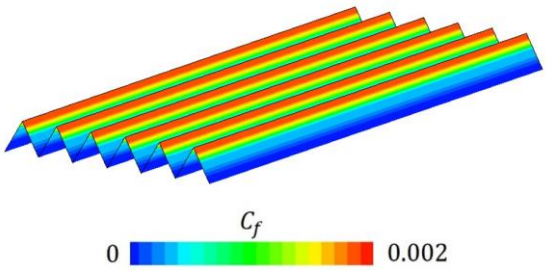

Fig. 3: Surface friction coefficient distribution on the riblet surface (subsonic)

Publications

- Oral Presentations

Shota Taniguchi, Akira Oyama, Propeller Vertical Position Effect on Aerodynamics of Wing, ACFD 2022, Korean Society for Computational Fluids Engineering, October 16-19, 2022

Shota Taniguchi, Akira Oyama, Effects of multiple propellers on aerodynamic characteristics of fixed-wing, AIAA AVIATION Forum 2022, American Institute of Aeronautics and Astronautics, June 27-July 1, 2022

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	720
Elapsed Time per Case	170 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.86

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	18,101,365.36	0.79
TOKI-ST	1,421,491.16	1.42
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	45.78	0.00
TOKI-TST	45,458.79	1.20
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	1,775.33	1.61
/data and /data2	112,793.33	0.87
/ssd	11,898.33	1.65

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	0.08	0.00

*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)	2,936.30	2.04

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