# CFD simulation of a rotor blade for high advance ratio flight

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## Abstract

In order to realize the high-speed compound helicopter proposed by JAXA, it is necessary to develop design technology that significantly reduces aerodynamic drag compared to conventional helicopters. One of the design technologies is the JAXA-proposed high-mu rotor blade, which has an outstanding performance under high advance ratio flight conditions. It is characterized by a distinctive chord length distribution that is small at the root and bulges at the blade tip, and an forward-sweep angle that is rare for helicopter blades. As part of the technical demonstration of this blade, we are conducting performance analysis using CFD and examining aerodynamic mechanisms.

## Reasons and benefits of using JAXA Supercomputer System

For analyzing the performance of helicopter blades, it is necessary to use a high-fidelity tool (CFD) that can correctly represent complex flow fields, such as interference with the tip vortex. In order to perform analyses of a large number of cases while maintaining a high resolution, it is desirable to use a supercomputer.

## Achievements of the Year

Figure 1 shows an overview of the high-mu rotor blade. By making the chord length of the root section thin, it is possible to reduce the drag caused by the reverse flow on the retreating side under high advance ratio conditions. In addition, the overall twist angle distribution has been optimized to make the thrust distribution on the rotor disk more efficient. This year, we have been analyzing the performance of the rotor blade during hovering as a way of checking its performance at off-design points.

Figure 2 shows the flow field in the hovering analysis. Although this blade is designed specifically for forward flight performance, it has been confirmed that it has hovering performance comparable to conventional helicopters. The figure shows the vortices generated at the blade tips flowing in the downstream, suggesting that sufficient

spatial resolution has been secured.

Figure 3 shows the distribution of the torsional moment across the blade span during the hovering analysis. This information can be used to consider the ease of pitching control during blade rotation and the magnitude of elastic deformation.

Fig. 1: Planform of high-mu rotor blade

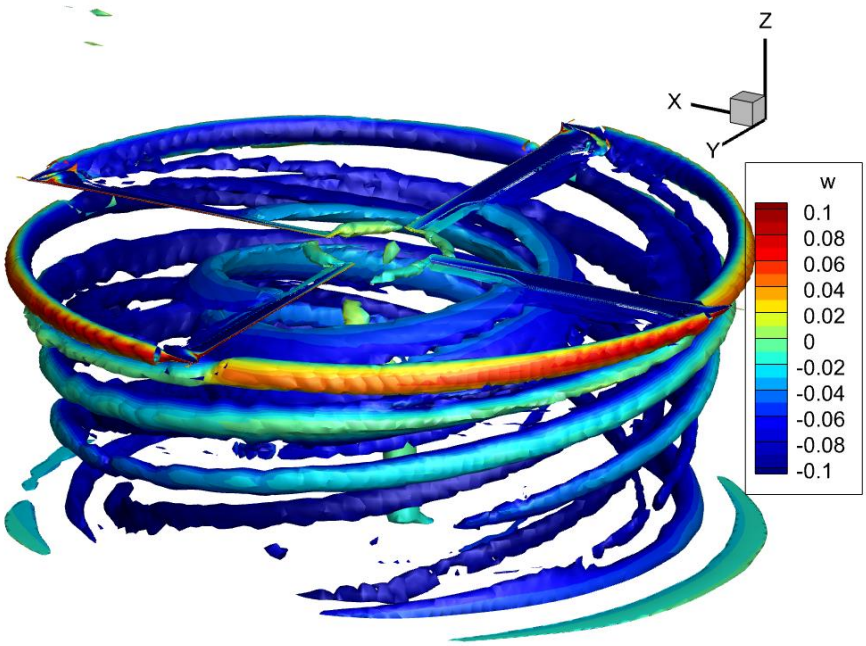


Fig. 2: Iso-surface of Q-criterion in hover condition

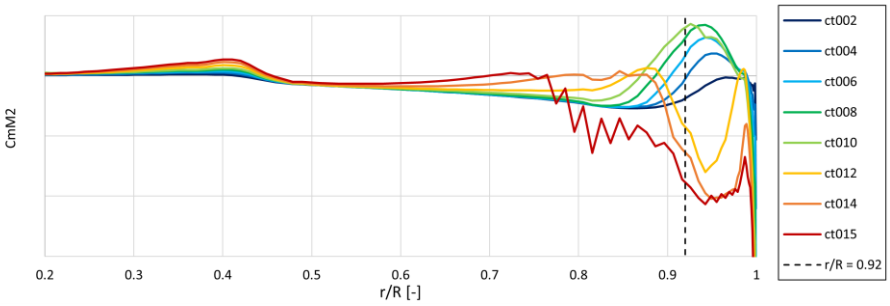


Fig. 3: Span-wise distributuion of pitching moment

## Publications

N/A

## Usage of JSS

### Computational Information

| | |
|---|---|
| Process Parallelization Methods | N/A |
| Thread Parallelization Methods | OpenMP |
| Number of Processes | 1 |
| Elapsed Time per Case | 72 Hour(s) |

### JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.23

Details

| Computational Resources | | |
|---|---|---|
| System Name | CPU Resources Used (core x hours) | Fraction of Usage[*2](%) |
| TOKI-SORA | 889,974.15 | 0.04 |
| TOKI-ST | 1,688,616.40 | 1.73 |
| TOKI-GP | 0.00 | 0.00 |
| TOKI-XM | 0.00 | 0.00 |
| TOKI-LM | 108.01 | 0.01 |
| TOKI-TST | 66,925.25 | 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 | 37.69 | 0.03 |
| /data and /data2 | 8,940.29 | 0.04 |
| /ssd | 386.15 | 0.02 |

| 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) | 0.00 | 0.00 |

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