Aerodynamic Performance and Aeroacoustic Analysis of Multi-Rotors

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Responsible Representative

Kanako Yasue, Aviation Technology Directorate, Aviation Integration Innovation Hub

Contact Information

Shigeru Sunada(shigeru.sunada@mae.nagoya-u.ac.jp)

Members

Mahiro Iwaki, Fumihiro Kajiwara, Ryo Nishino, Hideaki Sugawara

Abstract

In recent years, aircraft electrification has been advancing in the aviation industry. A flight of an airplane with batteries is strongly disturbed with a wind, because they are small and light. We focus on an electric airplane having multiple propellers. The objectives of this project are (1) investigation of the changes in the aerodynamics of the main wings and propeller in sideslip conditions for the aircraft using distributed propulsion system, (2) examination of the aerodynamic and noise of multiple counter-rotating rotors (coaxial rotors).

Reasons and benefits of using JAXA Supercomputer System

To analyze the interaction between blades and free vortices, the prediction of behavior of free vortices accurately is required. Then, rFlow3D, which can predict the behavior of free vortices accurately, is suitable for the present study.

Achievements of the Year

(1) Aerodynamic analysis for the Wing/Propeller Using Distributed Propulsion System in Sideslip

-The overall impact of aerodynamic interference on the system is minimal in terms of changes in the lift coefficient, while the drag coefficient decreases slightly.

-The effect of aerodynamic interference on the wing alone is small for both the lift coefficient and drag coefficient.

-The effect of aerodynamic interference on the propellers alone results in an increase in the thrust coefficient and a decrease in propeller efficiency.

-The impact of sideslip on the overall system is minor and is not expected to significantly degrade flight performance.

(2) Aerodynamics and Noise Analysis for Multiple Coaxial Rotors

-Aerodynamic performance: When the vertical spacing between the upper and lower rotors of the coaxial rotors

is increased, aerodynamic performance improves for all coaxial rotors under low advance ratio conditions. While under high advance ratio conditions, performance improvement is observed mainly in the rear coaxial rotors. This leads to an overall increase in aircraft efficiency.

-Aeroacoustic noise: When the vertical spacing between the upper and lower rotors of the coaxial rotors is increased, under low advance ratio conditions, the impact of wake interference from the front upper rotosr on the rear lower rotosr is reduced and the overall mean sound pressure level is reduced (Fig. 1).

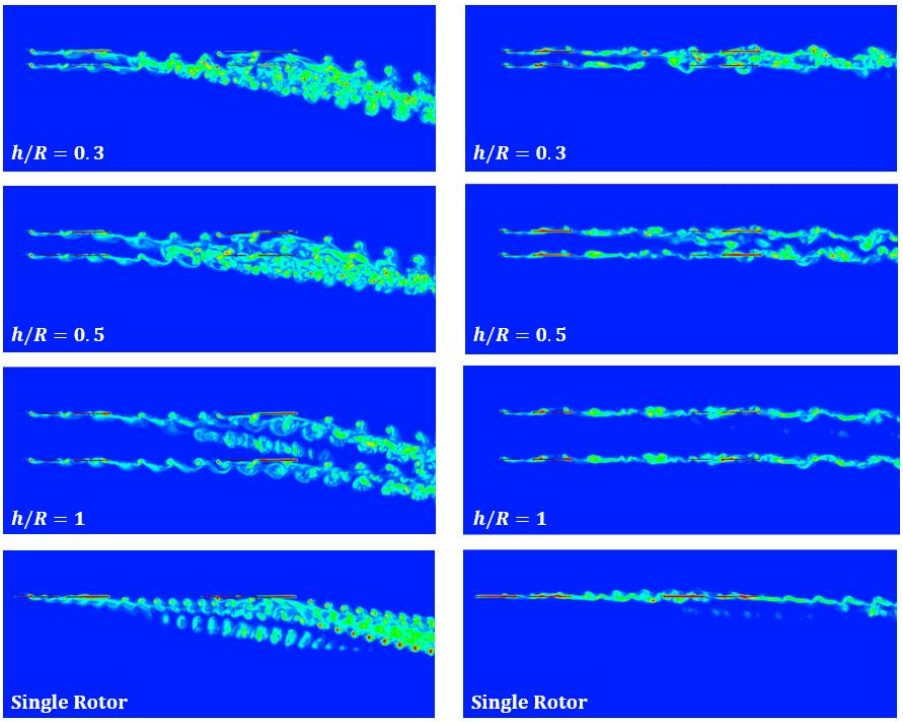

Fig. 1: Vorticity distribution in the cross-section of three coaxial rotors with different vertical rotor spacing and a single rotor

Publications

- Oral Presentations

Ryo Nishino (Nagoya University), Yasutada Tanabe, Hideaki Sugawara (JAXA), Shigeru Sunada (Nagoya University), "Impact of the Vertical Positions of Multi-Coaxial Rotors on Aerodynamic Performance and Noise", The 62nd Aircraft Symposium, 2024

Usage of JSS

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	24 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.51

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	0.00	0.00
TOKI-ST	4,351,396.67	4.47
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	0.00	0.00
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	1,001.31	0.68
/data and /data2	171,095.30	0.82
/ssd	5,238.26	0.28

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)	34.53	0.02

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