1A13

TASを用いたNASA-CRMの空力解析

Aerodynamic Analysis for NASA-CRM using TAS solver

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Summary for Simulation Method

☐ Objective

Investigate the following two points about CFD code "TAS".

- Slope of lift curve in low-speed and low-AoA
- Tendency of C_L and C_m in high-AoA

☐ Simulation method

- CFD Code : TAS (Tohoku Univ. Aerodynamic Simulation Code)
- Computational mesh : In-house mesh generated by MEGG3D
- Simulation case : Case 1

☐ Simulated AoA

Submit data is Medium

- Coarse : -3.22 / -0.67 / 2.89 / 5.95 / 9.01 / 10.03 / 11.05 / 12.06 / 13.08 / 14.08 / 18.08
- Medium : -3.22 / -0.67 / 2.89 / 5.95 / 9.01 / 10.03 / 11.05 / 12.06 / 13.08 / 14.08 / 18.08
- Fine : -3.22 / -0.67 / 2.89 / 5.95 / 9.01 / 10.03 / 11.05 / 12.06 / 13.08 / 14.08 / 18.08

Numerical Method

☐ Solver information

Solver name	TAS
Governing Eq.	Compressible NS Eq.
Discretization	Cell-vertex finite volume
Inviscid flux	HLLEW + U-MUSCL
Time integration	LU-SGS
Turbulence model	Spalart-Allmaras

☐ Grid generation method

Grid generation tool	MEGG3D provided by JAXA
Type	Unstructured mesh

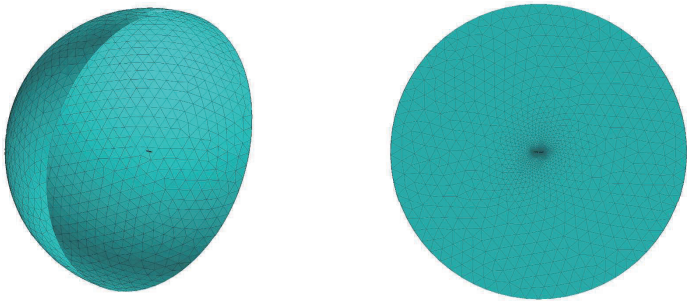
TAS code used in this paper is an original MPI version, so hexa mesh cannot be used.
→Computational grid has been generated without hexa mesh.

Computational Grids

☐ Grid information

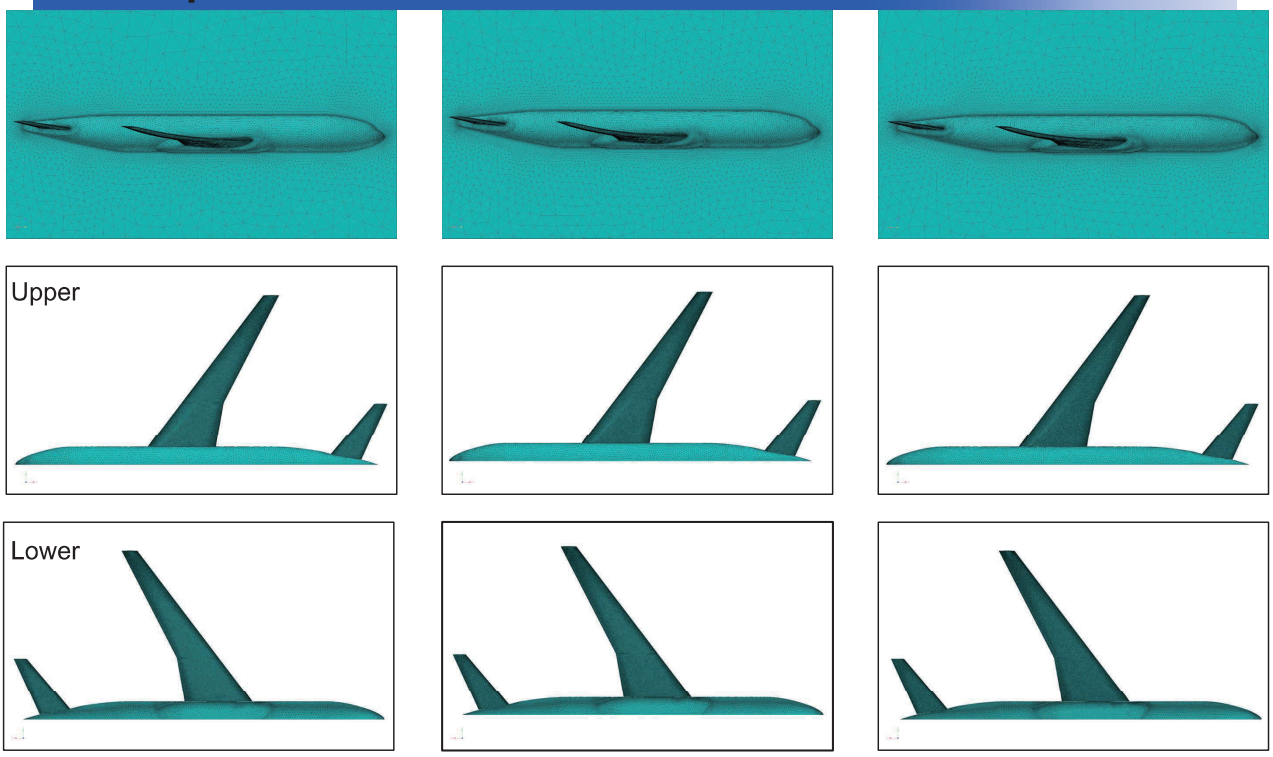
x 1.15 x 1.15

	Coarse	Medium	Fine
Number of elements	45,105,223	64,636,349	92,372,151
Number of nodes	16,275,869	23,581,655	34,490,859
Number of prism layer	39	45	52
Growth rate of prism layer	1.233	1.200	1.172
max y+	～1.61	～1.41	～1.25



External boundary of medium grid

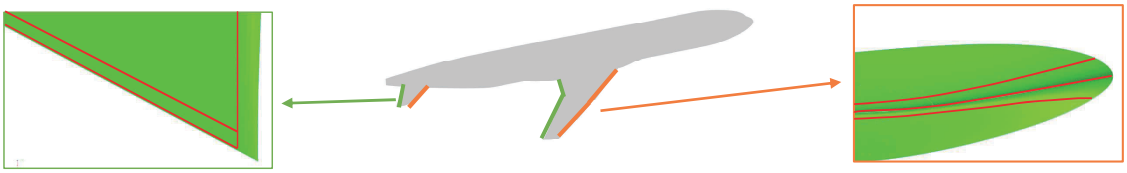
Computational Grids



Coarse Medium Fine

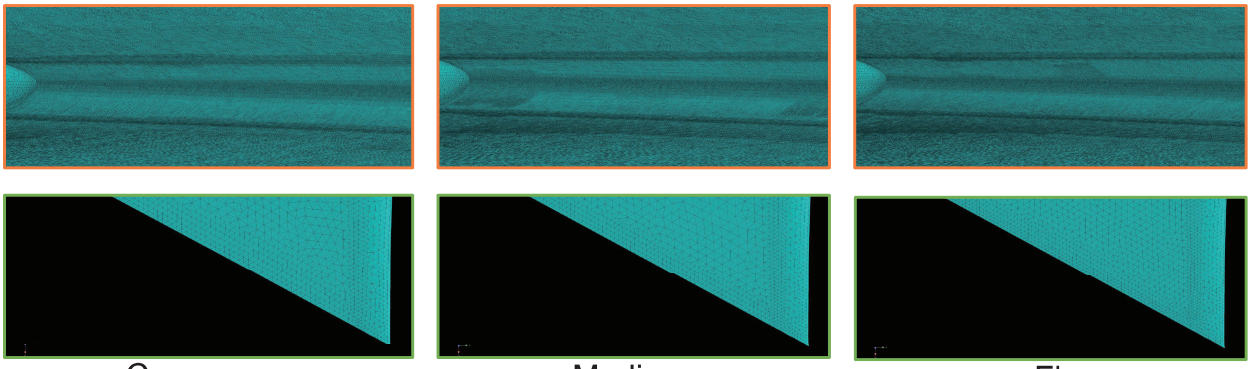
Computational Grids

- Feature of the surface grid to improve the quality



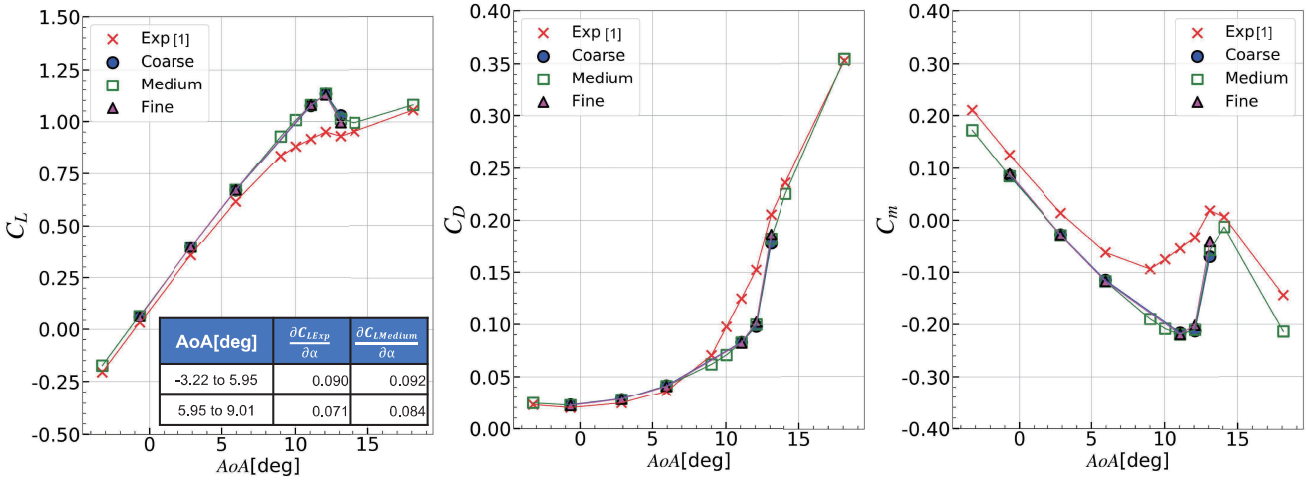
Arrange the very fine mesh
a little far from the trailing edge

Appended the ridge at upper and
lower of the leading edge



Coarse Medium Fine

Results C_L, C_D and C_m



AoA[deg]	$\frac{\partial C_{LExp}}{\partial \alpha}$	$\frac{\partial C_{LMedium}}{\partial \alpha}$
-3.22 to 5.95	0.090	0.092
5.95 to 9.01	0.071	0.084

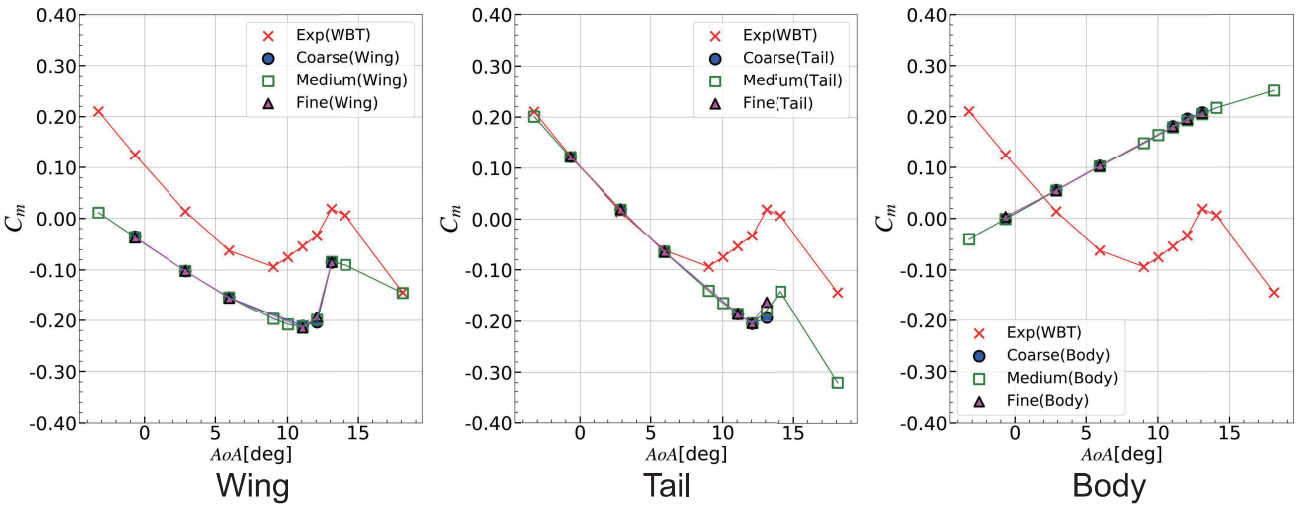
[1] : Takahiro Uchiyama, Masataka Kohzai, et al.
"Experimental Investigation of a 160% Scaled NASA Common Research Model at Low Speed Conditions,"
7-11 January 2019, San Diego, California, AIAA Scitech 2019 Forum, AIAA 2019-2190.

C_L :
- There are a little difference between Coarse, Medium and Fine at 13.08deg.
- The experimental result is changing the slope of lift curve after 5.95deg, but TAS is increased linearly.
- AoA at C_{Lmax} of TAS is in good agreement with the experiment. However, TAS estimate C_{Lmax} 0.18 larger than the experiment.

C_D :
- TAS estimate ～ 50 drag count large to 5.95deg.

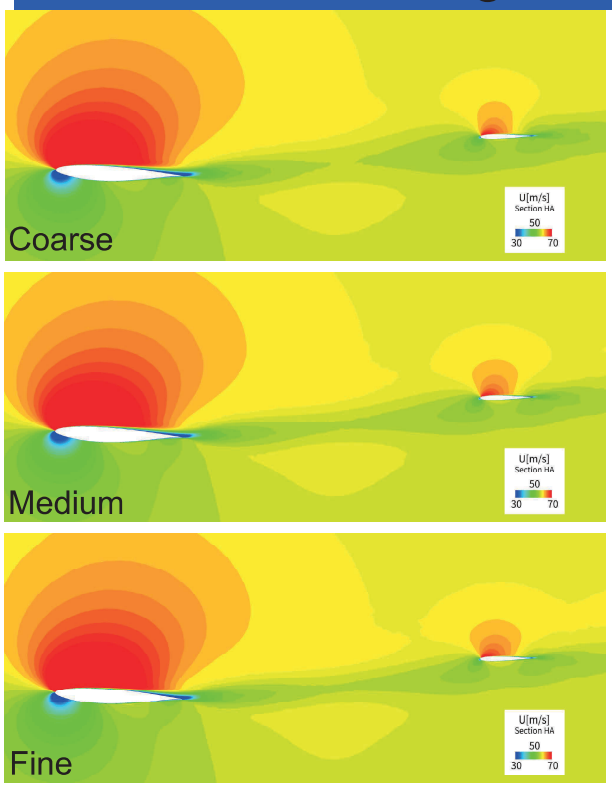
C_m :
- Each mesh could capture the similar trends of the experiment, but the value is estimated small.

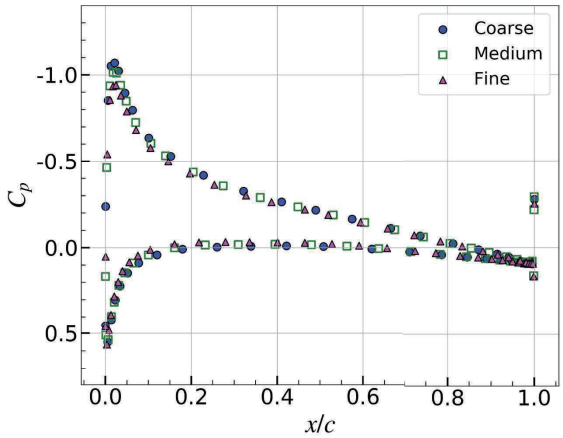
Results C_m



- Differences between grids appeared in 13.08deg at the tail.
- If C_m in the tail increases in the pitch up direction, it will be close to the experimental result.

Results 13.08deg U-velocity at Section HA

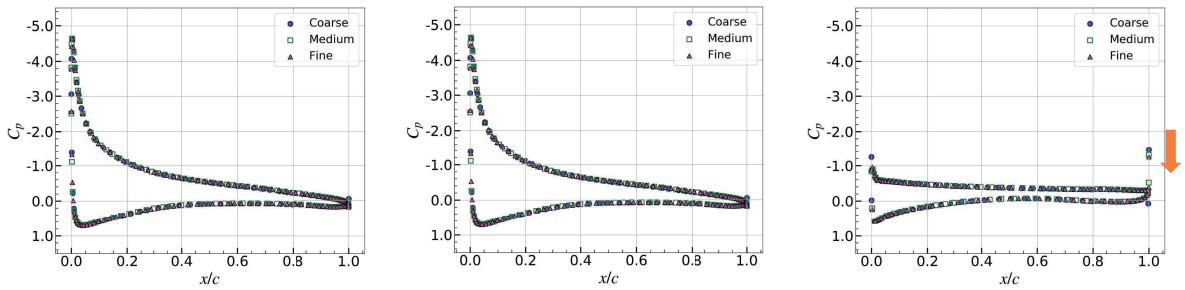




Section HA

- The wake distribution is different by mesh quality.
- As the mesh is finer, the wake velocity of the wing that hits the tail becomes low. Therefore, tendency of aerodynamic coefficient for fine mesh is different from coarse mesh.

Results C_p AoA=13.08deg



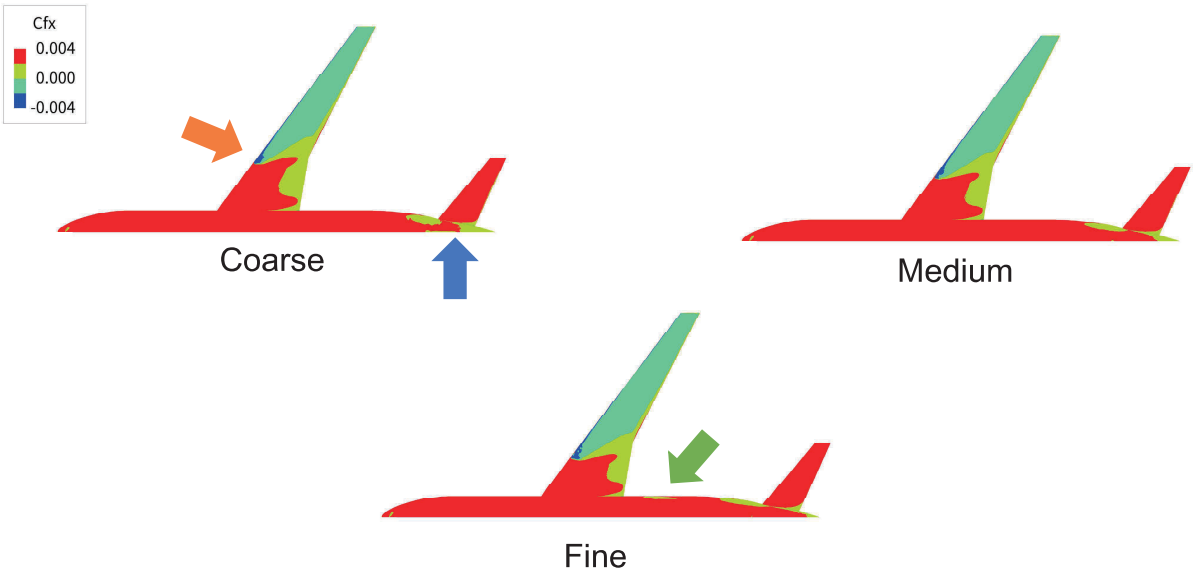
Section A Section E Section I

Upper

Coarse Medium Fine

- C_p is almost matched between grids at the wing except for trailing edge.
- The change in the C_p around the trailing edge becomes smaller by increasing the grid points.

Results C_{fx} AoA=13.08deg



- The differences between mesh at wing could see around kink.
- As the grid becomes finer, the attached flow area is large at the rear of the body.
- Only in fine mesh, the separation area on the body surface is appeared.
  (However, the difference from around this area is less than 0.0001.)

Conclusion

- Conducted the CFD simulation for NASA-CRM using TAS solver at the low-speed condition.

1. Lift coefficient

- The following two points were confirmed that TAS is matched with wind tunnel tests.
  - ✓ Lift slope
  - ✓ Angle of attack at C_{Lmax}
- C_{Lmax} is overestimated.

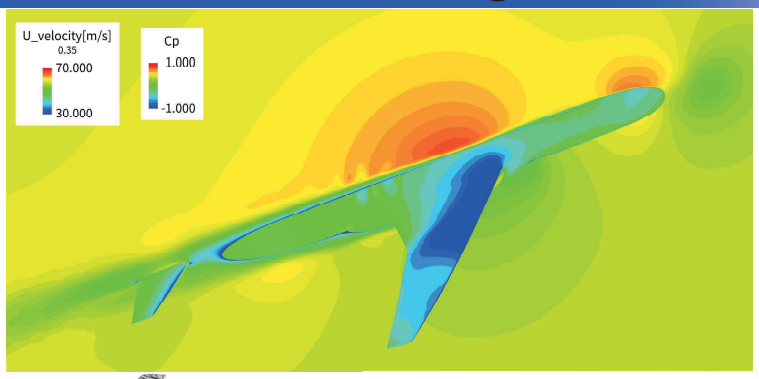
2. Moment coefficient

- TAS tend to estimate small in all angle of attack.
- It can capture the pitch up trend after separation.

3. Future task

- Generate the mesh which is denser for spatial direction to improve the aerodynamic coefficient.

Appendix Fine, 13.08deg



Boundary : Cp
Coordinate : U_velocity