A Rear-Slanted Protuberance for Side Force Reduction on Slender Launch Vehicle

● **Responsible Representative**

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● **Abstract**

In recent years, the demand for small rockets has been increasing, and the protrusion of devices such as control units outside of the rocket body has had a negative impact on aerodynamic performance. In the previous study, CFD and wind tunnel tests were conducted to clarify the aerodynamic characteristics of a long, slender object with protrusions during high-speed flight and its effect on the surrounding flow field. In this study, it was found that the maximum lateral force on the vehicle was generated when the protuberance was placed on the leeward side and the angle of attack was 15 deg. However, the previous studies have only clarified the phenomenon in the case of blunt-head protrusions. Many of the protrusions on actual rockets have a forward sloping shape, and it is expected that the ambient flow field and aerodynamic characteristics will change depending on the shape of the protrusions. In this study, numerical simulations are performed to investigate how the forward or backward inclined shape of the protuberance affects the aerodynamic characteristics of the entire slender body, and the mechanism of the change is discussed.

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

Computational fluid dynamics calculations are being performed to elucidate the aerodynamic characteristics of a long, slender object with protrusions during high-speed flight. In particular, it is necessary to resolve in detail the changes in the flow field around the protuberance due to changes in the inclined angle. The calculations using JSS3 have enabled us to obtain results similar to those obtained in wind tunnel tests, and the visualization results have allowed us to understande the 3D flow field.

● **Achievements of the Year**

Numerical calculations were performed for an angle of attack of 15 degrees and uniform flow Mach numbers of 0.7 and 1.3 around a slender body with an inclined protuberance. As a result, it was found that the coefficient of lateral force was reduced by up to 15% by adding a more acute slant angle behind the protuberance. Visualization

and discussion of the flow field revealed that the backward inclined shape weakened the separation vortex and expansion waves that developed behind the fuselage and reduced the pressure difference between the port and starboard sides. These results implied that the direction of the forward-slanted protuberance, which is commonly observed on actual rockets, should be reconsidered. The backward inclined shape can be a very effective choice in designing future rockets.

● **Publications**

- Oral Presentations

Kakimoto Haruyuki, Kumai Hibiki, Hara Yuka, Oonawa Yuki, Keiishi Kitamura, "A Rear-Slanted Protuberance for Side Force Reduction on Slender Launch Vehicle", 16th International Space Conference of Pacific-basin Societies, 2024

● **Usage of JSS**

● **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	480 - 3840
Elapsed Time per Case	72 Hour(s)

● **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.17

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	3,976,709.45	0.18
TOKI-ST	62,271.65	0.06
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	661.94	0.05
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	1,306.67	0.88
/data and /data2	112,373.33	0.54
/ssd	8,366.67	0.45

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage[*2] (%)
J-SPACE	0.00	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)	1,637.92	1.12

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