# Drag Report : Makara 'MAK-1'

## Aim :

To calculate the terminal velocity of MAK-1.

## CAD Design:

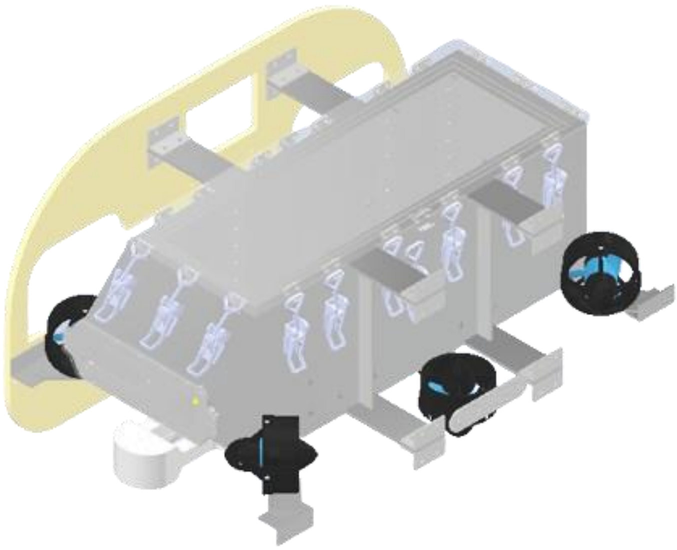

*Figure 1 : Makara 'MAK-1'*

## Simplified CAD :

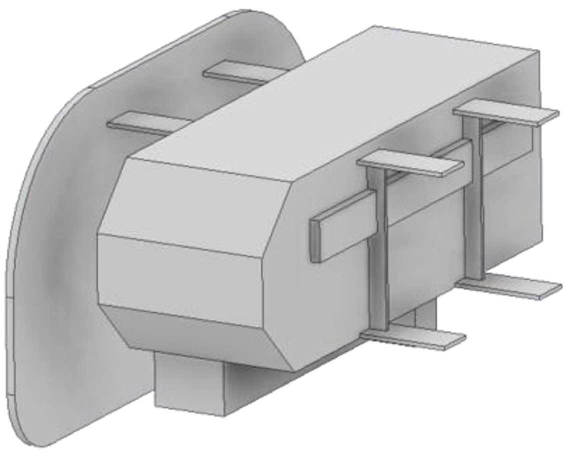

*Figure 2 : MAK-1 simplified*

The CAD was simplified to reduce computational complexity of the simulation.
Simple extrusions replace the robotic arm and latches.
The missing sideboard was removed for representational purposes only.

## Simulation Setup :

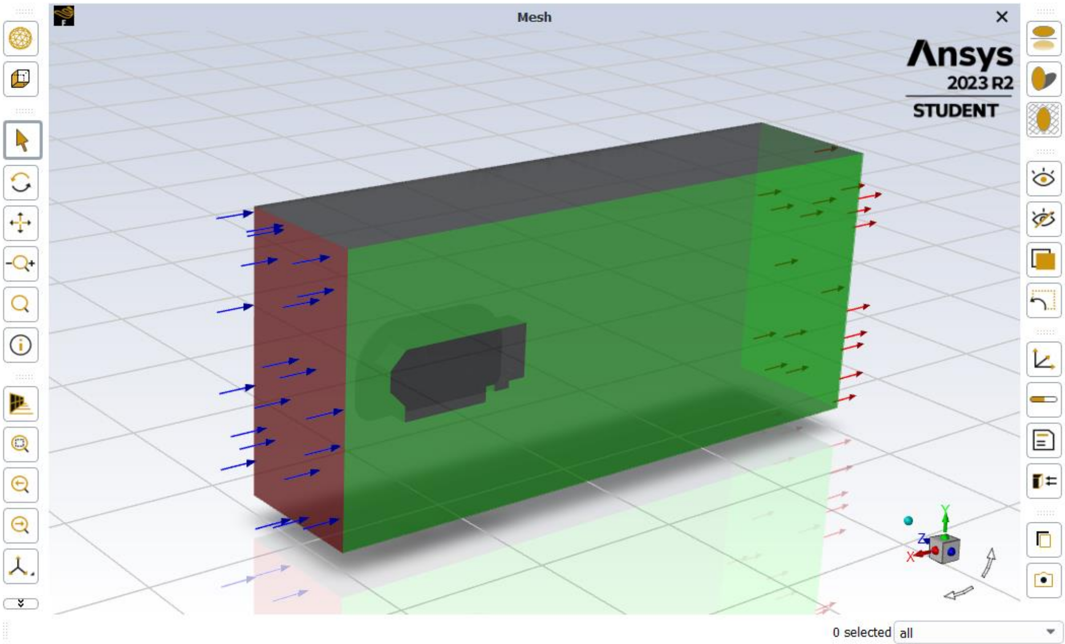


*Figure 3 : Wind tunnel Scene*

The wind tunnel was created in ANSYS Discovery and is large enough not to interfere with the wake of the body.
The body being mostly symmetric about the y-z plane, the simulation was performed for only **half of the volume** to reduce computational complexity. Results of the simulation should be **doubled** keeping in mind this fact.

Simulation Parameters :
Solver - Steady
Physics model – SSTKW, Laminar (2 simulations)
Fluid – Water
Solid – Aluminum
Inlet Velocity – 1 $ms^{-1}$
Outlet pressure – 0 Pa

## Simulation Results :

Turbulent Simulation :

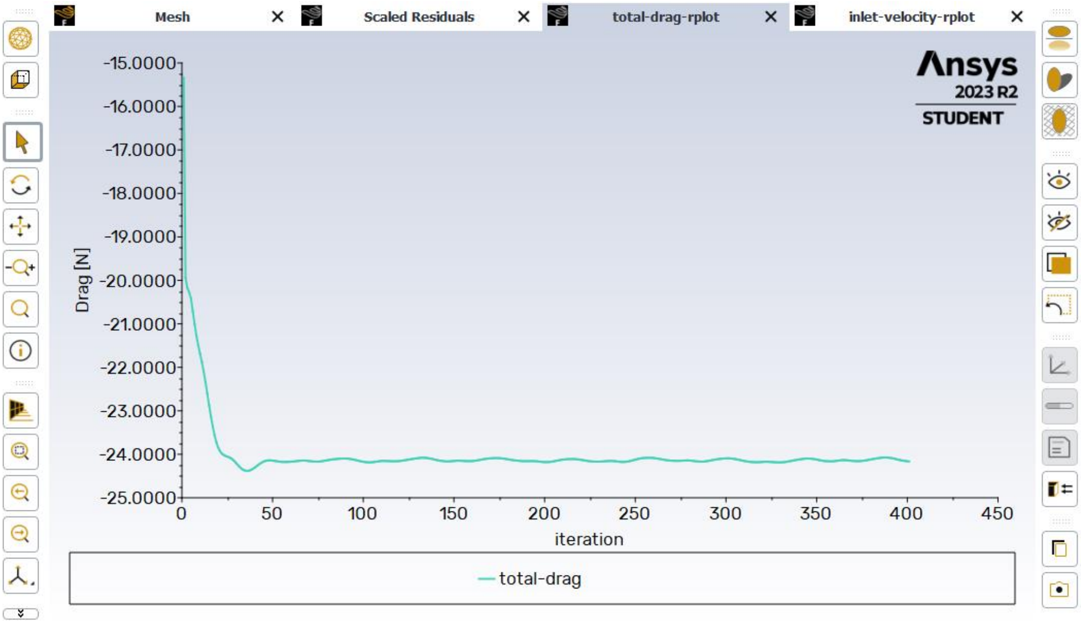


*Figure 4 : Total Drag*

**Simulation Drag = 24 N.**
**Total Drag = 48 N.**

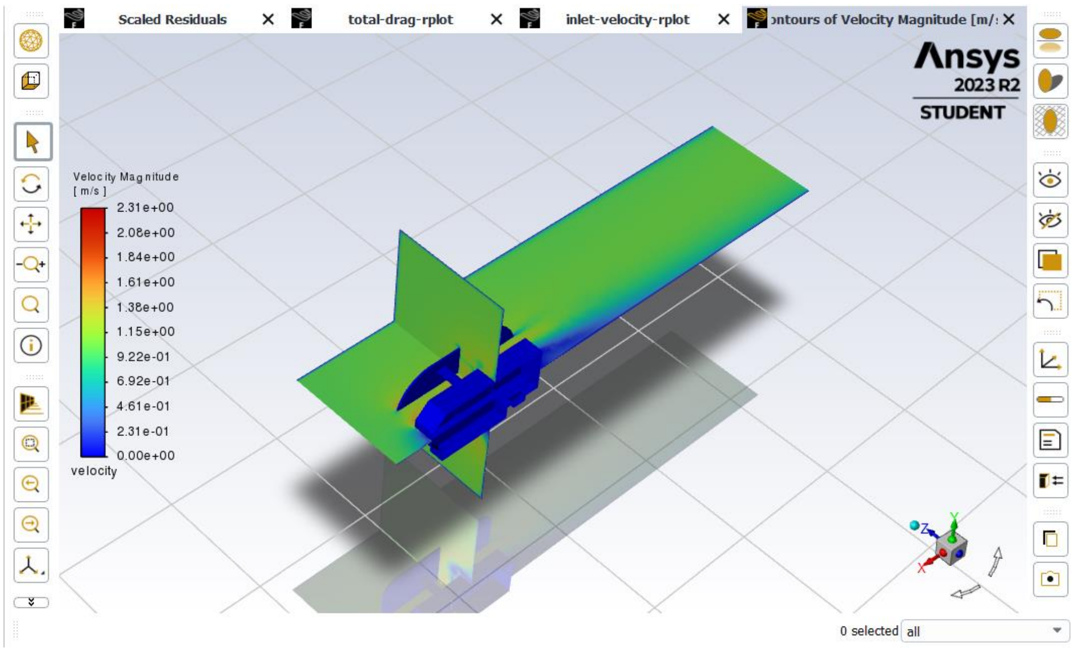


*Figure 5 : Velocity Contour*

Boundary walls do not interfere with the wake of the body. We can be confidant of the simulation results.

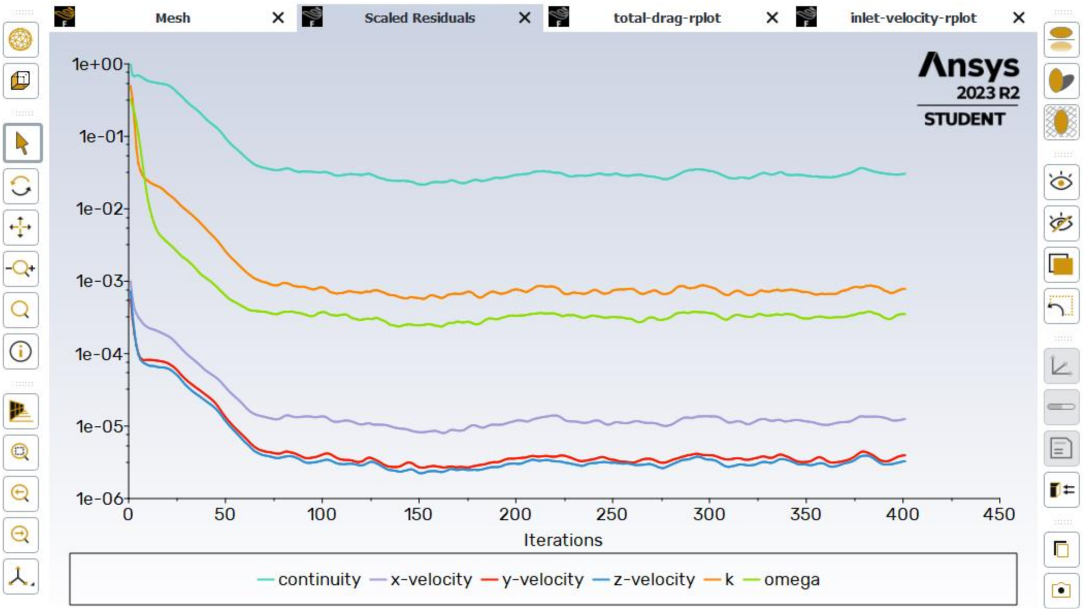


*Figure 6 : Simulation Residuals*

Simulation is close to convergence. Can trying refining mesh.

Laminar Simulation :

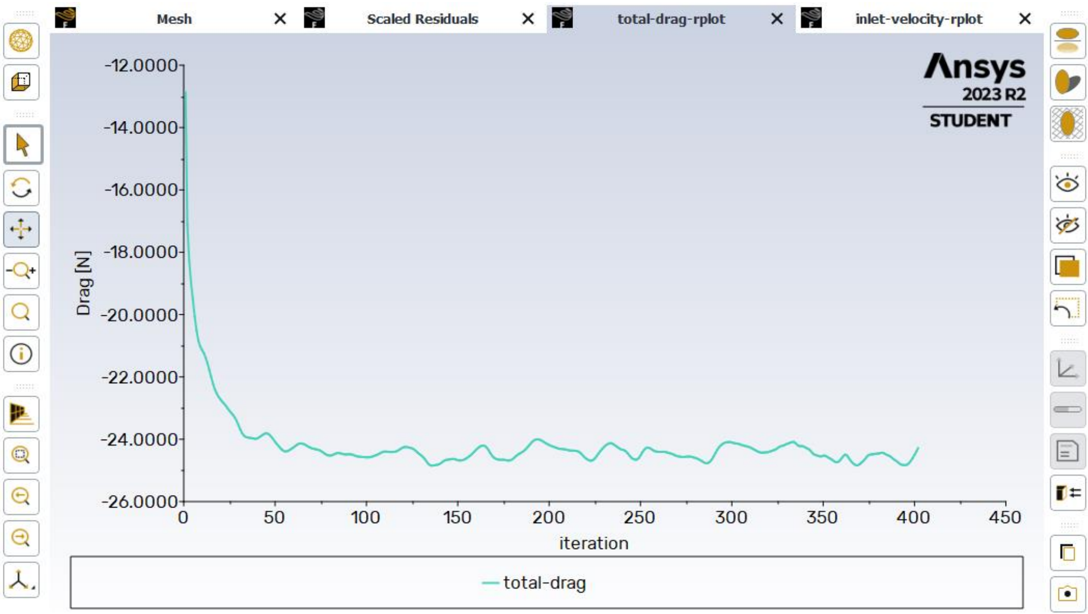


*Figure 7 : Total Drag*

Laminar simulation was not able to converge but volatility of the sim is confined to 24 +/- 0.5
Since Reynolds number for the flow was close to the critical point, both simulations were run and both sufficiently agree with each other.

Total Drag confirmed to be 48N.

## Calculations :

Assumptions :

- The AUV employs 3 surge thrusters as part of the 7-thruster system.

Under steady state conditions, moving at 1 $ms^{-1}$ :

Drag = 48 N

From the drag equation, assuming it is valid :

- ⇨ $F_D = kv^2$
- ⇨ $k = F_D/v^2$
- ⇨ k = 48/1
- ⇨ **k = 48**

Max surge thrust available = 5.25 x 3

= **15.75 Kgf**

**= 154.35 N**

Under steady state condition,

$F_{Drag} = F_{Thrust}$

$kv^2 = 154.35$

$v^2 = 154.35/k$

$v^2 = 154.35/48$ (Assuming drag coefficient remains constant for the 2 flow conditions.)

$v^2 = 3.22$

**v = 1.8 $ms^{-1}$**

The assumptions stated are valid and are verified in the following section.

This means MAK-1 can theoretically reach a top speed of 1.8 $ms^{-1}$.

## Simulation Setup :

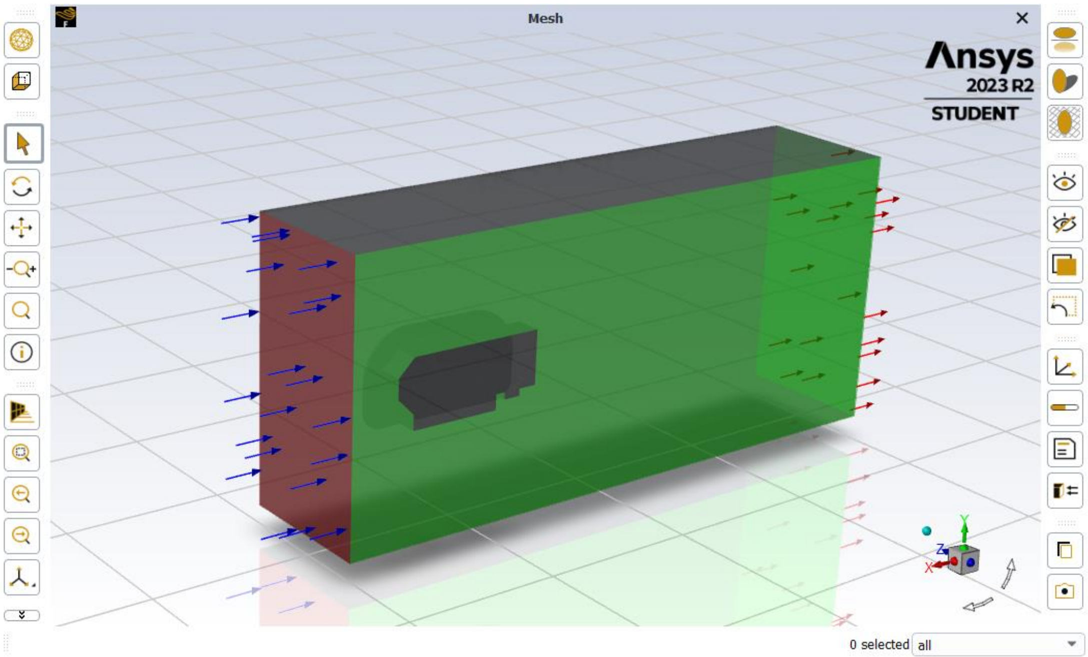


*Figure 8 : Wind tunnel scene*

The following simulation was run to validate the assumptions stated in the previously stated calculations.

Simulation Parameters :
Solver - Steady
Physics model – SSTKW
Fluid – Water
Solid – Aluminum
Inlet Velocity – 1.8 $ms^{-1}$
Outlet pressure – 0 Pa

## Simulation Results :

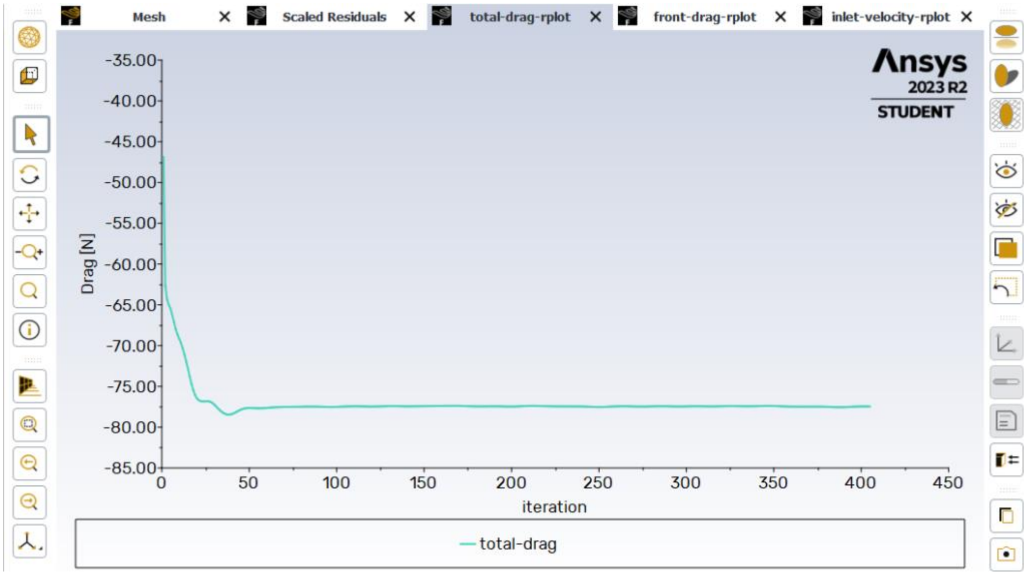


*Figure 9 : Total Drag*

**Simulation Drag = 77.5 N**
**Total Drag = 155 N**

The terminal velocity of MAK-1 is verified to be 1.8 $ms^{-1}$ and previous assumptions are validated.

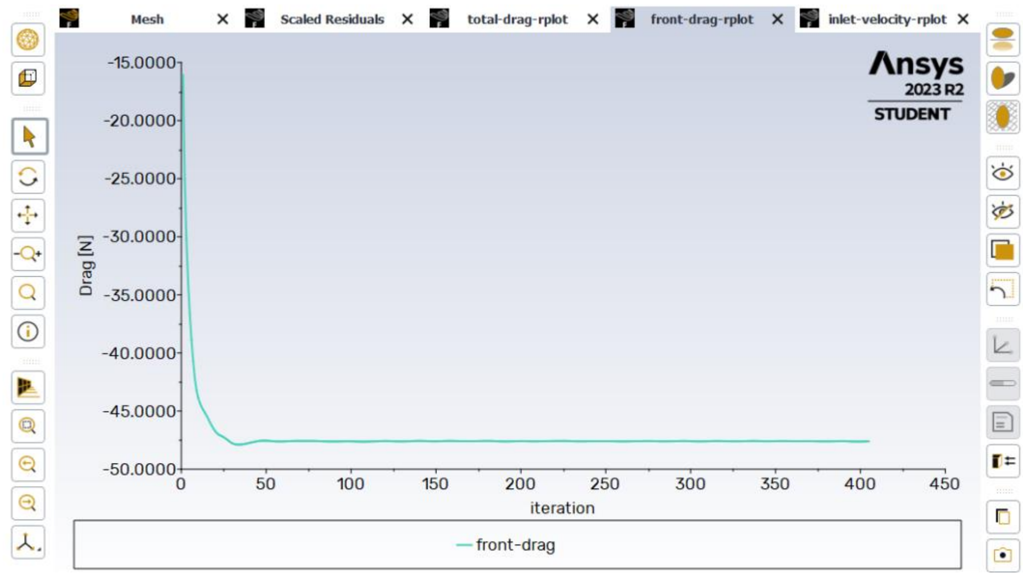


*Figure 10 : Frontal Drag*

Total **pressure Drag** on the body = 47.6 x 2 = **95.2 N**

This means that the simulation accounts for both pressure and form drags.
Form drag accounts for 38.6 percent of the total drag and cannot be ignored.

## Cool Visuals :

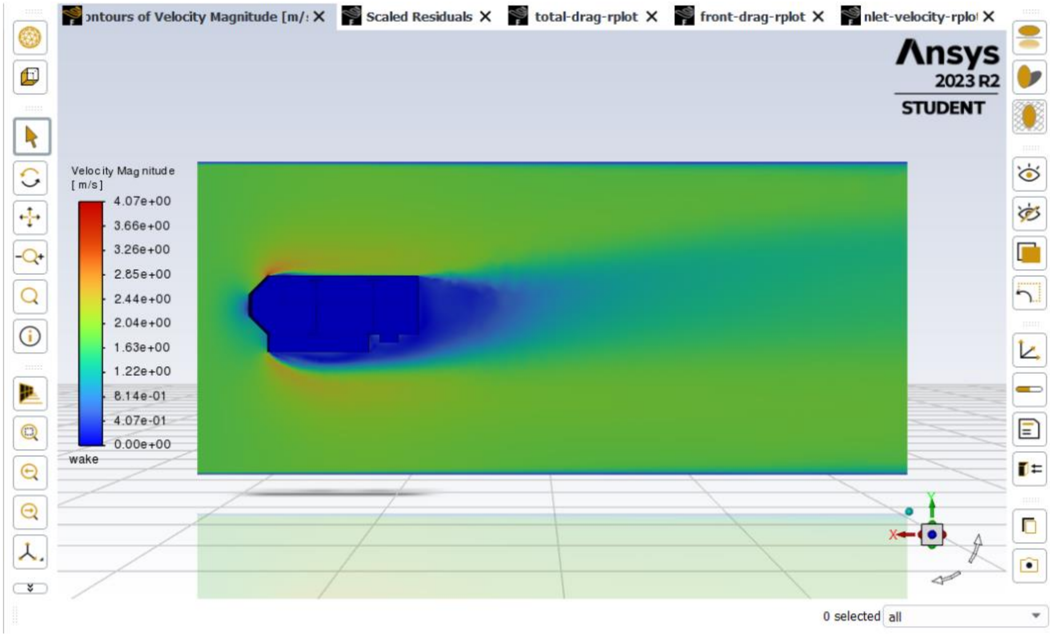


*Figure 11 : Wake Region*

We can notice that the wake of the body is significantly violent. It is almost equal to half the volume of the AUV. It should be investigated if the wake can be minimized.
Streamlining the AUV further could improve aerodynamic efficiency significantly.

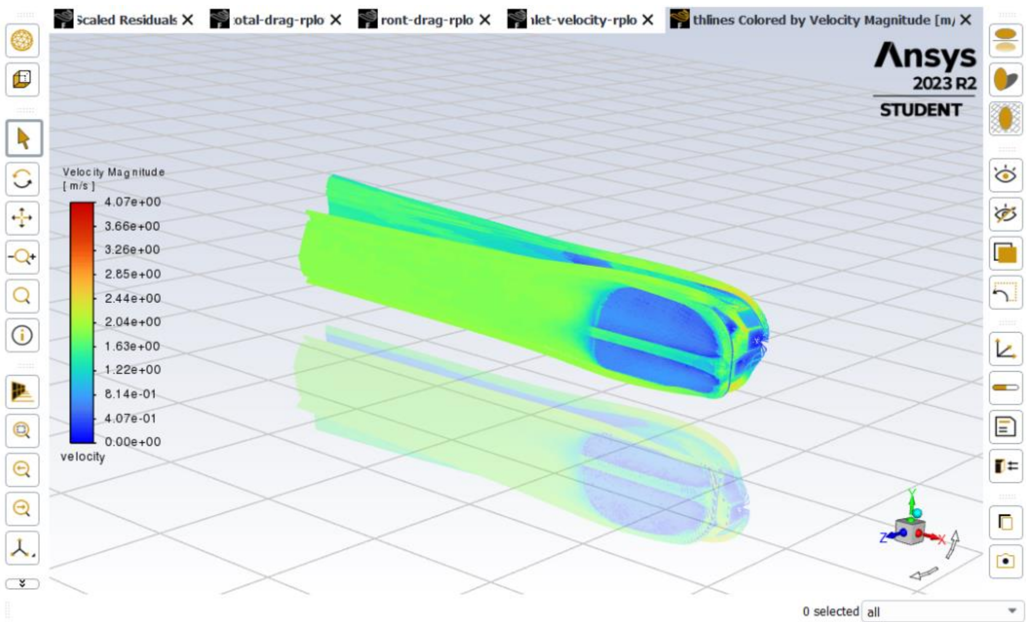


*Figure 12 : Velocity Pathlines*

It is noticed that there is a strange pattern of pathlines near the sideboards.
Can be investigated further.

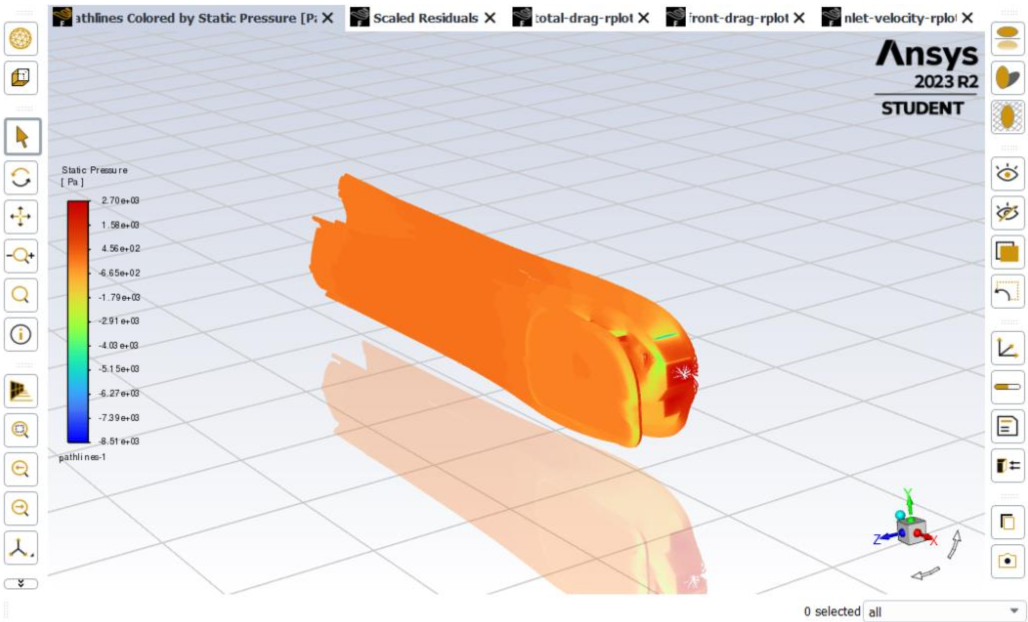


*Figure 13 : Pressure Pathlines*

## Notes :

The terminal velocity of MAK-1 is predicted to be 1.8 $ms^{-1}$. At this rate one would expect MAK-1 to pass through the gate (Round 1) in 10/1.8 = **5.55 s**.
But this does **not** account for the time taken to accelerate from 0 to 1.8 s. Hence, the actual time taken to pass through the gate would be higher.

A comprehensive calculation for the lap time of MAK-1, accounting for the acceleration and added mass of the AUV is required and will be performed.

For the 6 - Thruster System with 2 surge thrusters,

Substituting $F_T$ = 102.9, k = 48 into the drag equation, we get :

**v = 1.46 $ms^{-1}$**

Similarly, for the 8-thruster system :

Substituting $F_T$ = 205.8, k = 48 into the drag equation, we get :

**v = 2.07 $ms^{-1}$**

The 8-thruster system would be necessary if it is observed that the acceleration and added mass factors increase the lap time past the possibility of the team qualifying Round 1.