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Initial Static Stability Analysis for Composite UAVs

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Overview

1. Introduction
2. Methodology
3. Analysis
4. Results
5. Conclusion

Introduction

Preliminary assumptions

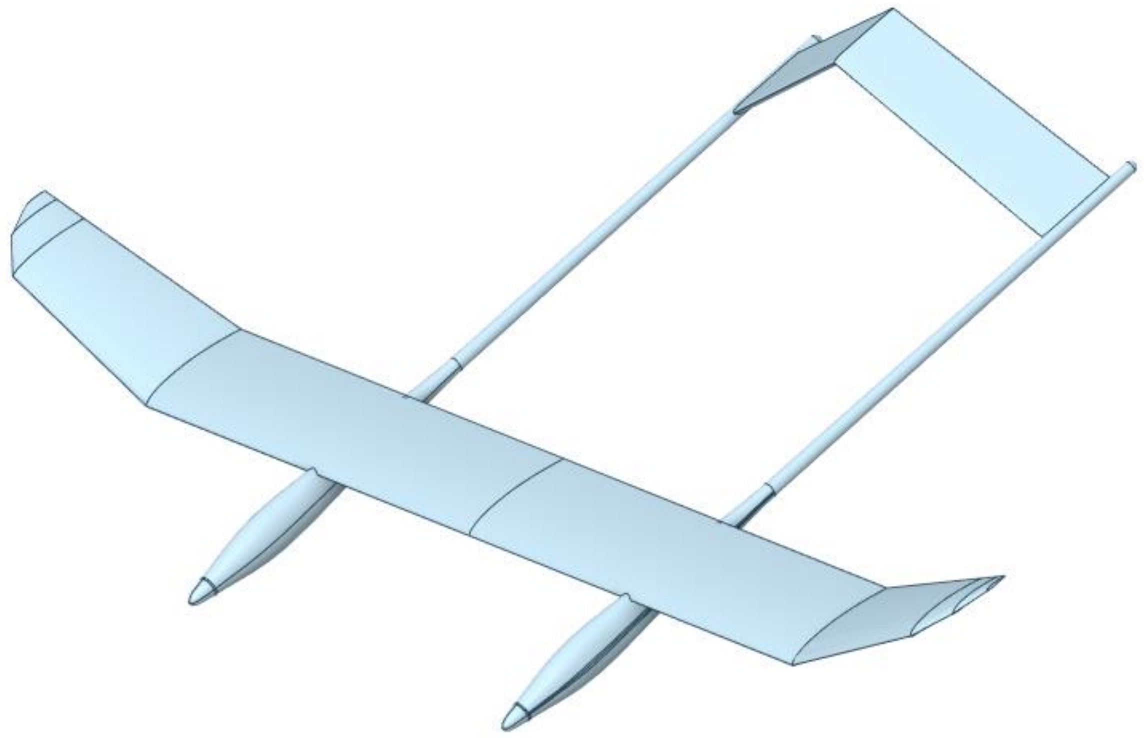
Unmanned Aerial Vehicles (UAVs) have seen significant advancements in recent years. Composite materials offer lightweight and strong alternatives to traditional materials. This study focuses on the initial static stability analysis of composite UAVs.

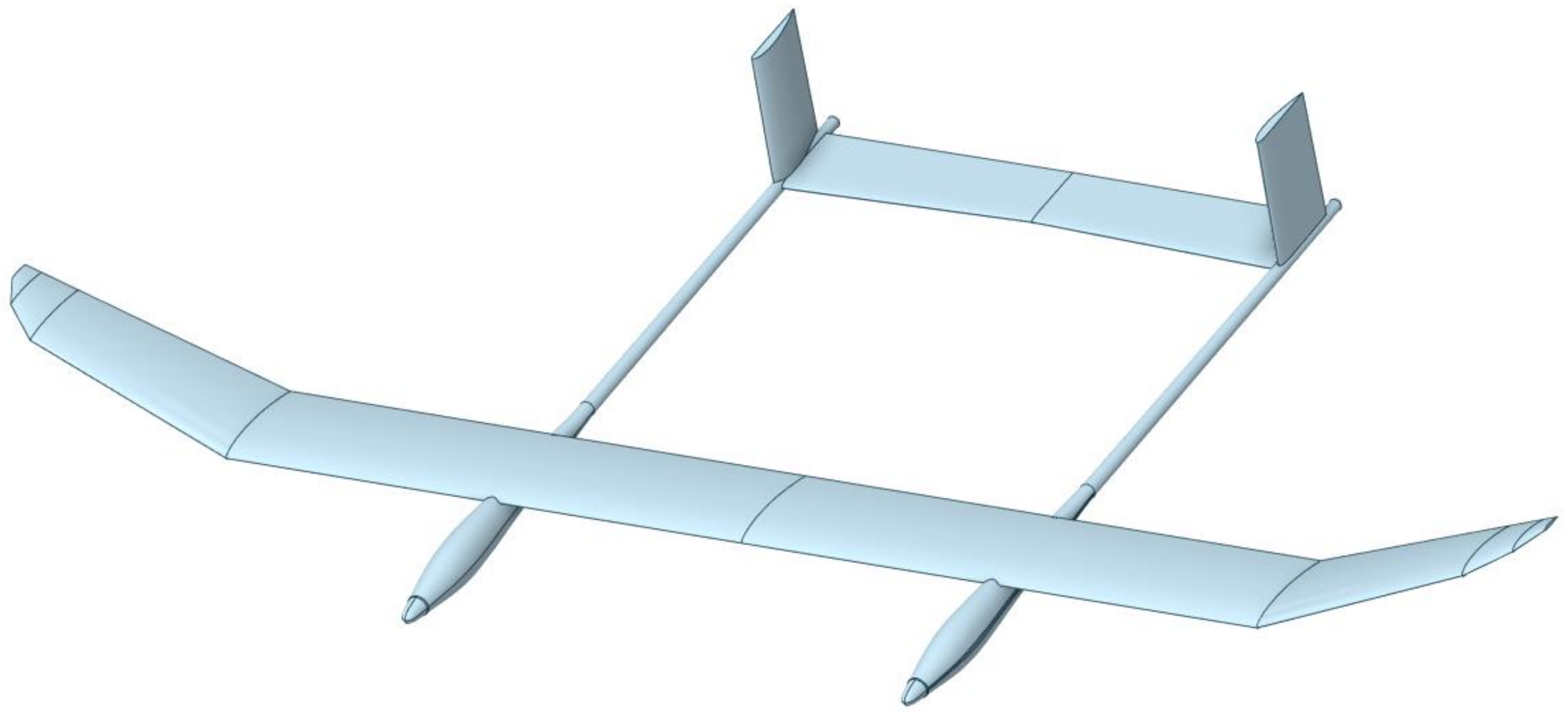
Constant assumptions for calculations

- flight speed,
- Security factor,
- Aircraft mass
- Shape – without tail unit
- Fixed control surfaces

The following changes:

- The type and shape of the tail





Introduction

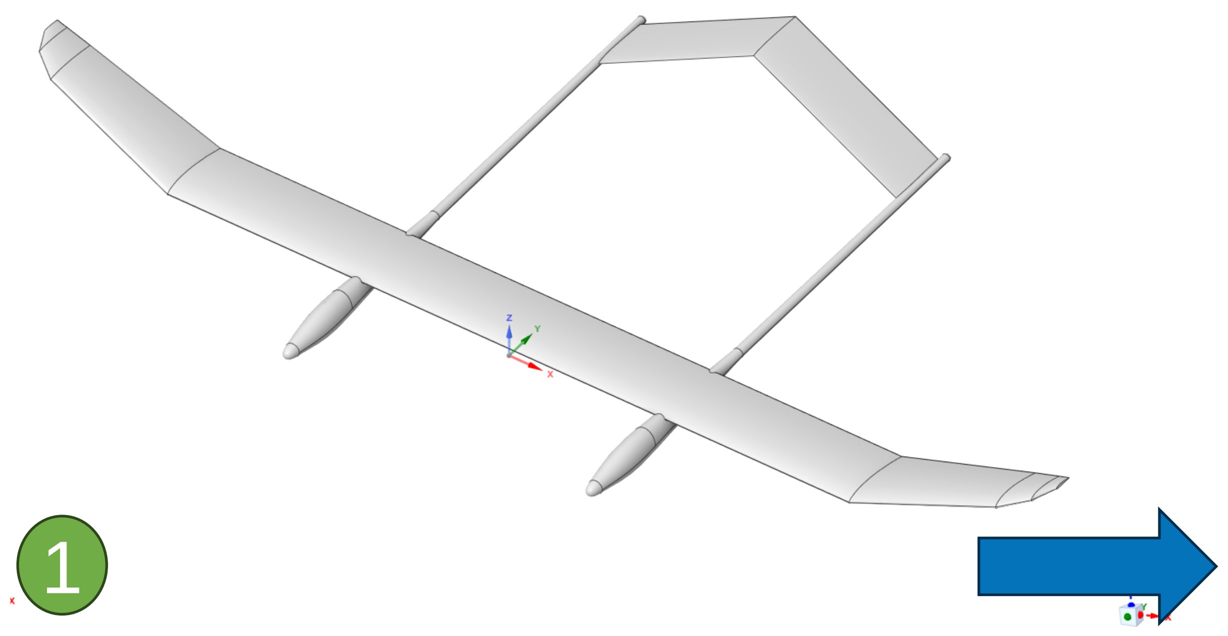
Parameters of the test object

- The subject of comparative research is an unmanned aircraft and its configuration regarding the tail and its influence on the behavior of the UAV during its horizontal flight.

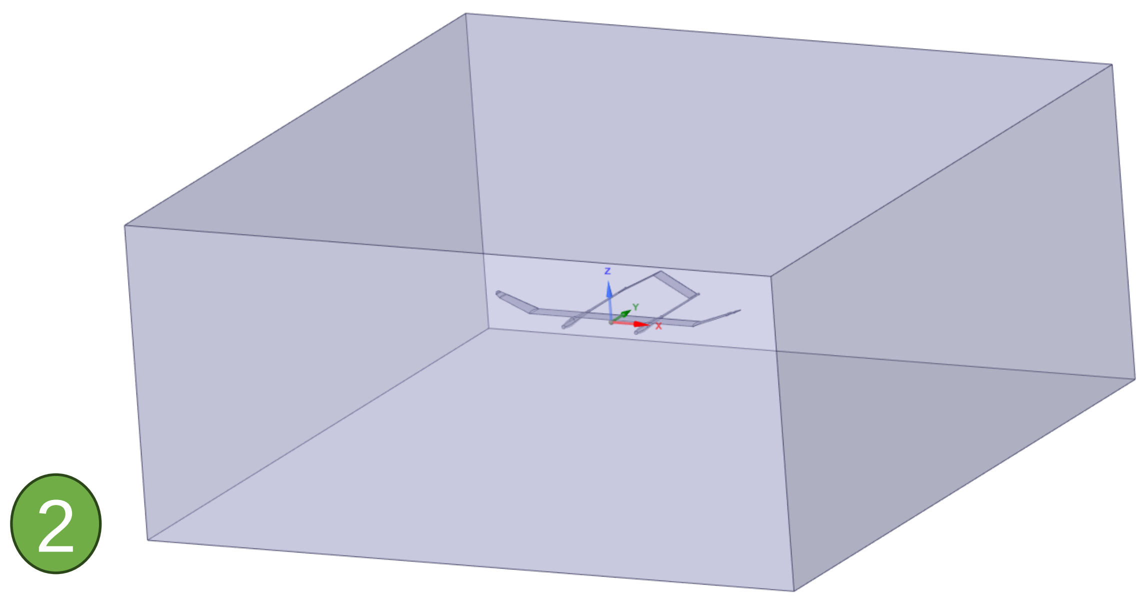
Tab 1 Parameters of TS17

Scale	1:7	Unit
Take off mass	9,8	[kg]
Aspect Ratio (AR)	14,46	[-]
Wing area	0,70	[m^2]
Maximum celling	5000	[m]
Assumed Maximum flight duration	24	[h]
Payload	2,5	[kg]
Middle chord	0,28	[m]
Wing Span [A]	3,6	[m]
Tail unit area	0,25	[m^2]
Length of aeroplane [C]	1,8	[m]
Height of tail unit [B]	0,29	[m]
Assumed motors power	300	[W]

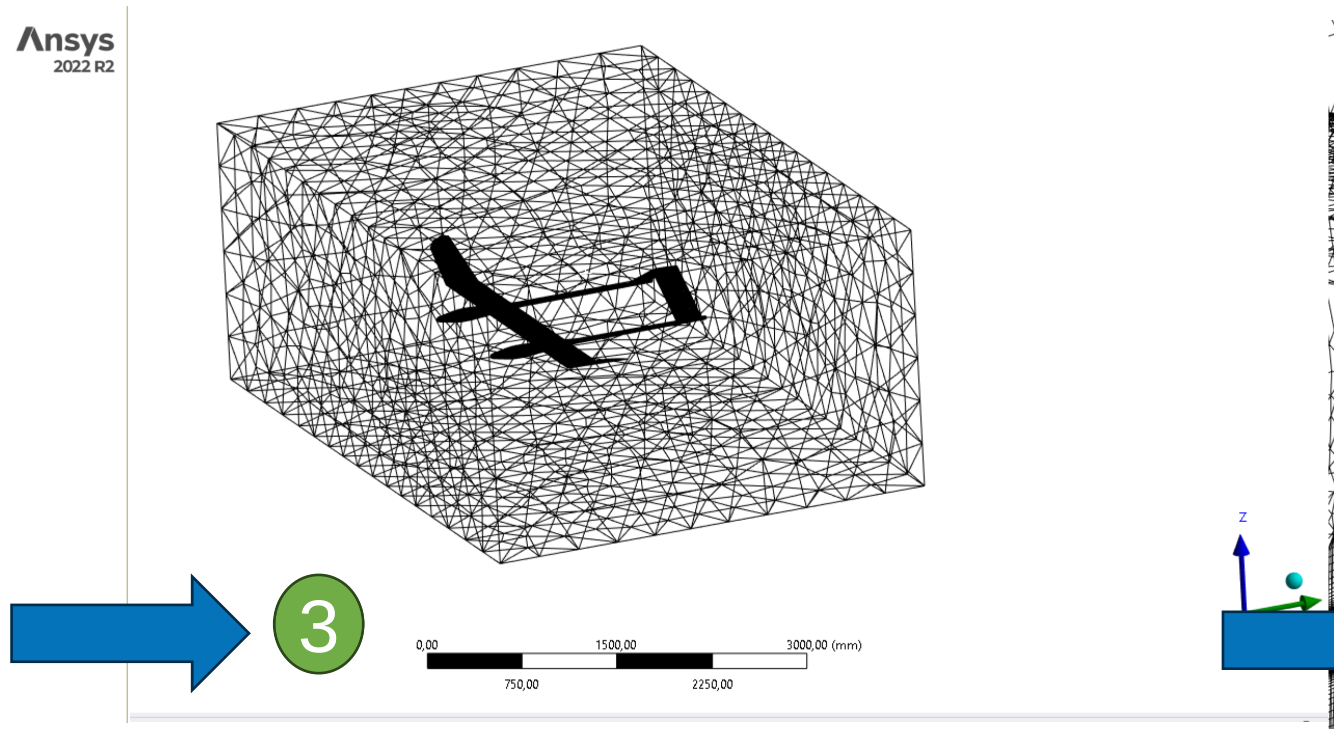
Methodology



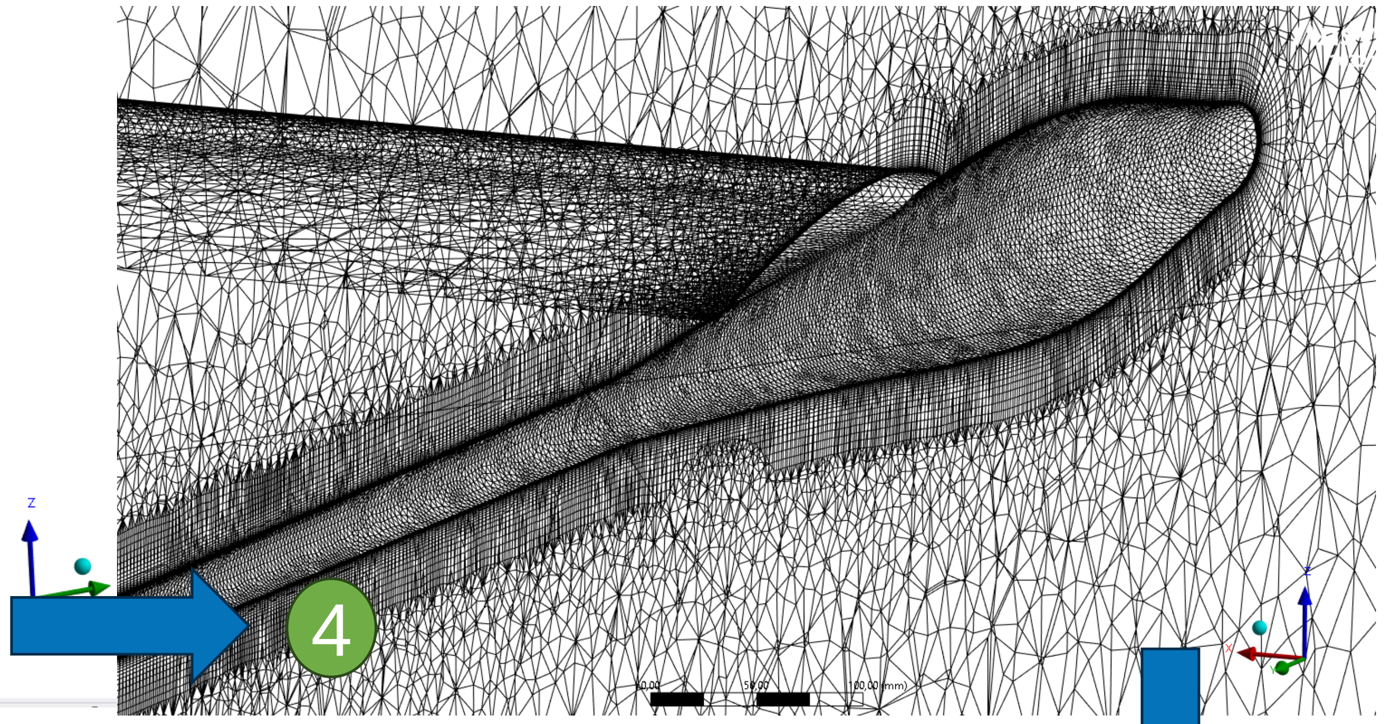
1. Creation of a surface model



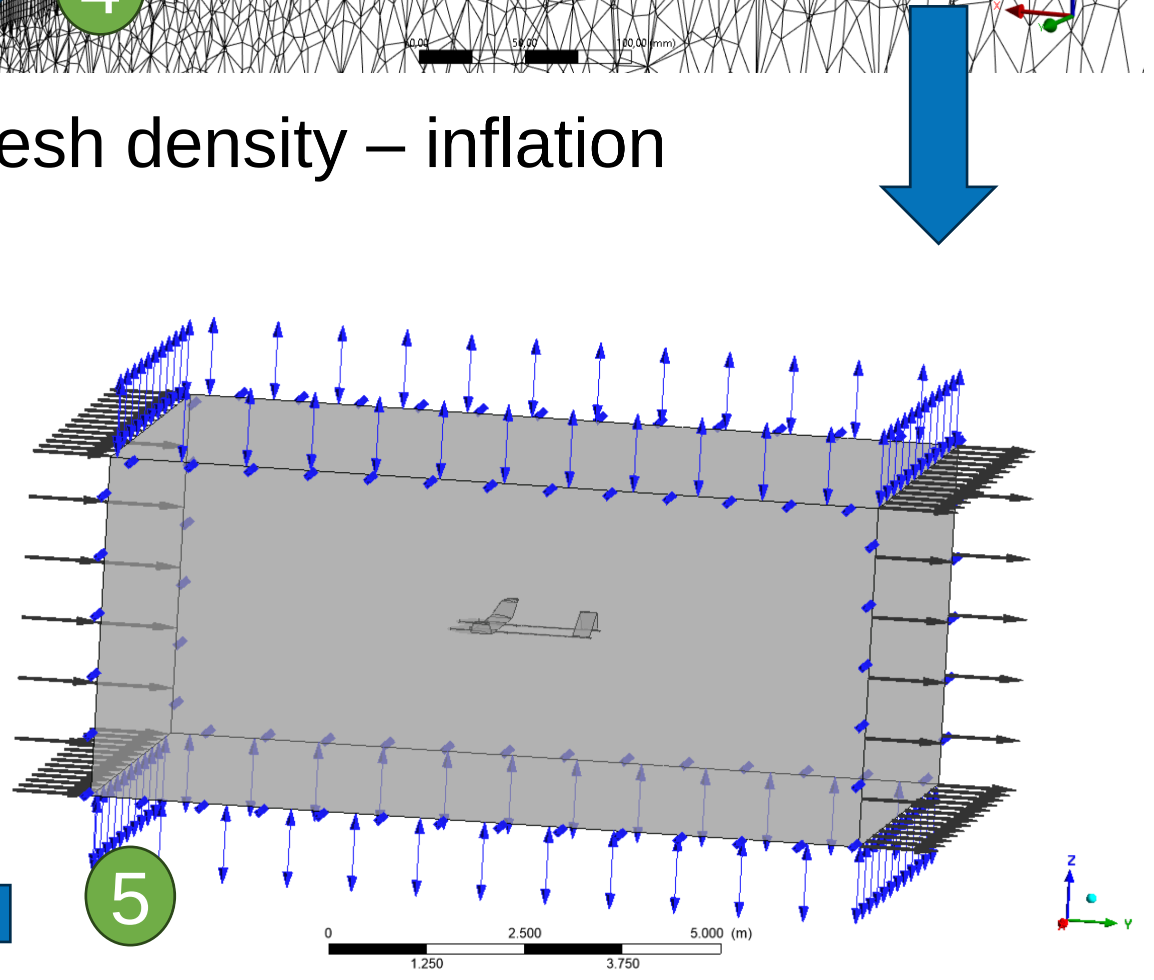
2. Creation of a wind tunnel model



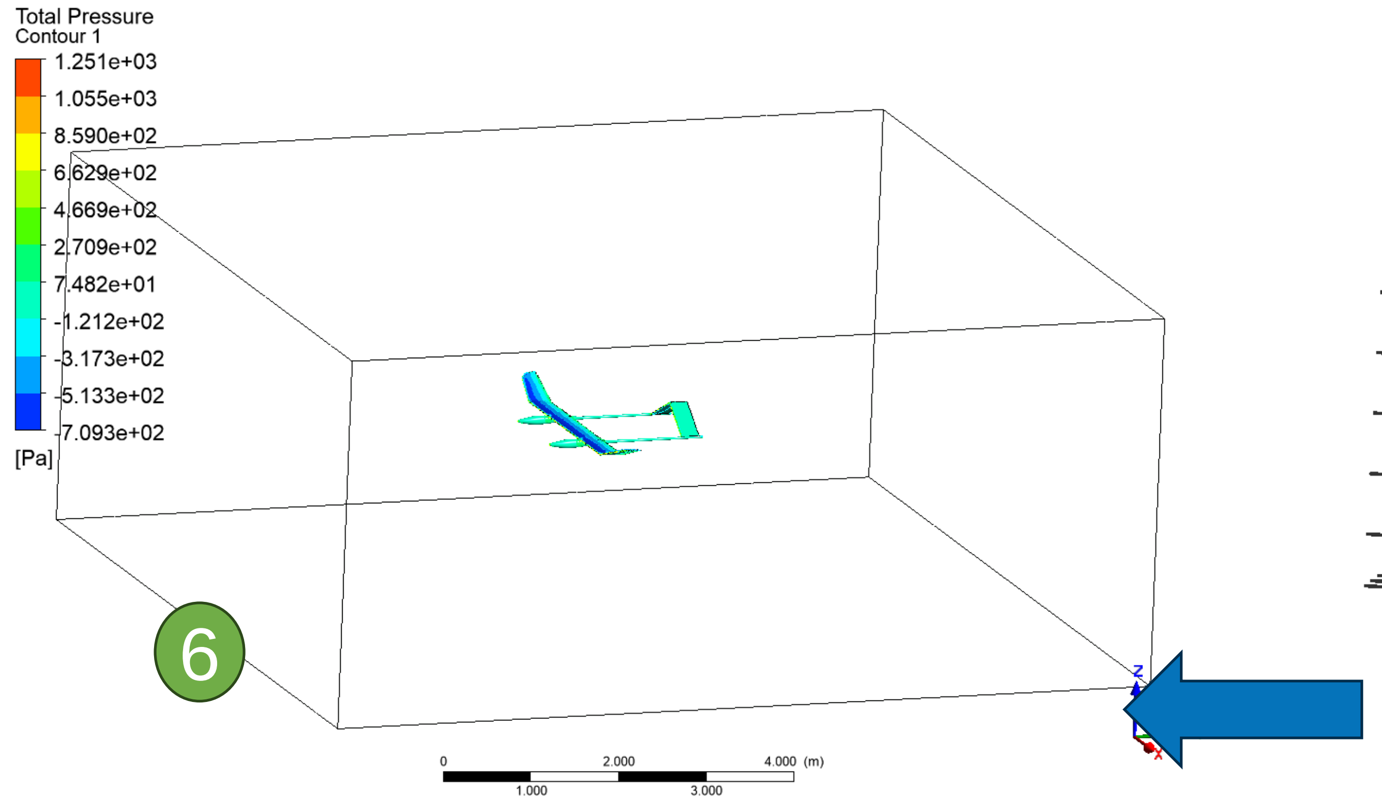
3. Discretization of models

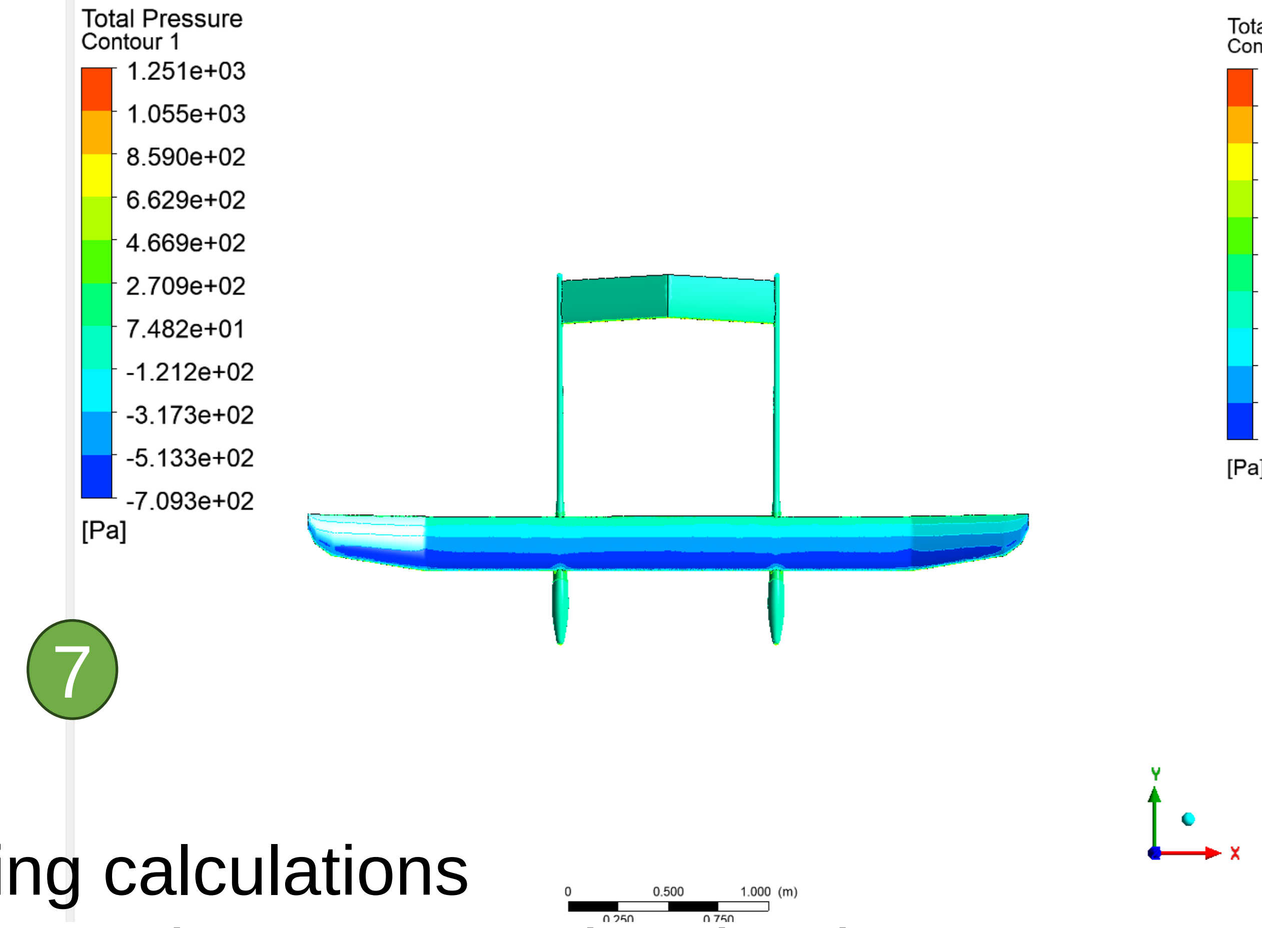


4. Mesh density – inflation



5. Selection of simulation boundary conditions

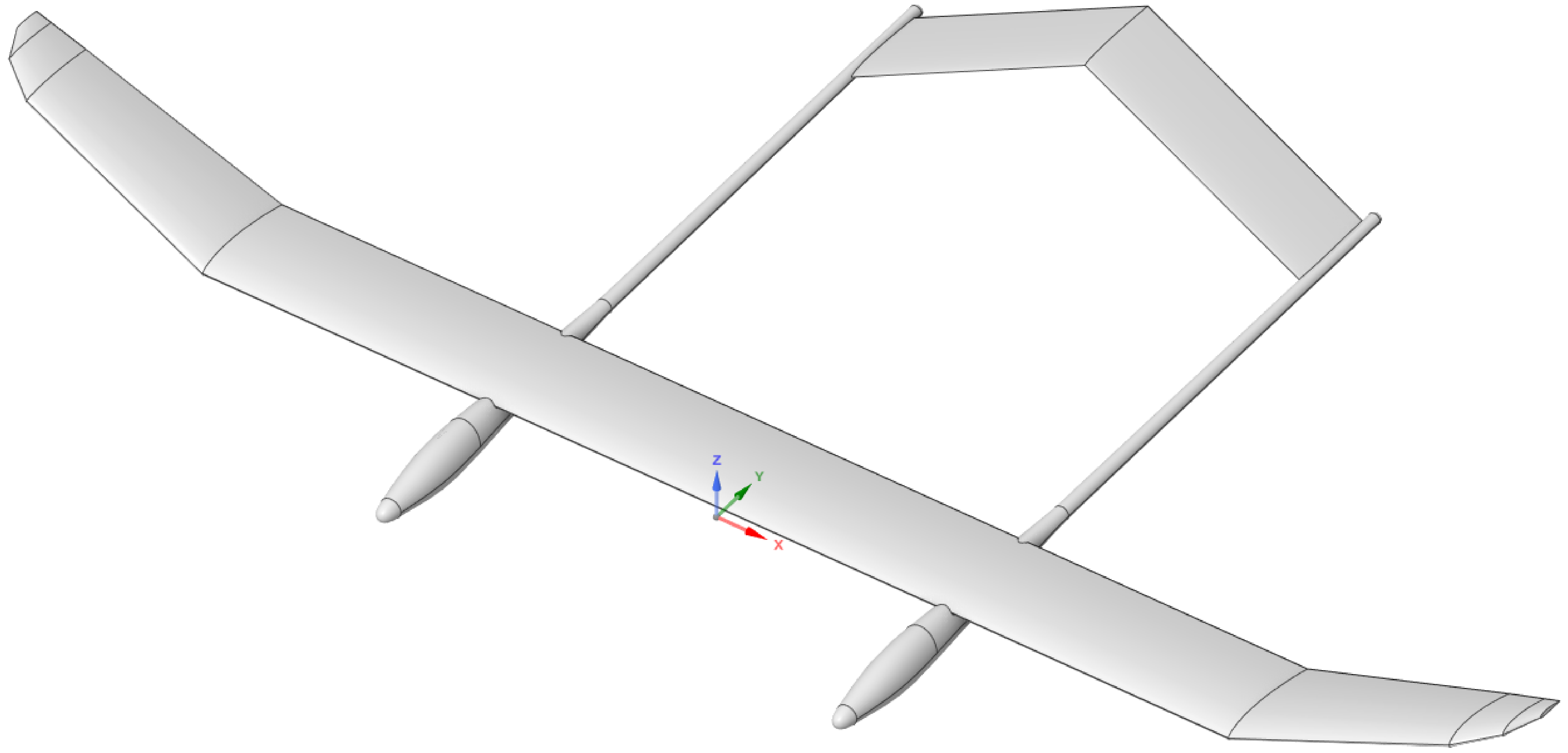




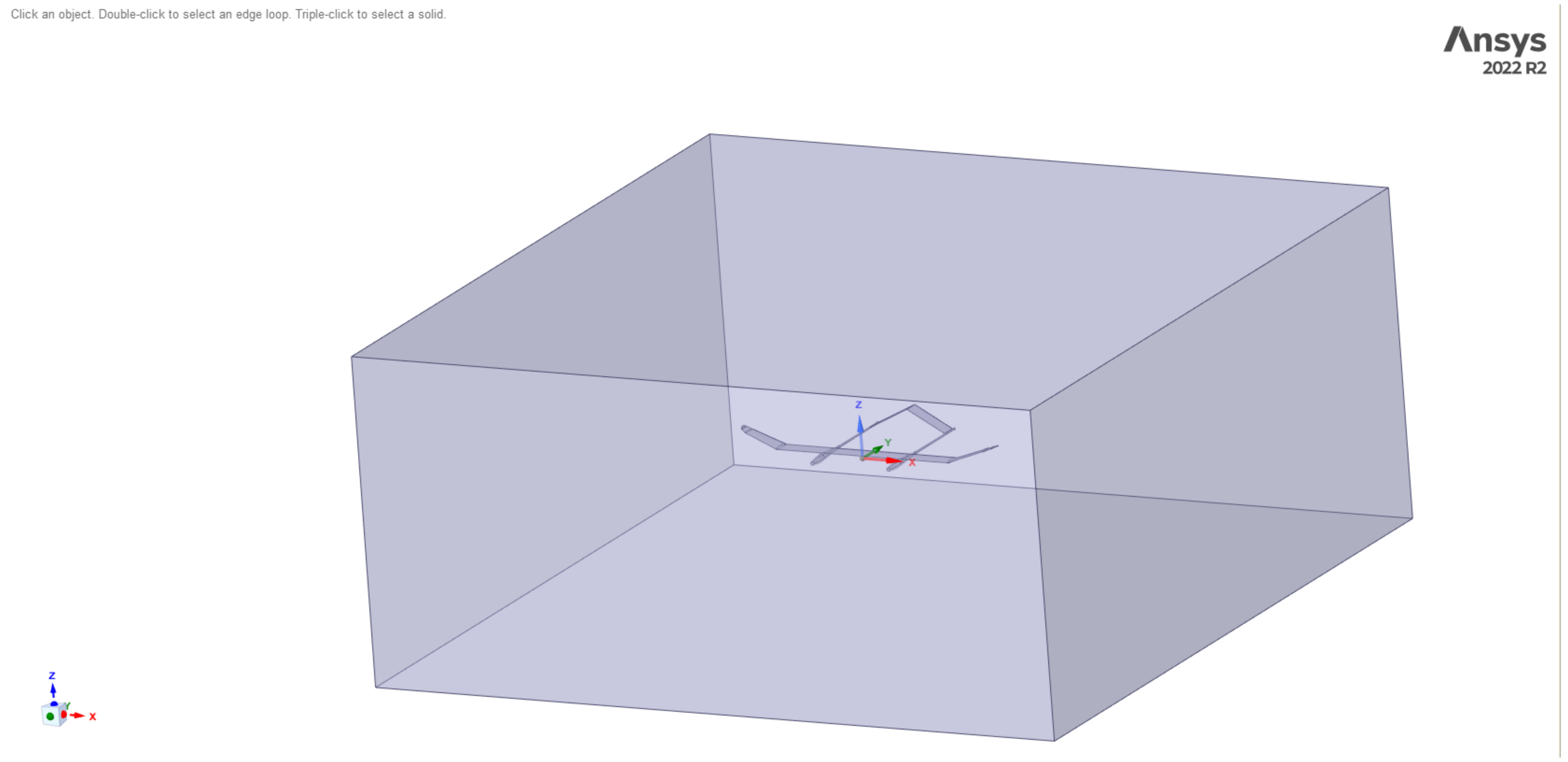
6. And 7. Performing calculations
Reading the results and postprocessing the data

Analysis

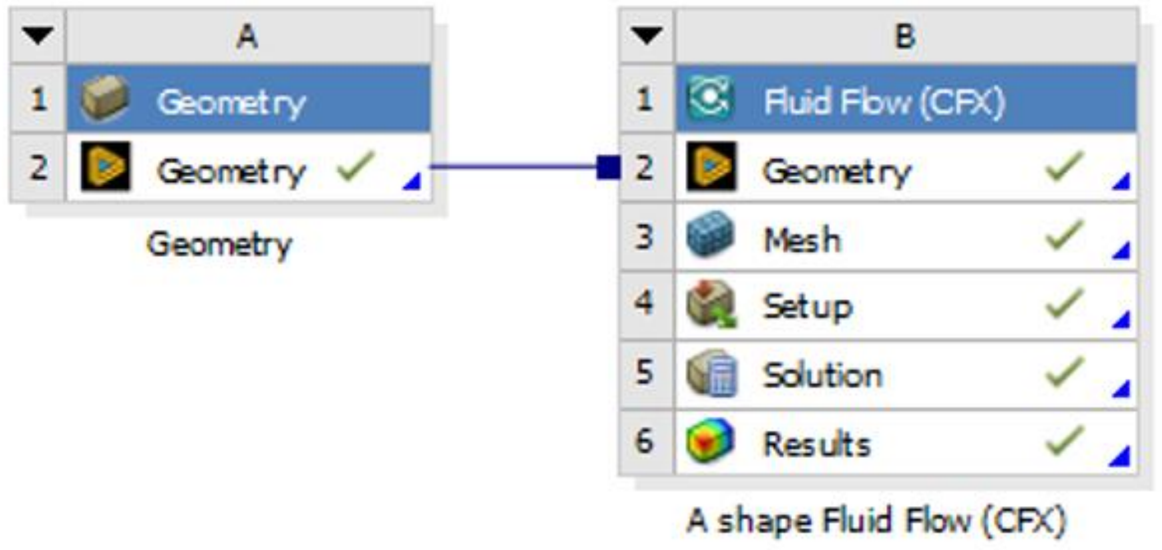
Surface model



tunel model

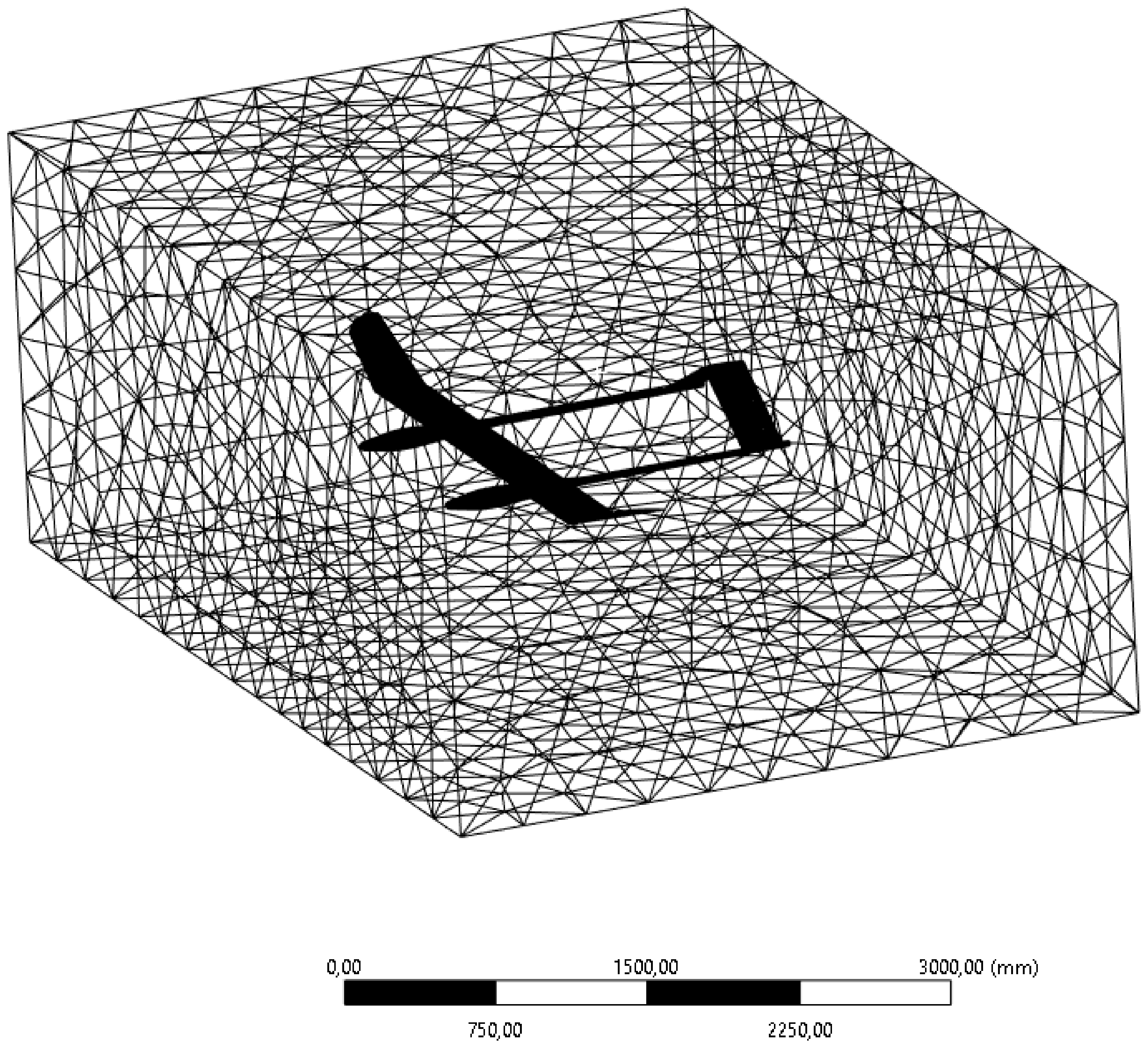


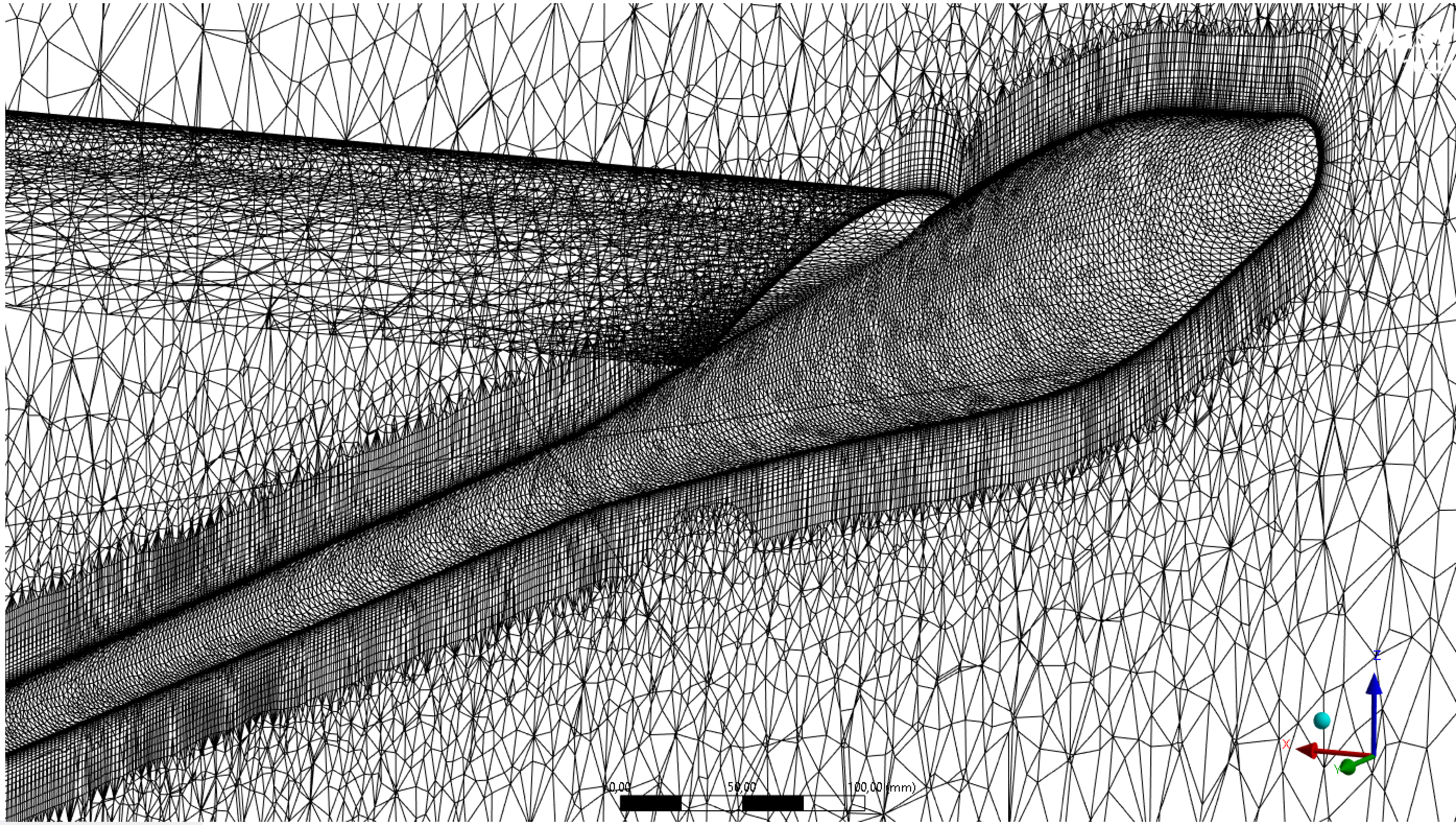
ANSYS Workbench model – CFX module



Analysis

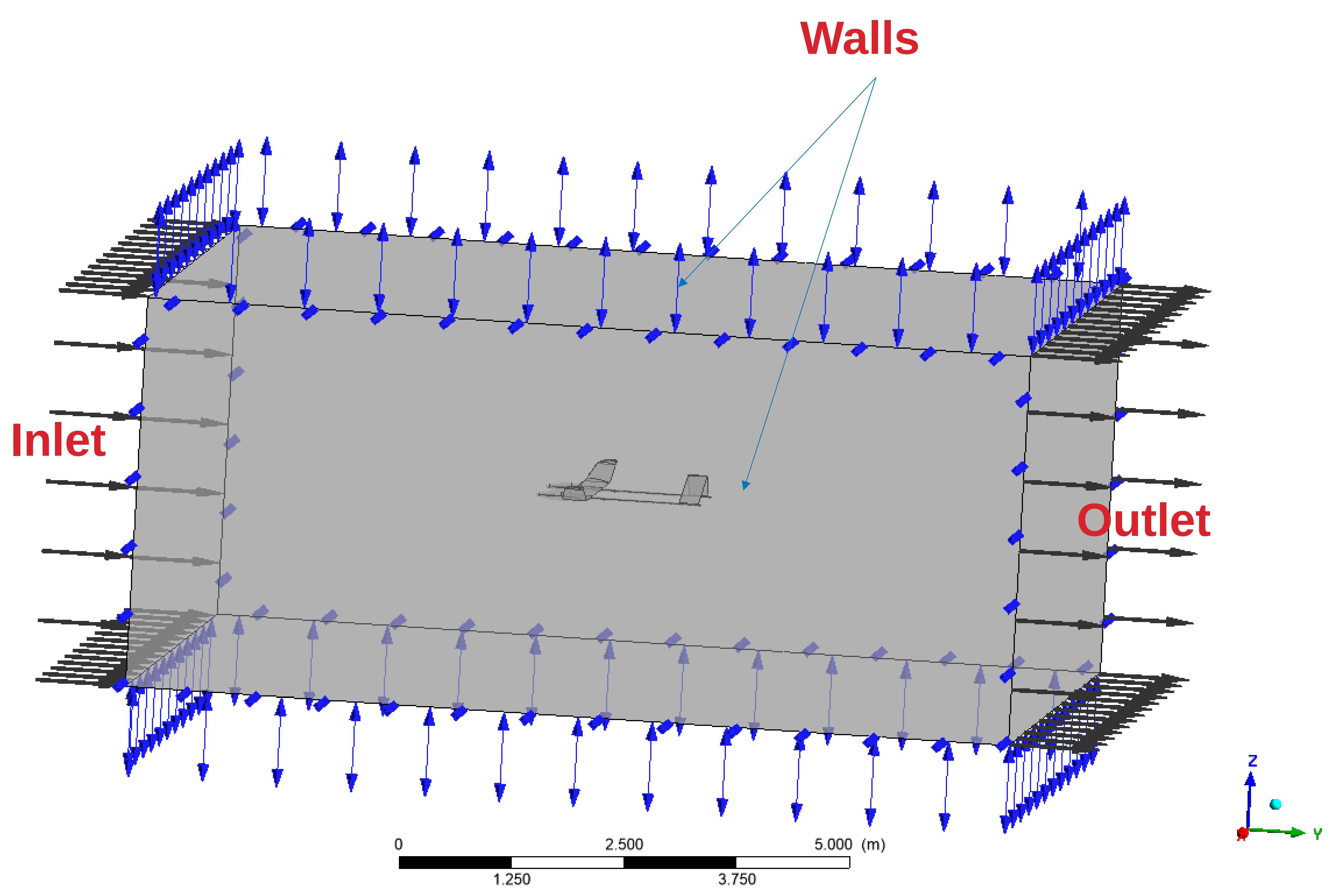
Model discretization taking into account grid inflation





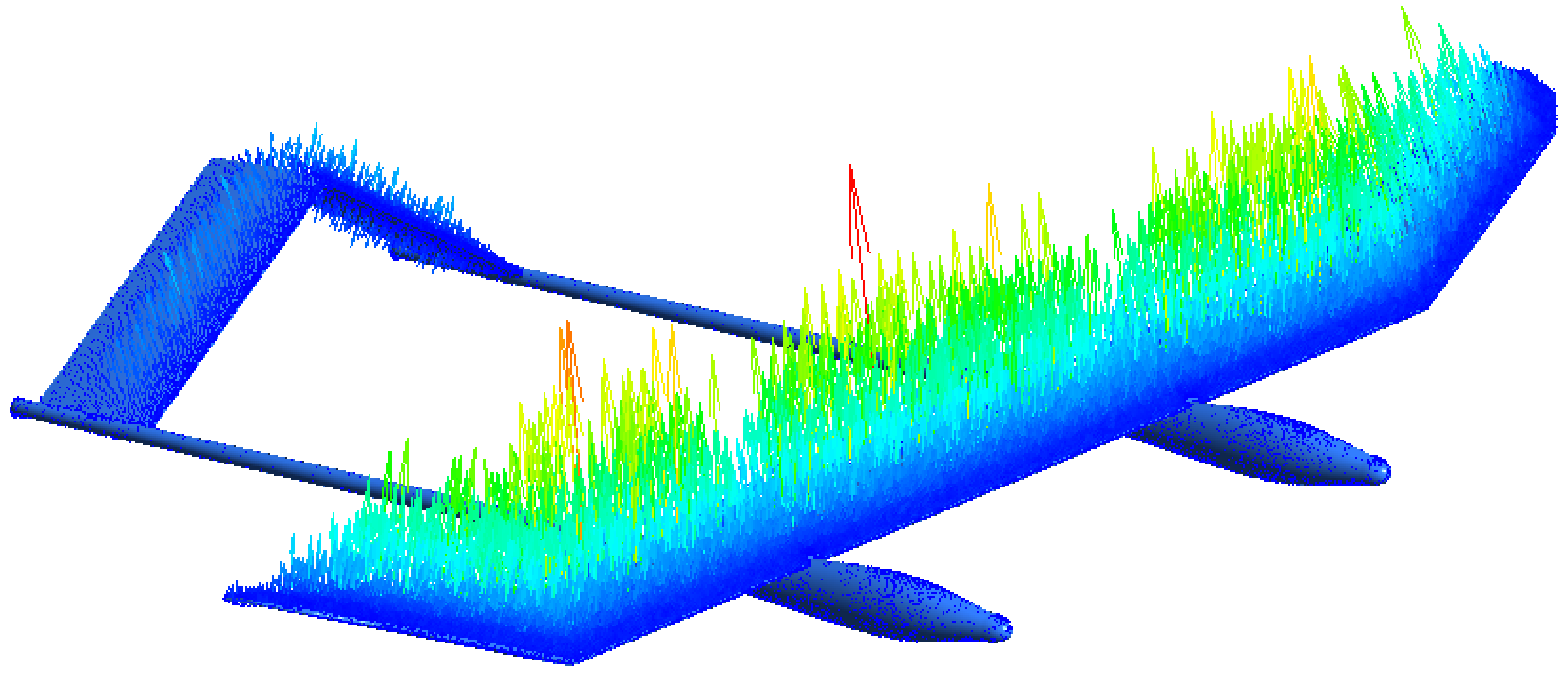
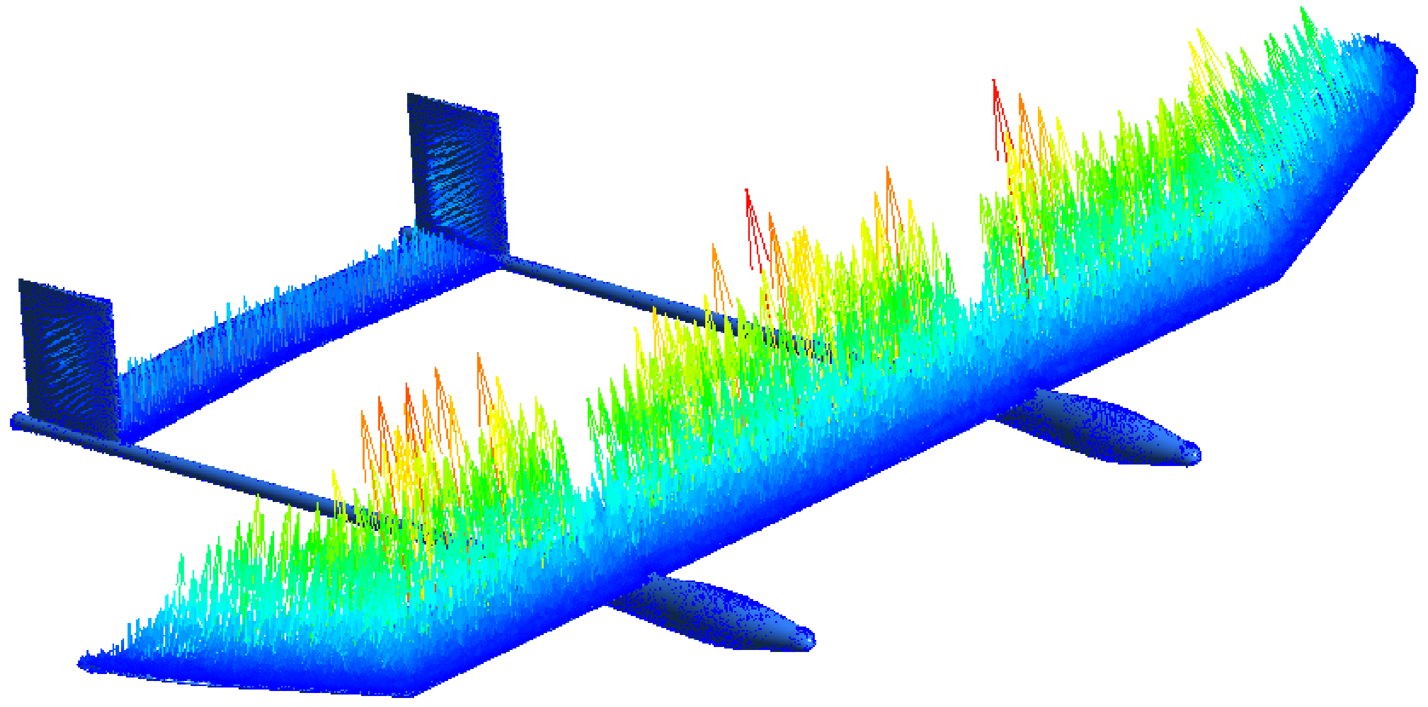
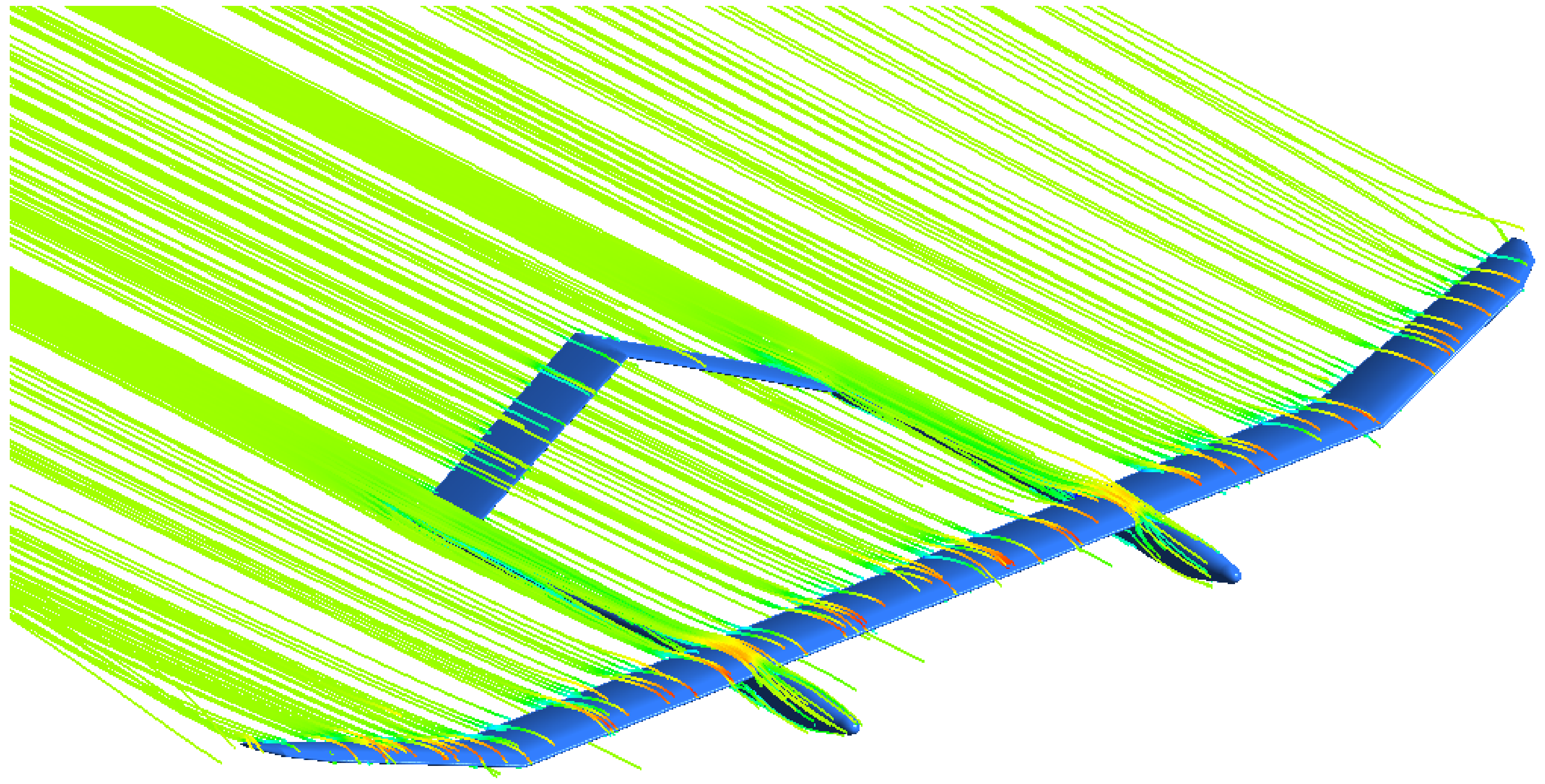
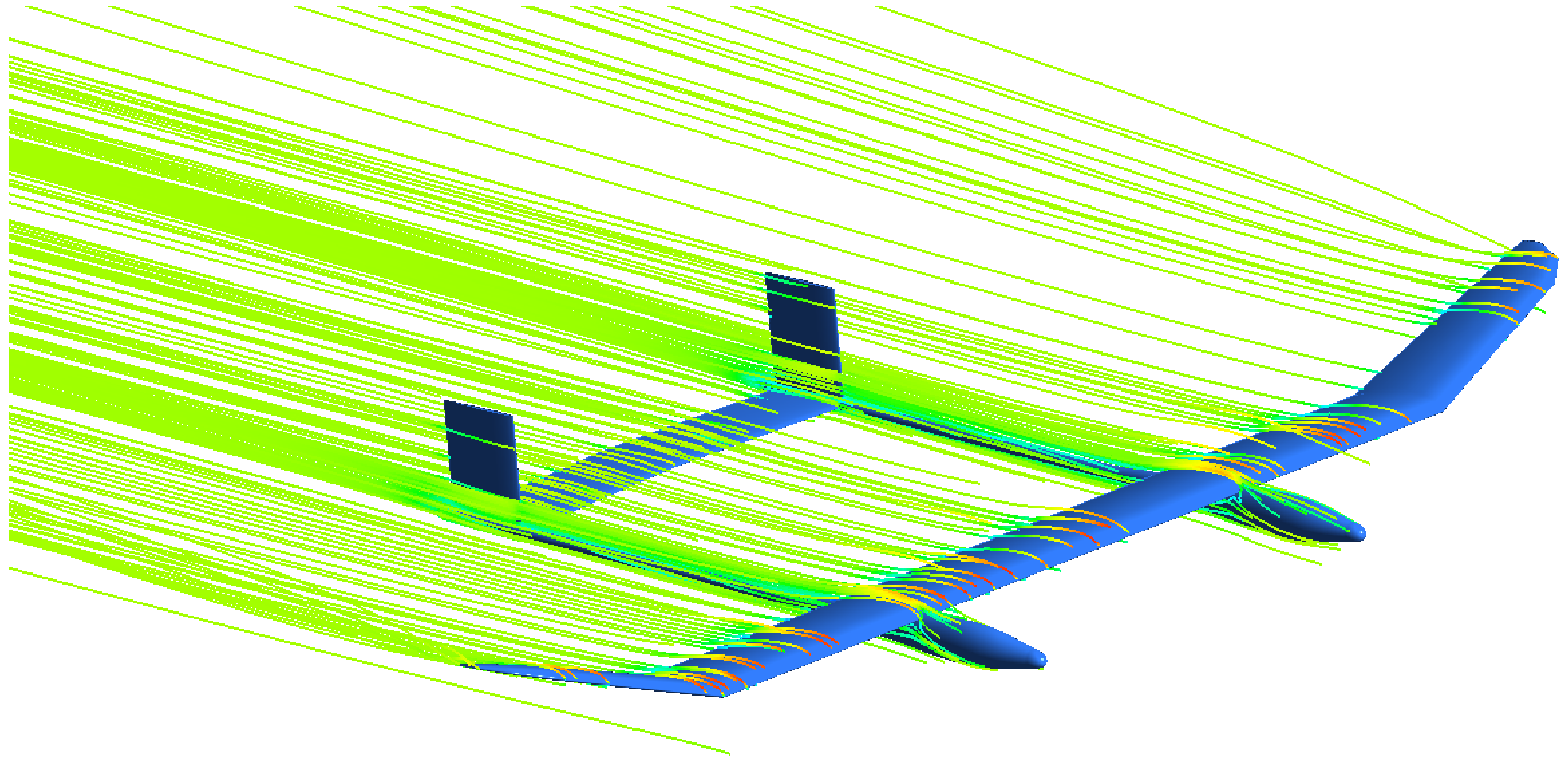
Analysis

Boundary conditions

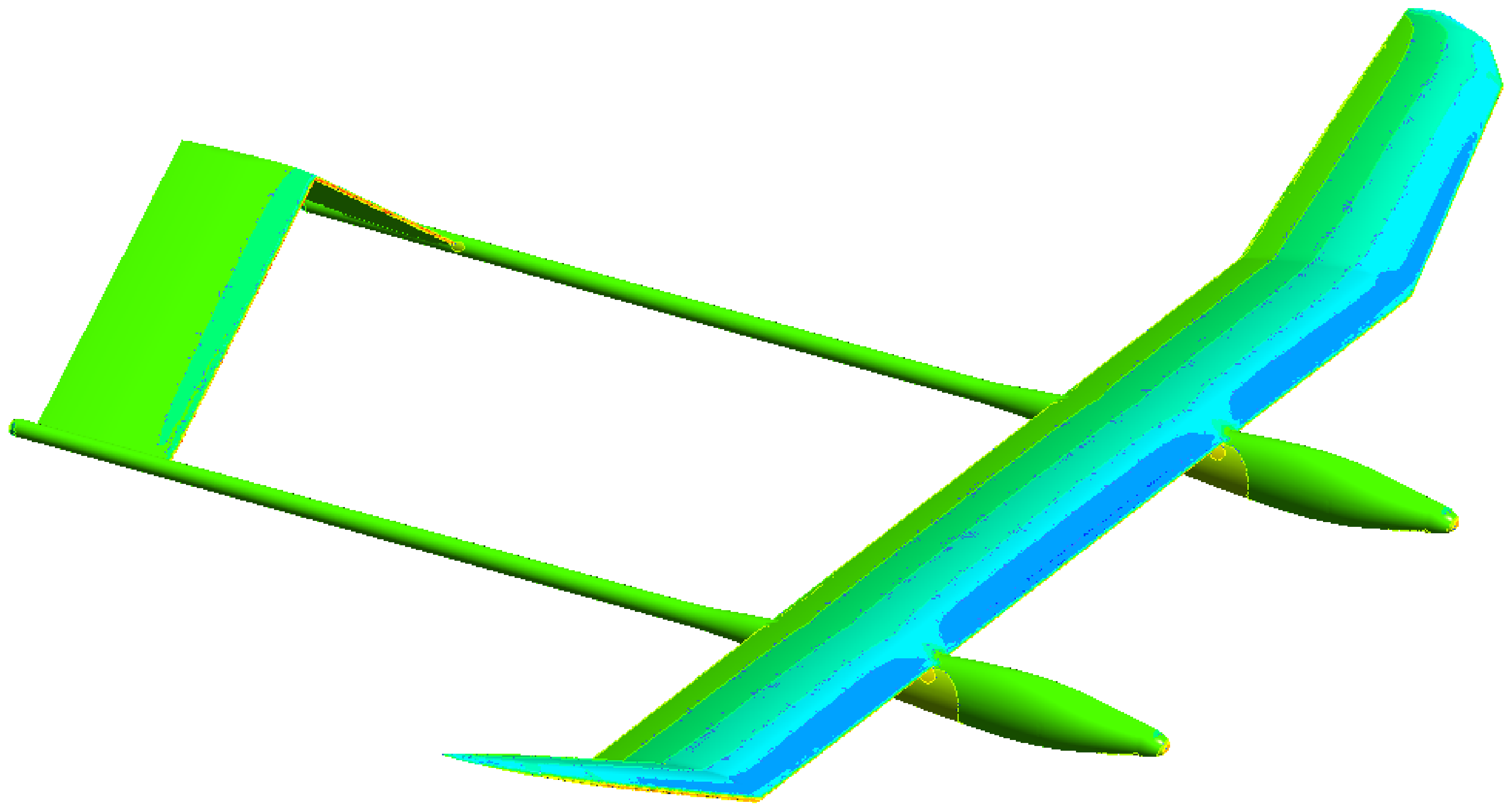
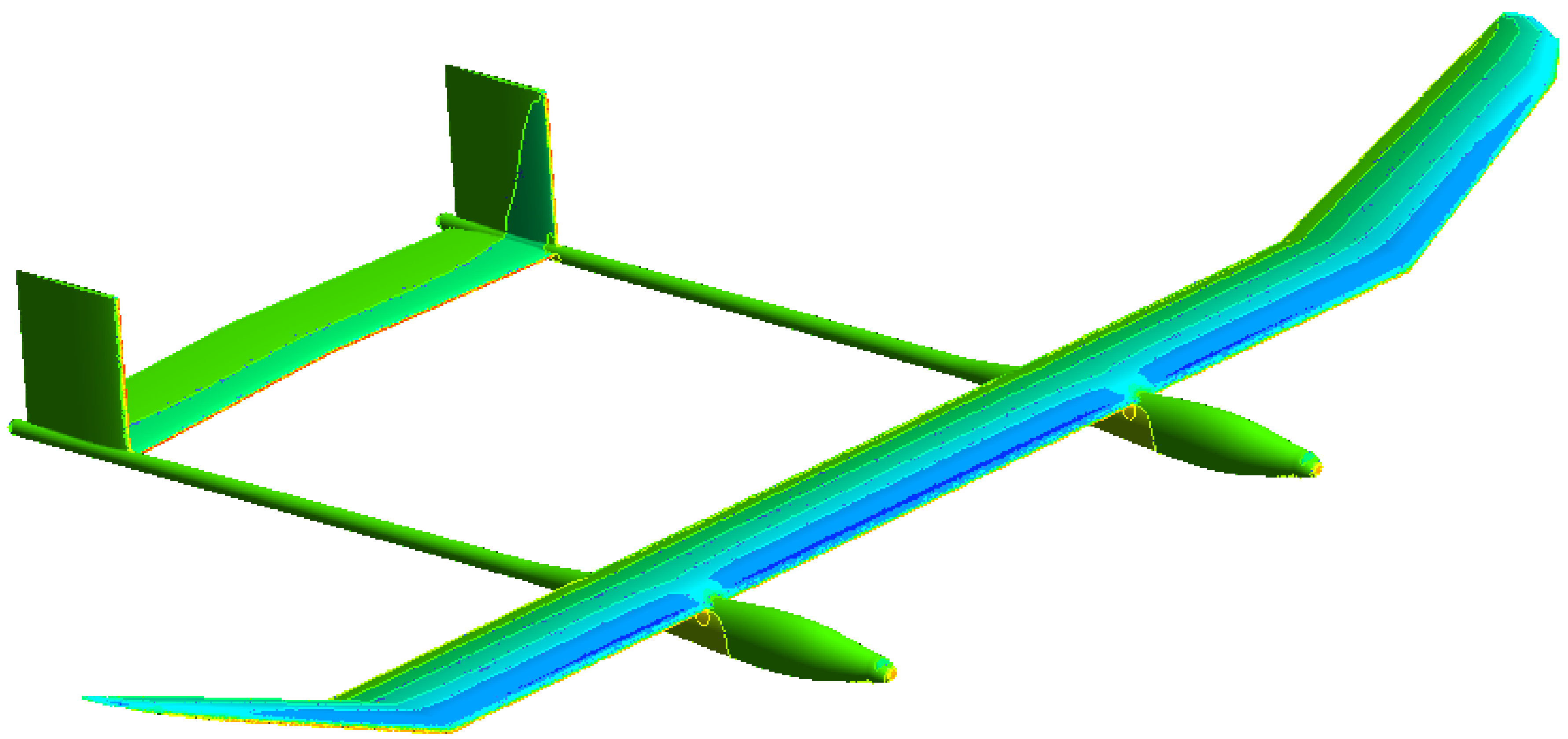


AoA: angle for 0% stability margin (4,3 and 2,9[deg])
Velocity: 14,5 [m/s]
Fixed control surfaces
Setup in ANSYS - Inlet, outlet, walls.

Results

	A-tail	Conventional tail
Distribution of forces		
Flow around the tested object		

Results

	A-tail	Conventional tail
Pressure distribution		
Obtained results	see table Tail A	see table Tail Con.

	Tail A
Alfa [°]	4,3
L [N]	109,60
D [N]	6,86
L/D [-]	15,98
L [kg]	11,17
D [kg]	0,70

	Tail Con.
Alfa [°]	2,9
L [N]	107,89
D [N]	6,54
L/D [-]	16,50
L [kg]	11,00
D [kg]	0,67

Conclusion

- Aerodynamic stability is crucial for UAVs as it ensures efficient flight and the ability to maintain altitude, which is essential for long-duration missions and variable weather conditions.
- Higher lift generated by the aircraft's surfaces enhances operational capabilities by allowing heavier cargo transport, enabling takeoff and landing on shorter runways, and improving maneuverability at low speeds.
- Proper longitudinal stability is achieved by balancing the lift and center of gravity, which is vital for safe and stable flight.
- Optimizing the drag coefficient significantly impacts fuel efficiency and flight duration, with lower drag leading to longer flight times and higher cruising speeds. However, the right balance of aerodynamic drag is necessary to ensure stability and control, especially at low speeds and during challenging conditions.

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Thank you!

I You have any questions, please feel free to contact: Paulina.Zenowicz@polsl.pl

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