# Research on Airframe Noise Reduction Design in the FQUROH Project

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## Responsible Representative

Kazuomi Yamamoto, FQUROH Project Team, Aeronautical Technology Directorate

## Contact Information

Kazuomi Yamamoto　yamamoto.kazuomi@jaxa.jp

## Members

Kazuomi Yamamoto, Yasushi Ito, Takehisa Takaishi, Mitsuhiro Murayama, Ryotaro Sakai,
Tohru Hirai, Kentaro Tanaka, Kazuhisa Amemiya, Gen Nakano, Takashi Ishida

## Abstract

This research is being carried out as part of the FQUROH project aimed at raising the technical maturity level of the noise reduction technology for high-lift devices and landing gear, which draws international attention to reduce noise in areas around airports, to a level applicable to future development of aircraft and related equipment. This contributes to reduction of aircraft noise in local communities around the airport and airline operating costs by reducing landing fee. One of the objectives of the FQUROH project is to verify the feasibility of practical noise reduction concepts and design methods based on advanced computational simulations based on large-scale Reynolds-averaged Navier-Stokes (RANS) simulations and more advanced computational simulations, such as Large/Detached Eddy Simulations (LES/DES).

http://www.aero.jaxa.jp/eng/research/ecat/fquroh/

## Reasons for using of JSS2

The JSS2 was used to understand detailed physics of noise generation, to optimize noise reduction designs. The FQUROH project aims to accelerate technology maturity of airframe noise reduction methods using advanced computational simulations on the JSS2's high performance computing platform and to demonstrate the high-fidelity design technologies through flight tests. Computational simulations using the JSS2 made it possible to design low-noise devices by understanding detailed physical phenomena, which was difficult only with wind tunnel tests.

## Achievements of the Year

In the FQUROH project, unsteady flow simulations based on Delayed Detached Eddy Simulations (DDES) were conducted to improve noise reduction designs for slats, one of the major airframe noise sources. Two kinds of noise reduction devices have been investigated using DDES around representative parts of an actual aircraft wing with a limited span length. They were effective in DDES and wind tunnel tests using a scaled model. The aerodynamic and aeroacoustic effect of structural constrains due to small scale devices were also evaluated by computational fluid dynamics prior to the wind tunnel tests to reduce their risks.

In our simulations based on original DDES proposed by Spalart, it was confirmed that mixing of the shear layer from the slat cusp was delayed, which led to overestimation of acoustic peaks characteristic to the slat noise. Such the delay has been pointed out by several researchers and they also have proposed new definitions of subgrid length scale in DDES in order to solve this problem. In this research five subgrid length scales ever proposed have been tested through aeroacoustic simulations for the 30P30N and DLR F16 three-element high-lift airfoils known as benchmark problems for the slat noise. Mixing of the shear layer has been facilitated and flow statistics along the shear layer have been improved by using the subgrid length scales proposed by Deck or Shur in which the direction of vortex is taken into consideration. Due to geometrical constraints, computational meshes around the slats tend to stretch along spanwise direction. It has been found that the subgrid length scales focusing on cell spacings contributing to resolving vortices are needed to avoid possible negative effect caused by anisotropic cells around the slats.

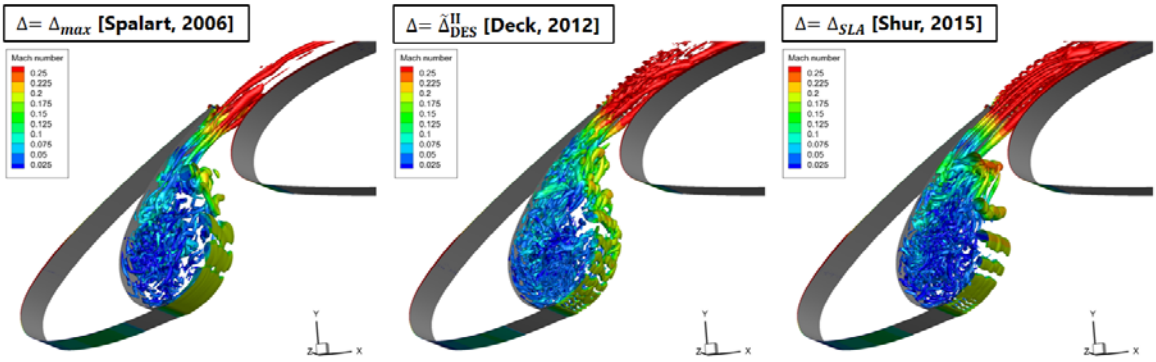


Fig.1 Comparison of isosurfaces of Q-criterion around the slat of DLR F16 airfoil (colored by Mach number) with different subgrid length scales

## Publications

- Non peer-reviewed papers

1) Yamamoto, K., Takaishi, T., Murayama, M., Yokokawa, Y., Ito, Y., Arizono, H., Sakai, R., Shoji, H., Ueno, Y., Isotani, K., Lee, H.-H., Inoue, T. and Kumada, T., "FQUROH: A Flight Demonstration Project for Airframe Noise Reduction Technology - the 1st Flight Demonstration," AIAA Paper 2017-4029, 23rd AIAA/CEAS Aeroacoustics Conference, Denver, CO, 2017, DOI: 10.2514/6.2017-4029.

2) Sakai, R., Ishida, T., Murayama, M., Ito, Y. and Yamamoto, K., "Effect of Subgrid Length Scale in DDES on Aeroacoustic Simulation around Three-Element Airfoil," AIAA Paper 2018-0756, 2018 AIAA Aerospace Sciences Meeting, Kissimmee, FL, 2018, DOI: 10.2514/6.2018-0756.

## Usage of JSS2

### Computational Information

| | |
|---|---|
| Parallelization Methods | MPI |
| Thread Parallelization Methods | N/A |
| Number of Processes | 1728 |
| Elapsed Time per Case | 130.00 hours |

### Resources Used

Fraction of Usage in Total Resources*1 (%): 5.81

Details

| Computing Resources | | |
|---|---|---|
| System Name | Amount of Core Time (core x hours) | Fraction of Usage*2 (%) |
| SORA-MA | 48,916,266.87 | 6.46 |
| SORA-PP | 36,243.83 | 0.45 |
| SORA-LM | 26.32 | 0.01 |
| SORA-TPP | 0.00 | 0.00 |

| File System Resources | | |
|---|---|---|
| File System Name | Storage assigned(GiB) | Fraction of Usage*2 (%) |
| /home | 064.49 | 0.04 |
| /data | 8,954.25 | 0.17 |
| /ltmp | 2,682.33 | 0.20 |

| Archiver Resources | | |
|---|---|---|
| Archiver System Name | Storage used(TiB) | Fraction of Usage*2 (%) |
| J-SPACE | 177.48 | 7.63 |

*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