Using CEASIOM-SUMO Rapid-Meshing in Computational Study of Asymmetric Aircraft Design

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Key words explanation:

1. CEASIOM

2. SUMO

3. RDS

What is CEASIOM?

- Computerized Environment for Aircraft Synthesis and Integrated Optimization Methods

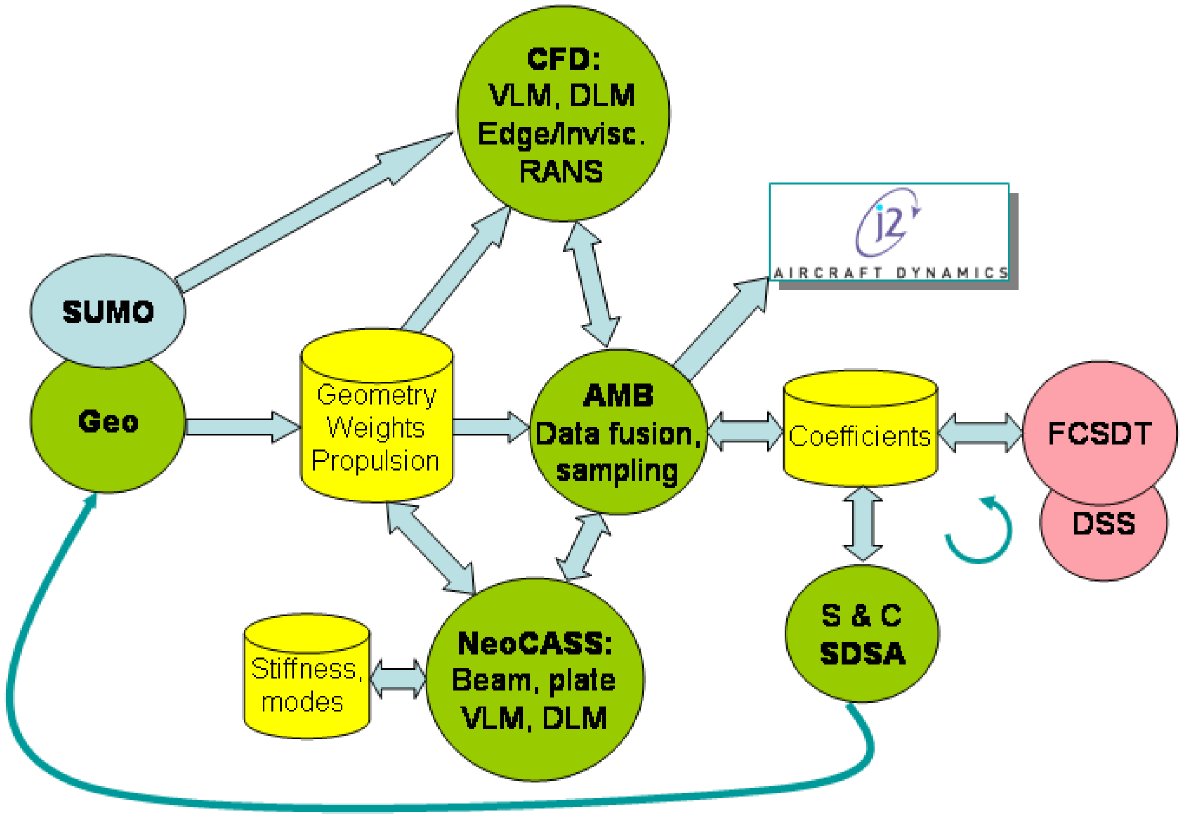
- Supported and developed within 6th FP project SimSAC

- A set of tools for aircraft preliminary design

- Aerodynamic dataset generation tools:

- DATCOM : empirical
- Tornado: VLM
- EDGE : Euler

CEASIOM overview



SUMO

- Quick & automatic surface mesh generator

  - surface-modeling and grid-generation tool developed by KTH (http://larosterna.com/sumo.html)

- Automatic unstructured volume mesh generated together with TetGen (http://tetgen.berlios.de/)

- Could handle CAD geometry from various of sources
  - One of them is: RDS

- Aim: Enable early computational analysis

- Key: Rapid-meshing

- take rough CAD model and quickly create a meshable model

- How? With SUMO tool (SUrface MOdeller)

- embodied into CEASIOM framework
- prepares volume mesh for Euler calculation

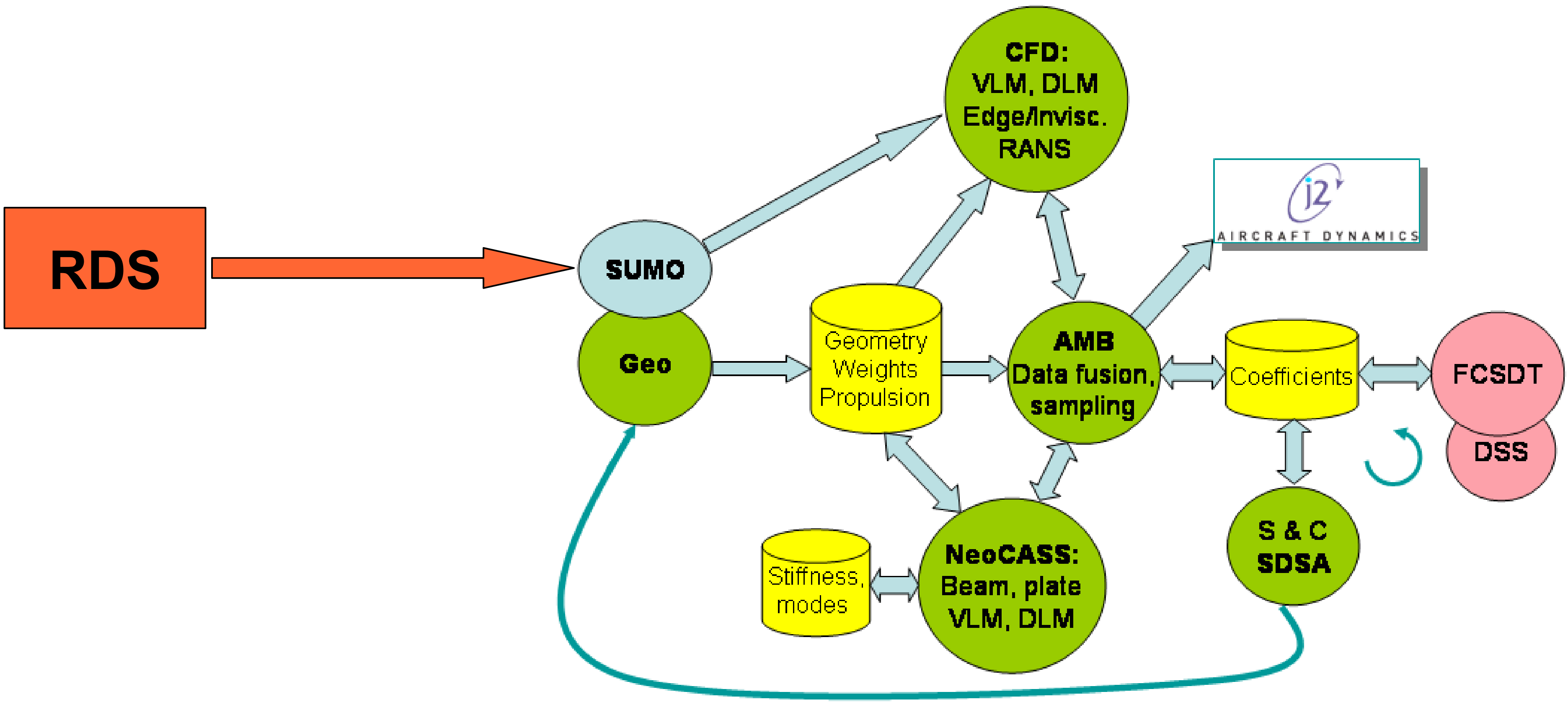
RDS – Integrated Aircraft Design & Analysis software

- Developed by Dr. Raymer

- Includes MDO (Multidisciplinary Design Optimizer) module and coupl0ed with CAD module for automatic design revision
- → introduces even more of model inconsistencies that are difficult to mesh
- → requires a grid tool that turns the through CAD into a meshable model
- → only small amount of manual intervention is acceptable

RDS – aircraft geometry representation strategy

- Defined by components: wing, tail, fuselage, tire, etc...
- The surface of each component is represented by : 1. surface points; 2. quartics (4^{th} Bezier curve)
- Each component has its own axis system
- Component symmetry options


RDS
SUMO
Geo
CFD:
VLM, DLM
Edge/Invisc.
RANS
AIRCRAFT DYNAMICS
Geometry
Weights
Propulsion
AMB
Data fusion,
sampling
Coefficients
FCSDT
DSS
Stiffness,
modes
NeoCASS:
Beam, plate
VLM, DLM
S & C
SDSA

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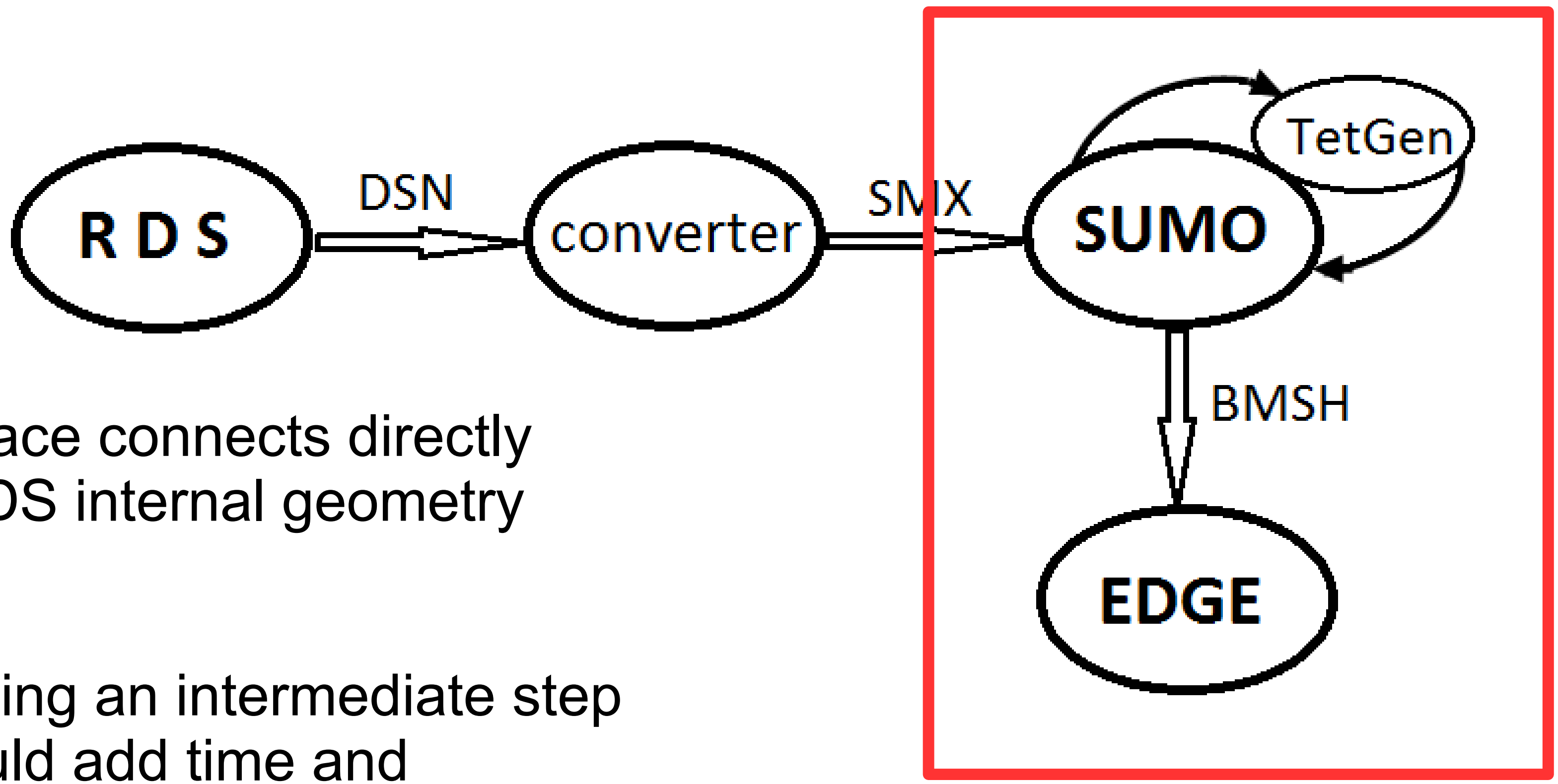
RDS-SUMO-CEASIOM process:
Aircraft design software into rapid-meshing loop

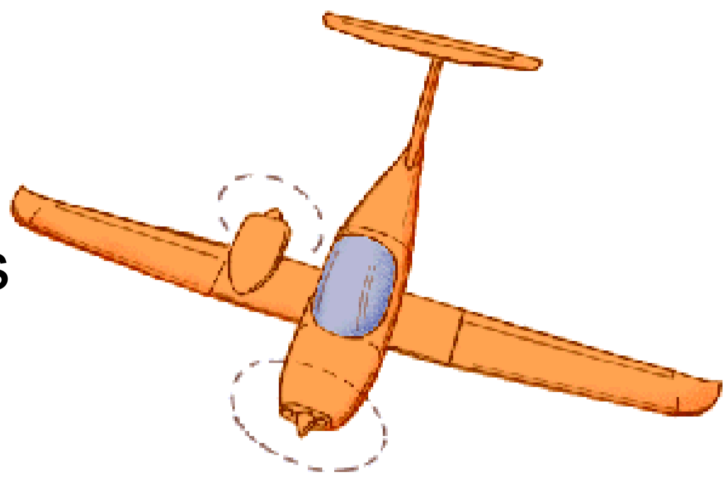


- Interface connects directly from RDS internal geometry format
- Avoiding an intermediate step that could add time and inaccuracies

Inside CEASIOM

Test Case: asymmetric aircraft concept

- Developed by Dr. Raymer
- Twin-prop with tractor and pusher
- Offset fuselage
- Facilitates collaborative working – Los Angeles & Stockholm
- Meshable model ready after less than 2 hours work including manual intervention
- Euler solutions for stability analysis and re-sizing the rudder



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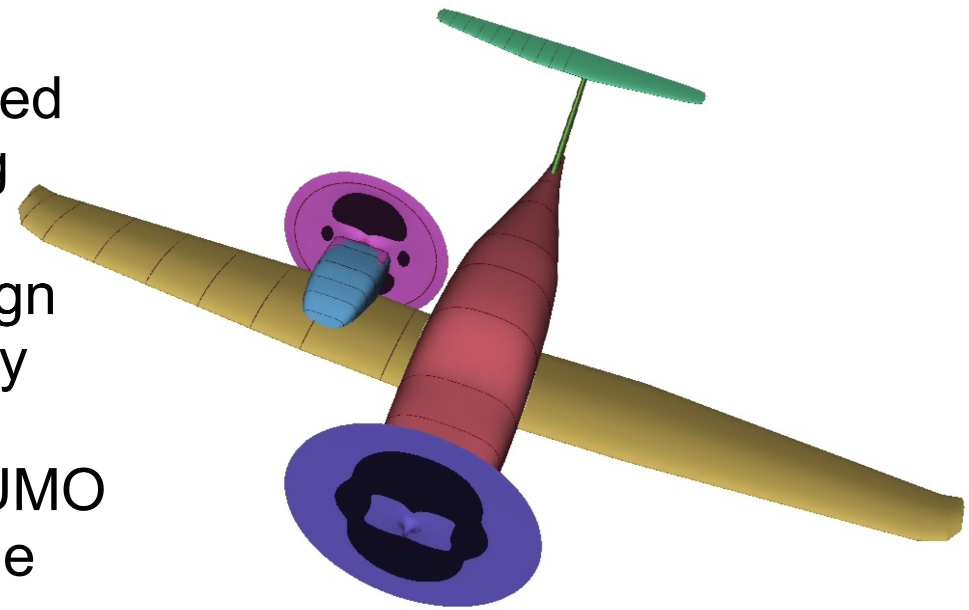
From RDS imperfect CAD to SUMO meshable model

- Automatically done by applying a set of Matlab scripts, usually for conventional configurations

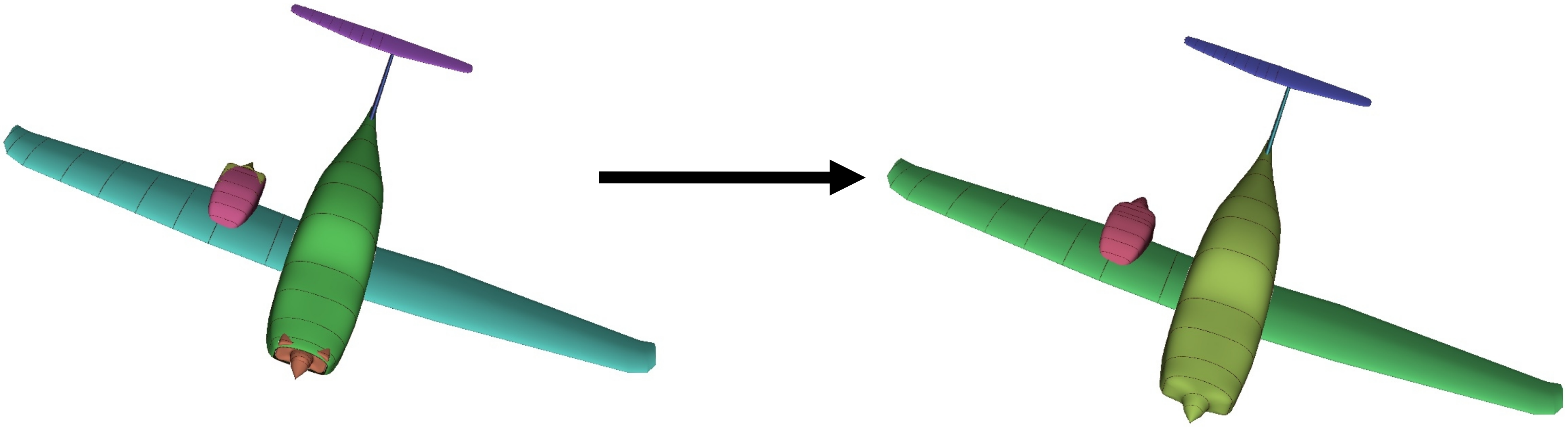
- Some manual interventions are required for this case to avoid possible meshing errors, because:

- the geometry mathematics of the Design Layout Module which is NOT necessarily turning out a meshable model
- infinite thin disk is non-meshable in SUMO
- complicated end section of the fuselage



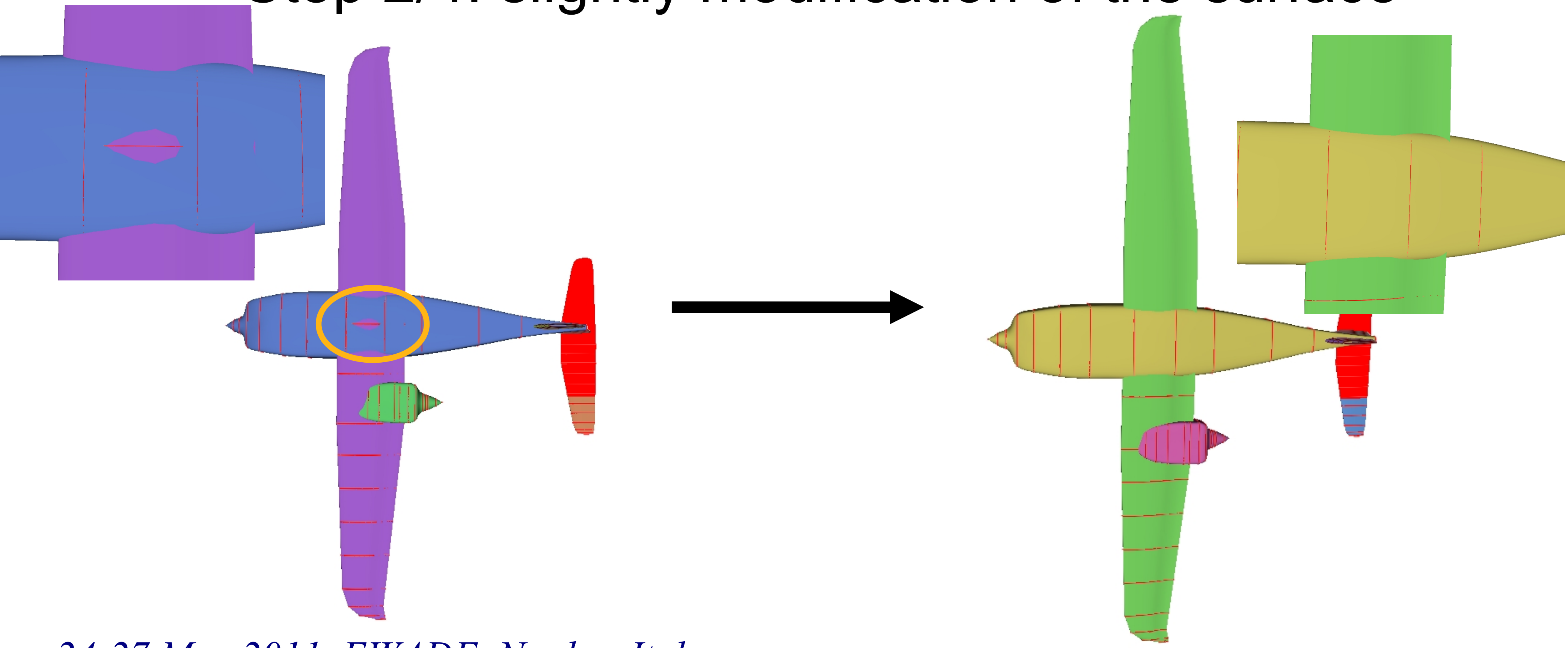
Manually rendering the RDS-SUMO model

Step 1/4: remove nacelle
&
Re-modeled the nose of the fuselage and nacelle by single surfaces

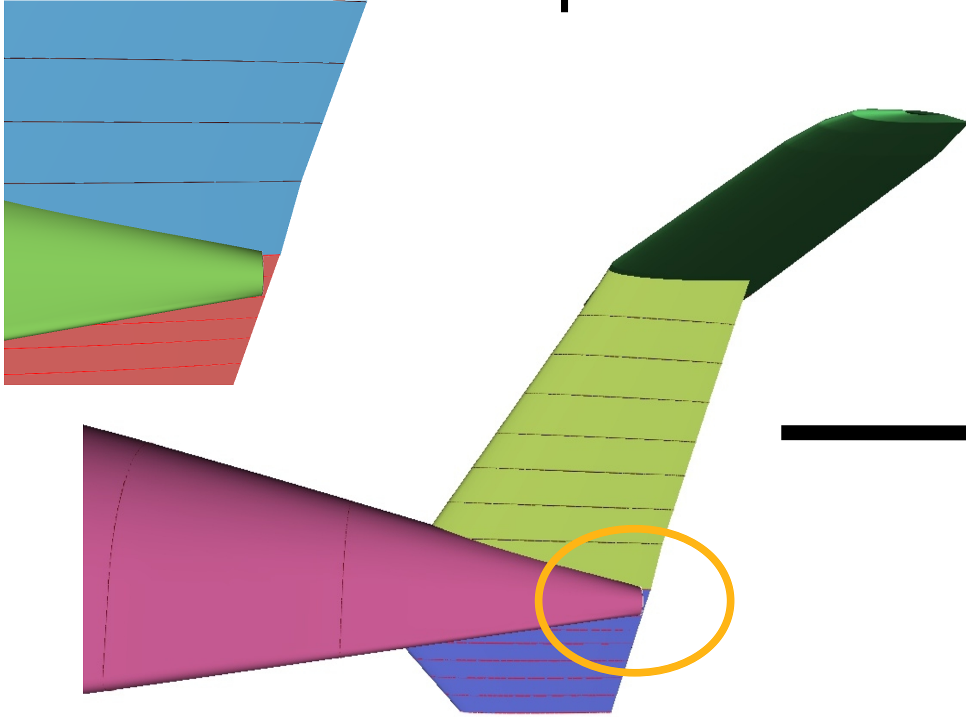


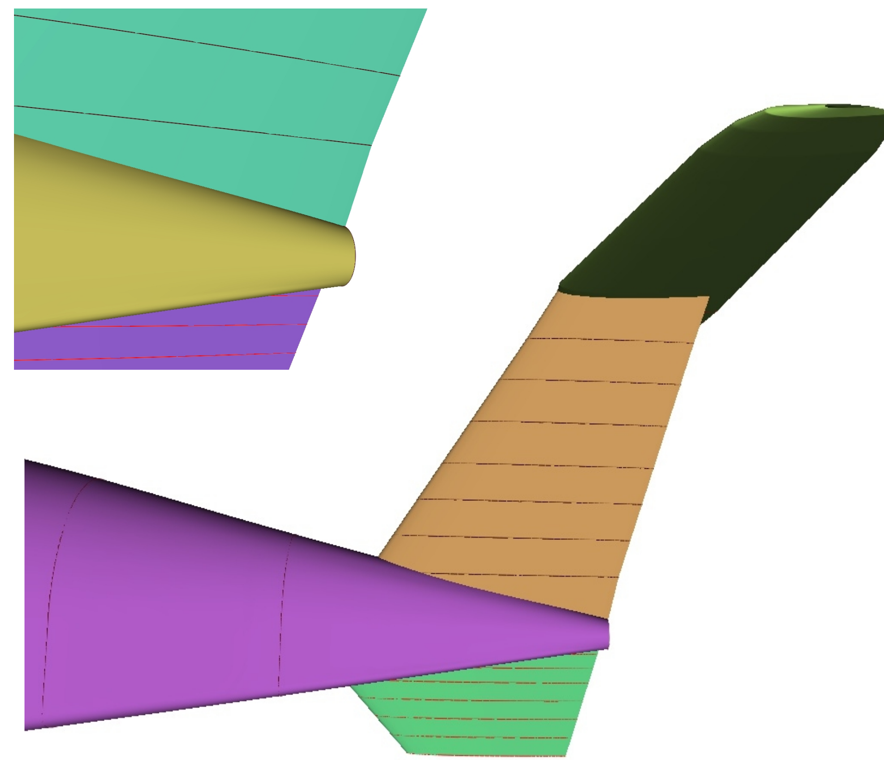
Manually rendering the RDS-SUMO model

Step 2/4: slightly modification of the surface



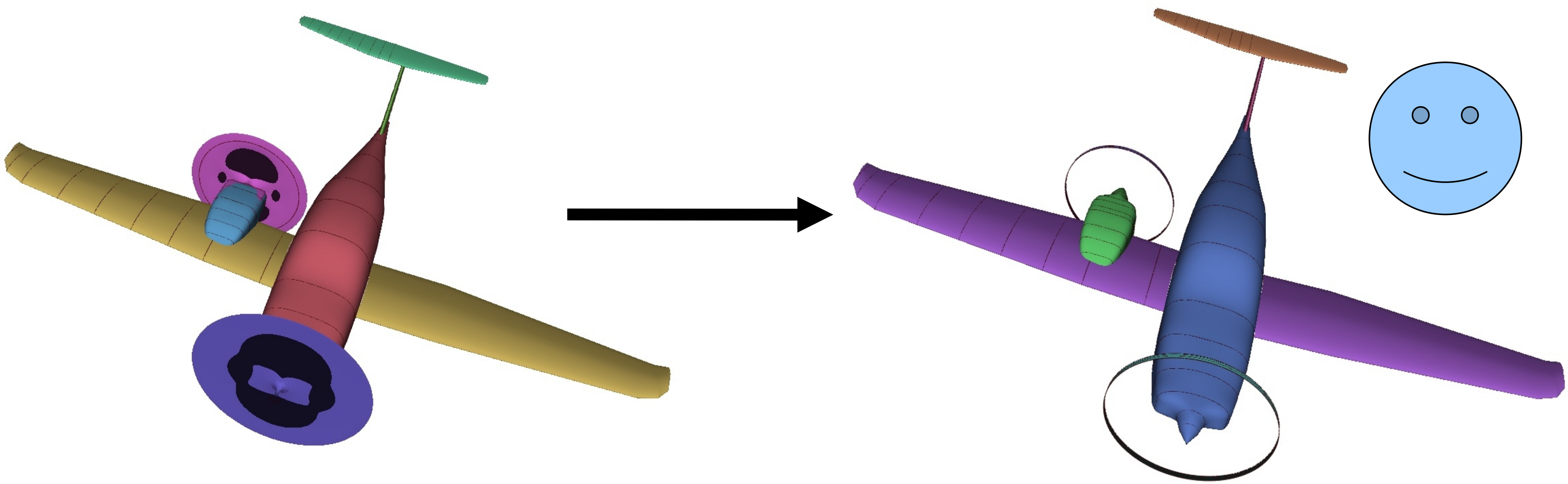
Manually rendering the RDS-SUMO model
Step 3/4: vertical/ventral tail remedy



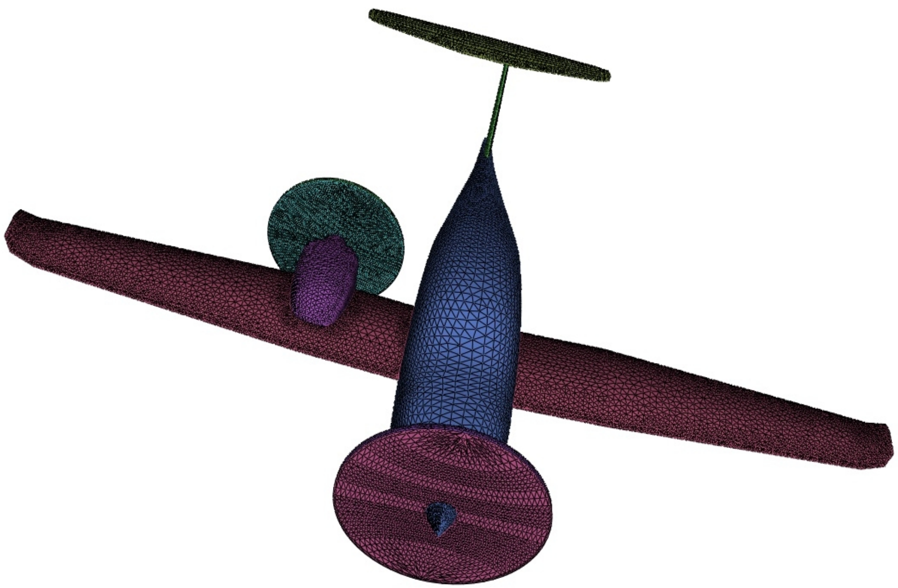


Manually rendering the RDS-SUMO model

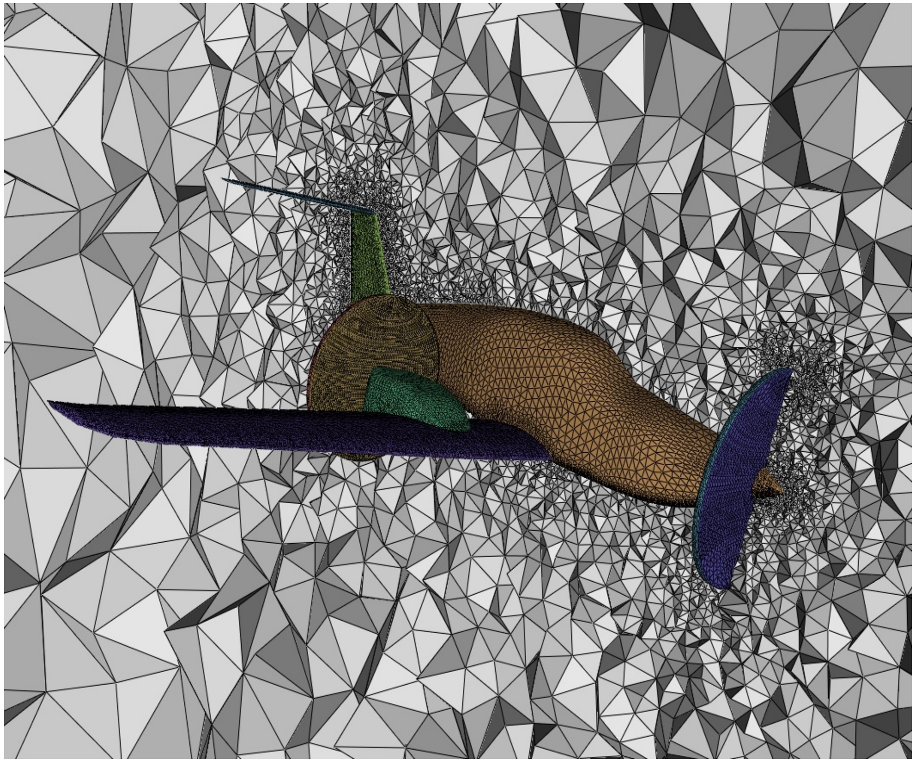
Step 4/4: add a “very short” nacelle as propeller



SUMO mesh (+ TetGen for volume mesh)



SUMO surface mesh



Volume mesh (~1.6 M nodes) used for Euler EDGE calcuation

Propeller modeled in EDGE

- In EDGE standalone: disk model (available for mesh that made from commercial meshing software (ICEM/CFD)

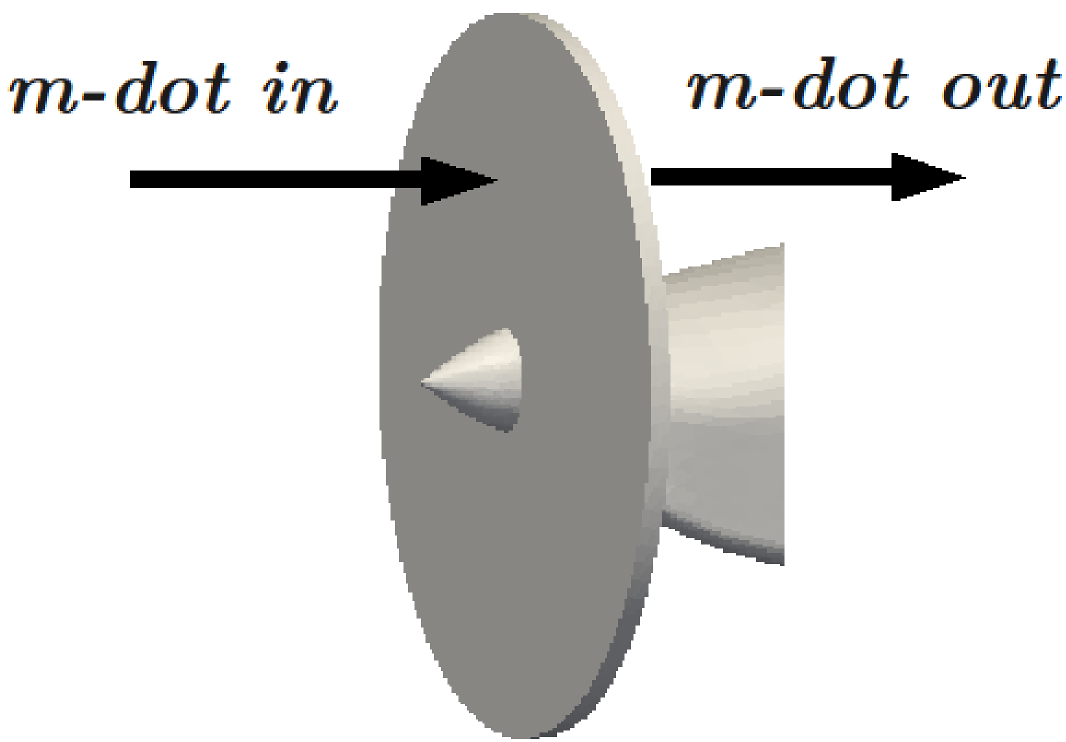
- In CEASIOM (SUMO): disk model is NOT available

- Idea: adds a momentum to the propeller that results pressure jump → "very short" nacelle to present the propeller

- Mass flow boundary condition
    - Specification of the mass flow into and out of the disk

Modeling propeller in SUMO-CEASIOM:

the mass flow rate m-dot goes in and out



- Adds a momentum that provides the pressure jump
- Cannot account for finer details such as swirl in the propeller slipstream
- The propeller thrust is chosen to balance the estimated cruise drag

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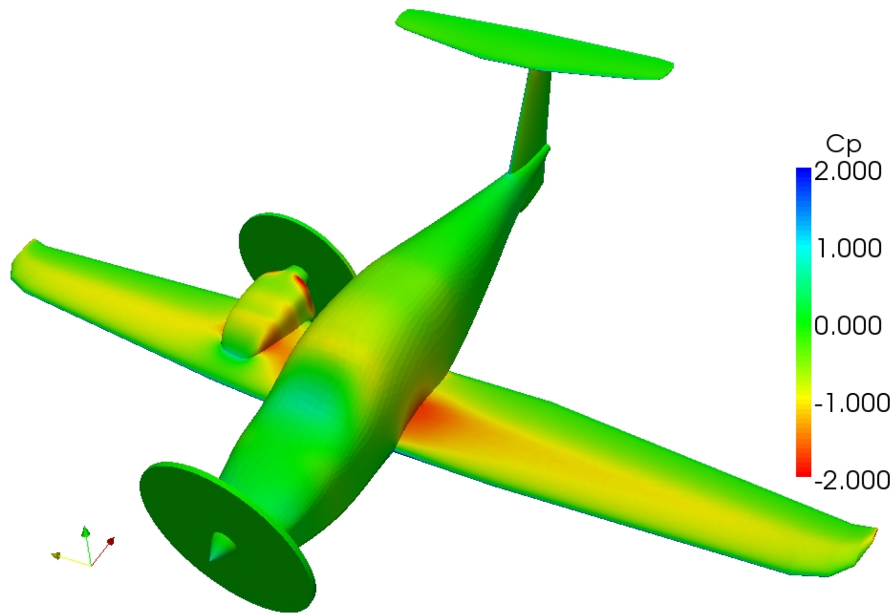
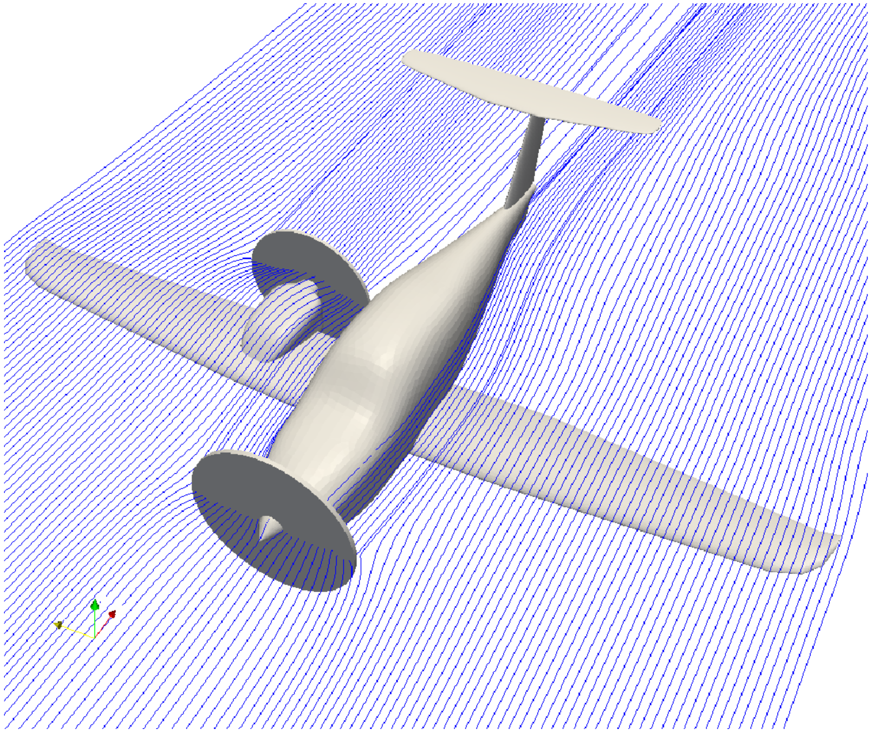
Results collected: CP and flow streamline -1





M = 0.282, AoA = 1.2 deg

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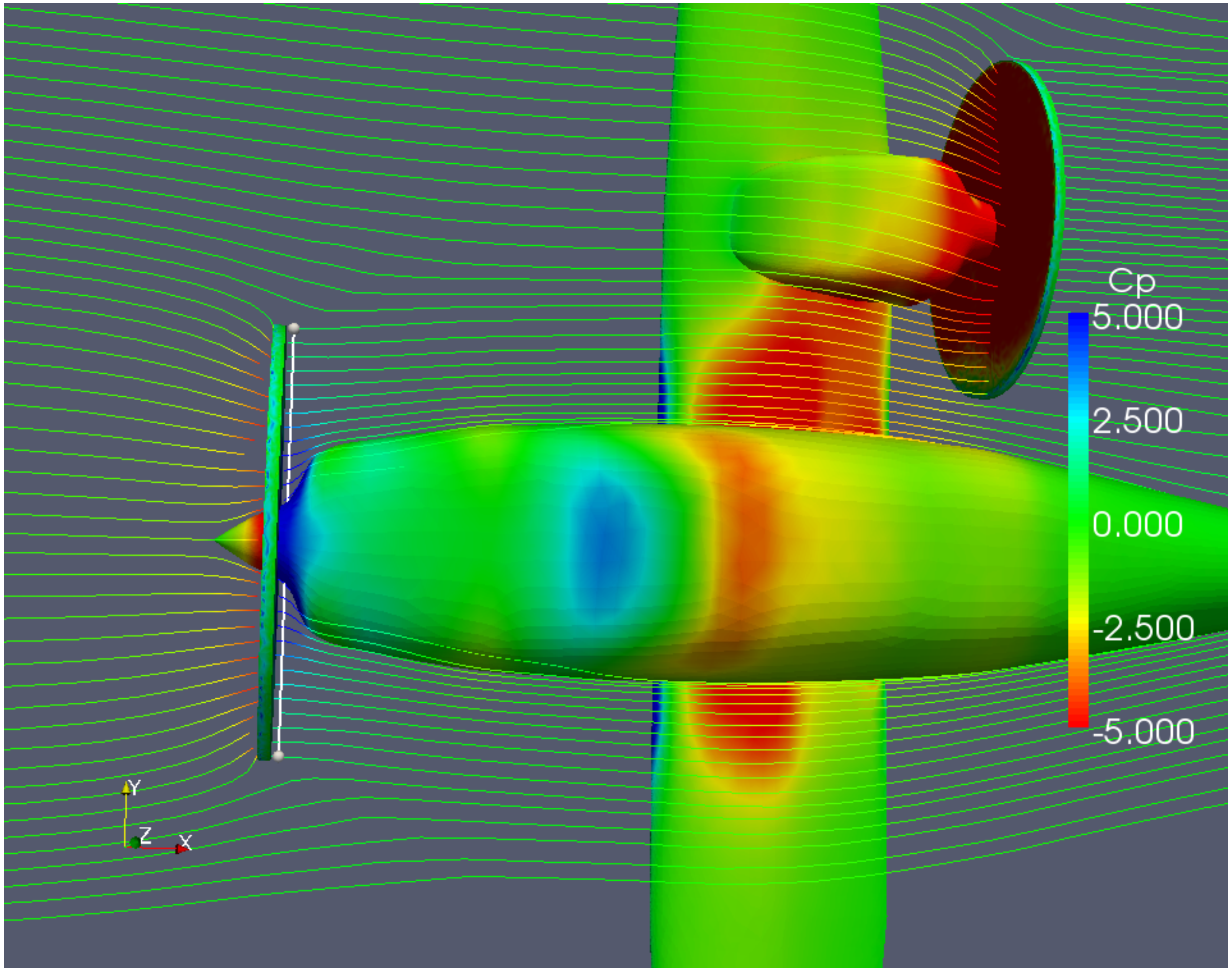
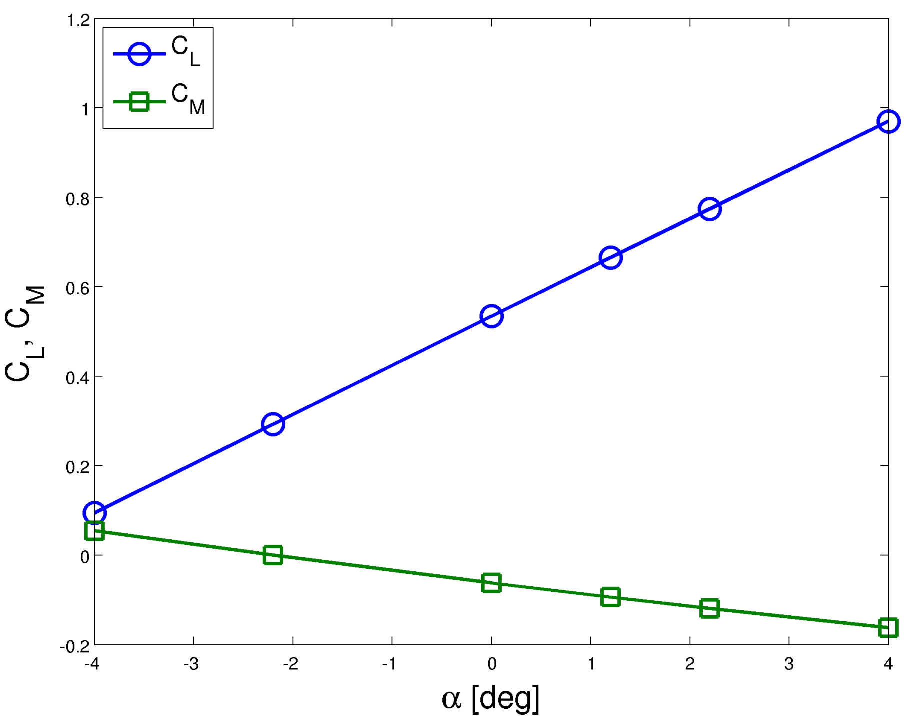
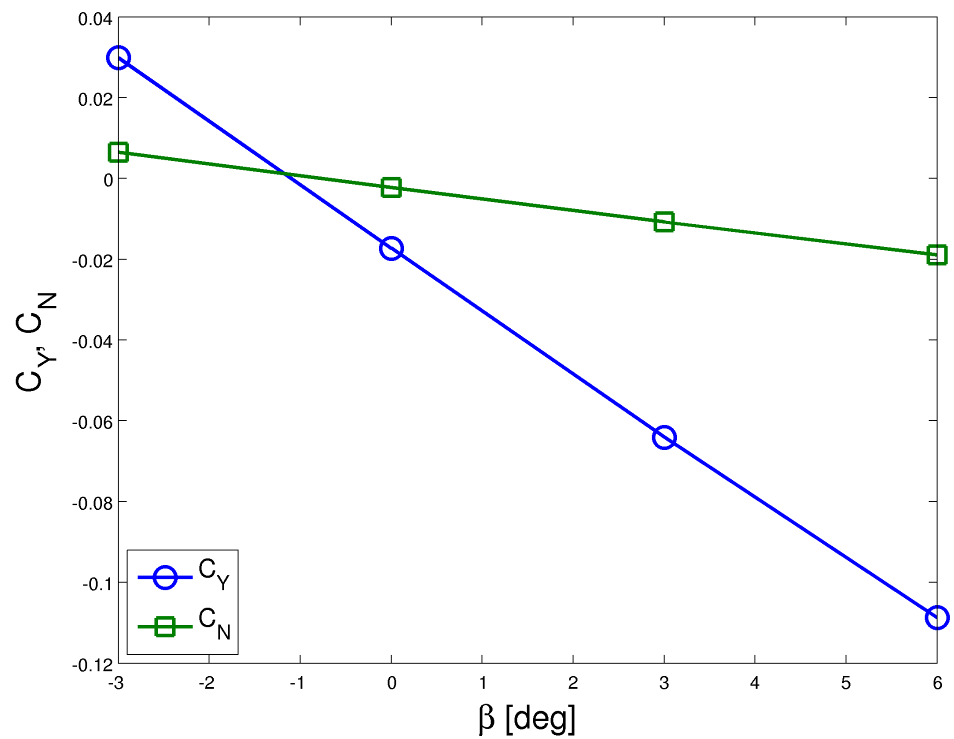
Results collected: CP and flow streamline -2



Results collected: aerodynamic forces and moments





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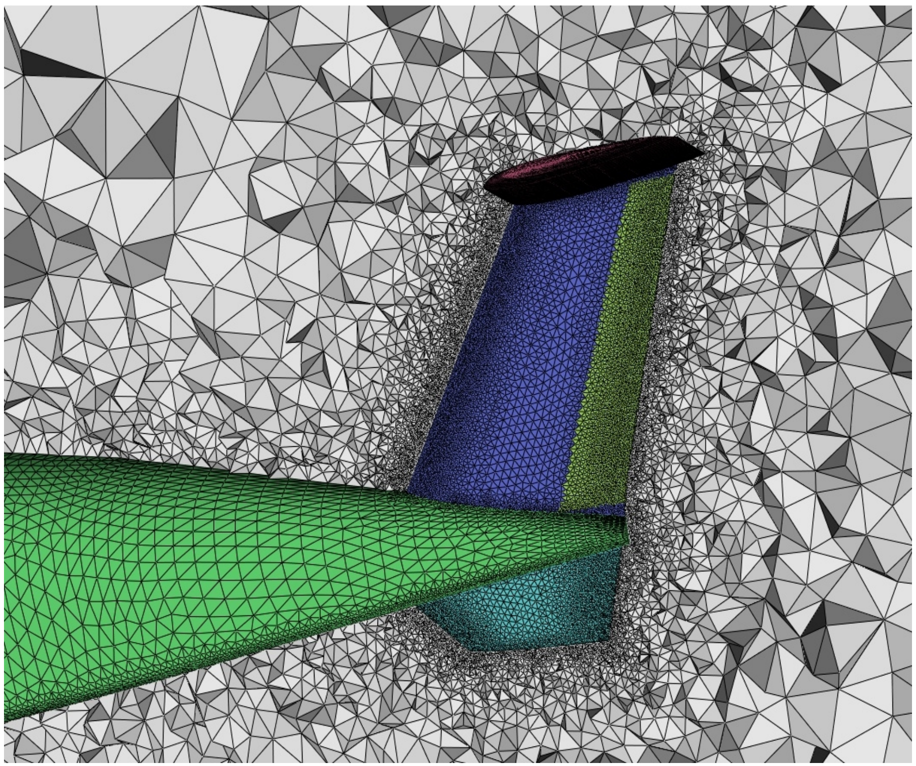
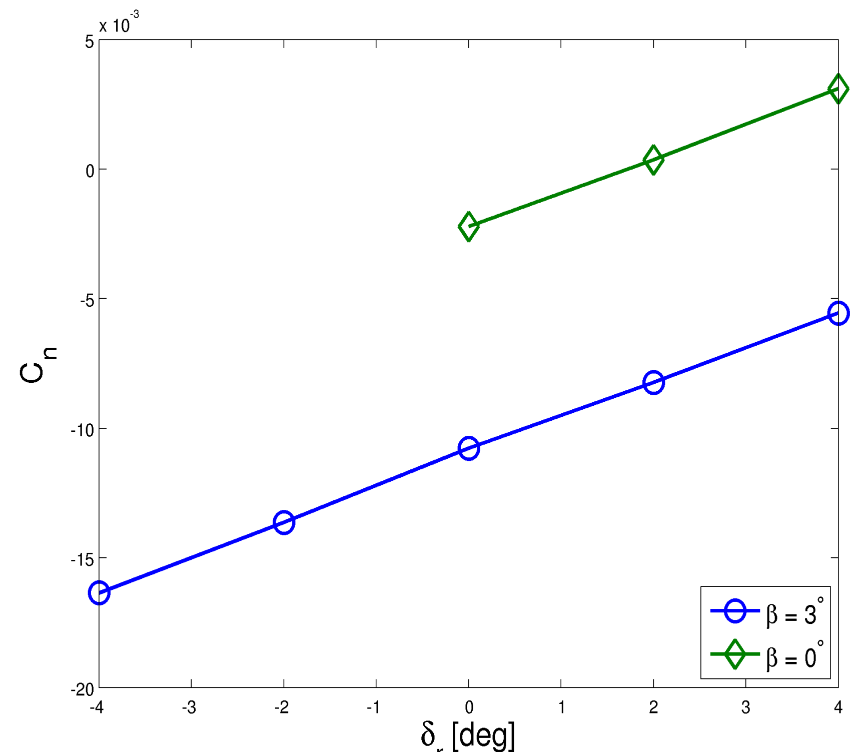
Results collected: trim in yaw



Rudder visualized in mesh
Transpiration bc applied



Beta = 0 deg, delta ~ 2 deg to left to trim in yaw
Beta = 3 deg (nose left), delta ~ 8 deg to left to trim in yaw

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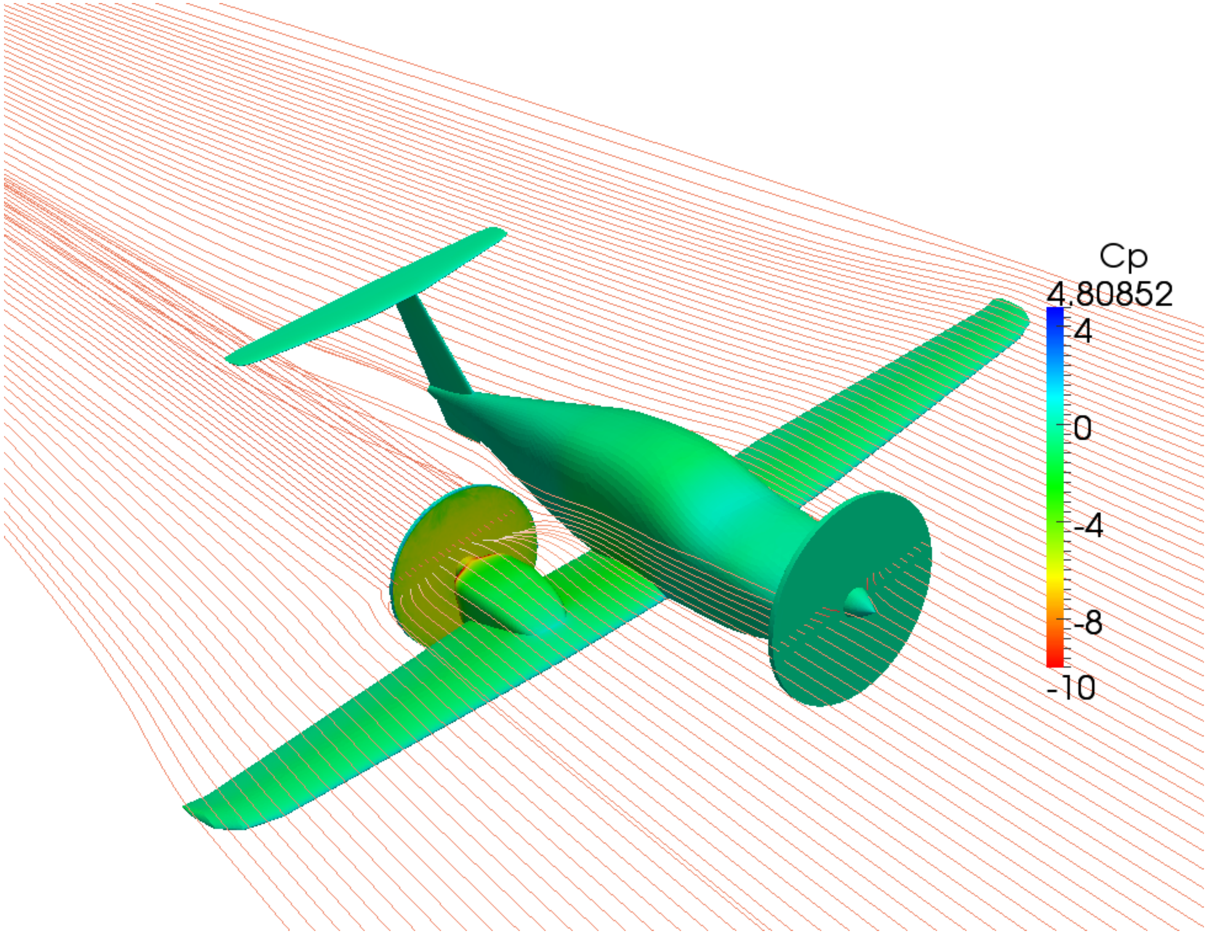
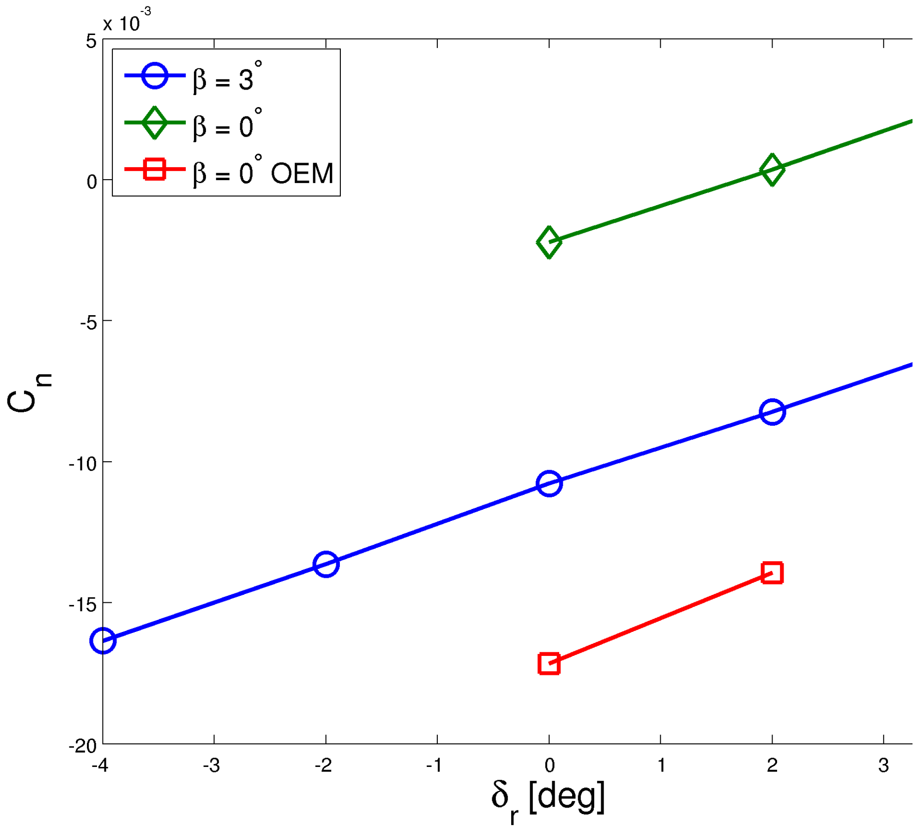
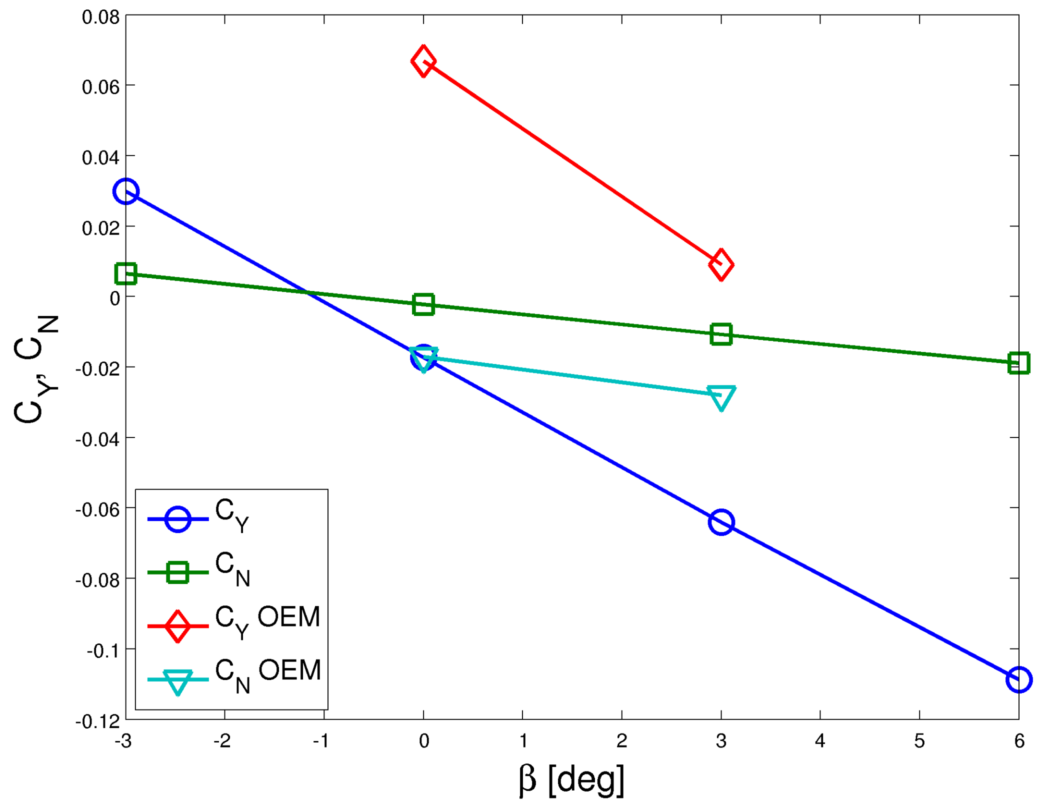
Investigation: One engine-out mode (OEM)

- Front engine, the tractor lost function
- Only the pusher mounted on the wing provides thrust
- More flow accelerated by the single propeller



Investigation:
One engine-out mode (OEM)





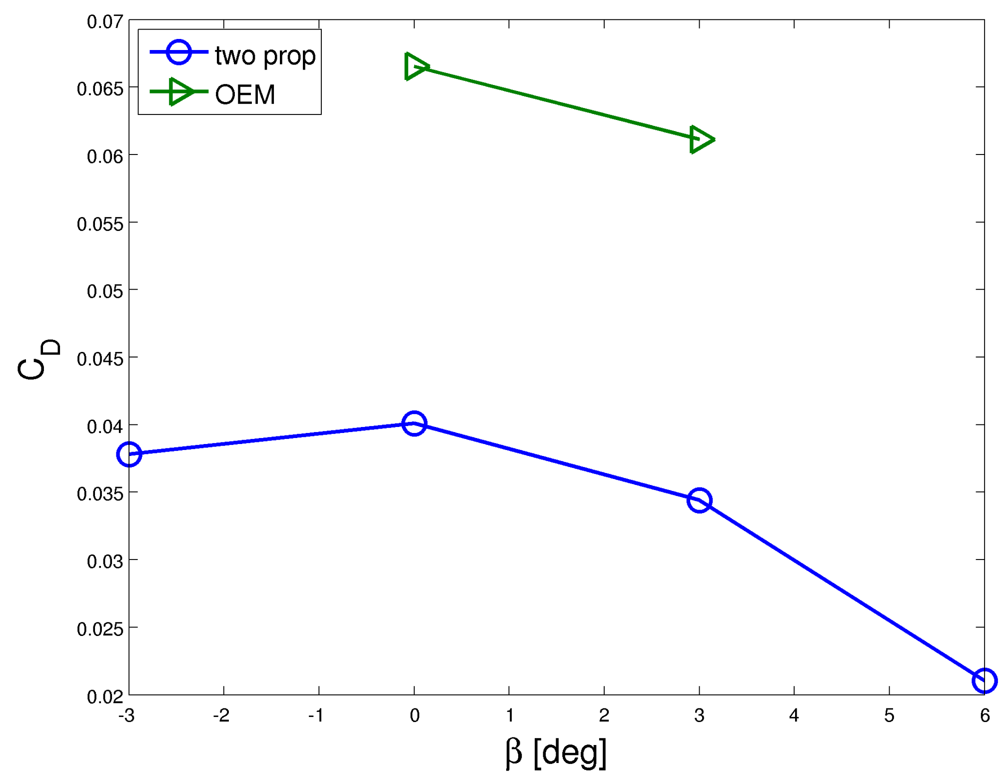
Investigation:
One engine-out mode (OEM)

- Needs more rudder deflections to fly at beta = 0

- Or needs more negative beta to fly with less rudder deflection

- Or think about re-sizing the rudder

- Substantively increased in drag, needs more thrust



Conclusion and future work

- Fast meshing tool is efficient and simple to turn a rough CAD to a meshable model which would be available for getting further CFD solutions and flying analysis
- Propeller model developed in SUMO-CEASIOM has expected performance
- The one engine-out mode needs to be investigated more
- A design-optimized loop between RDS and CEASIOM could be made in the future

The end

Thanks for your attention