NWTF

Development of Aircraft Half Model Testing at the 10x5 Wind Tunnel

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Ricardo Huerta Cruz
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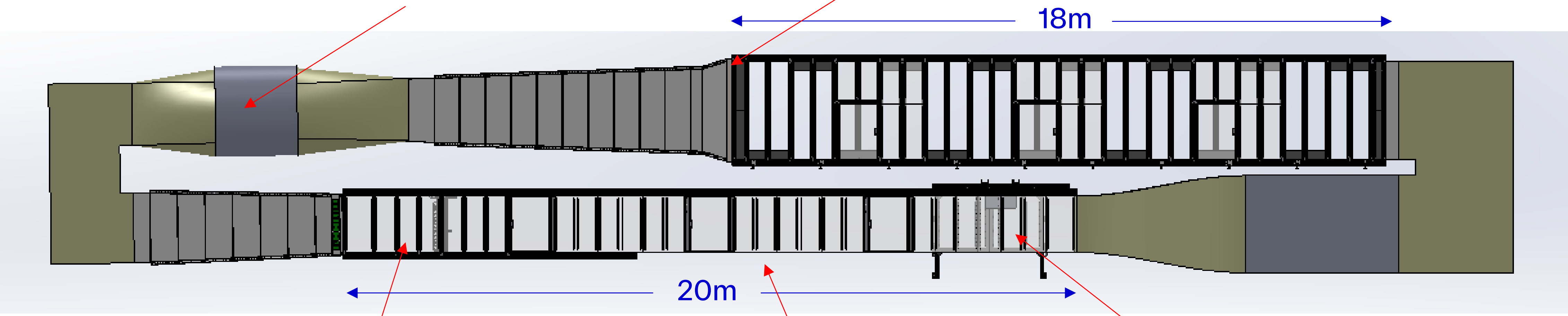
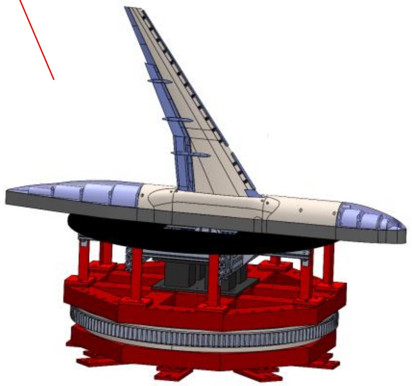
William McArdle, Ricardo Huerta-Cruz
03/04/2025

10’×5’ Wind Tunnel
Imperial College



- Max speed = 30 m/s
- $Re\ =\ 2x10^{6}\ m^{-1}$



Agenda

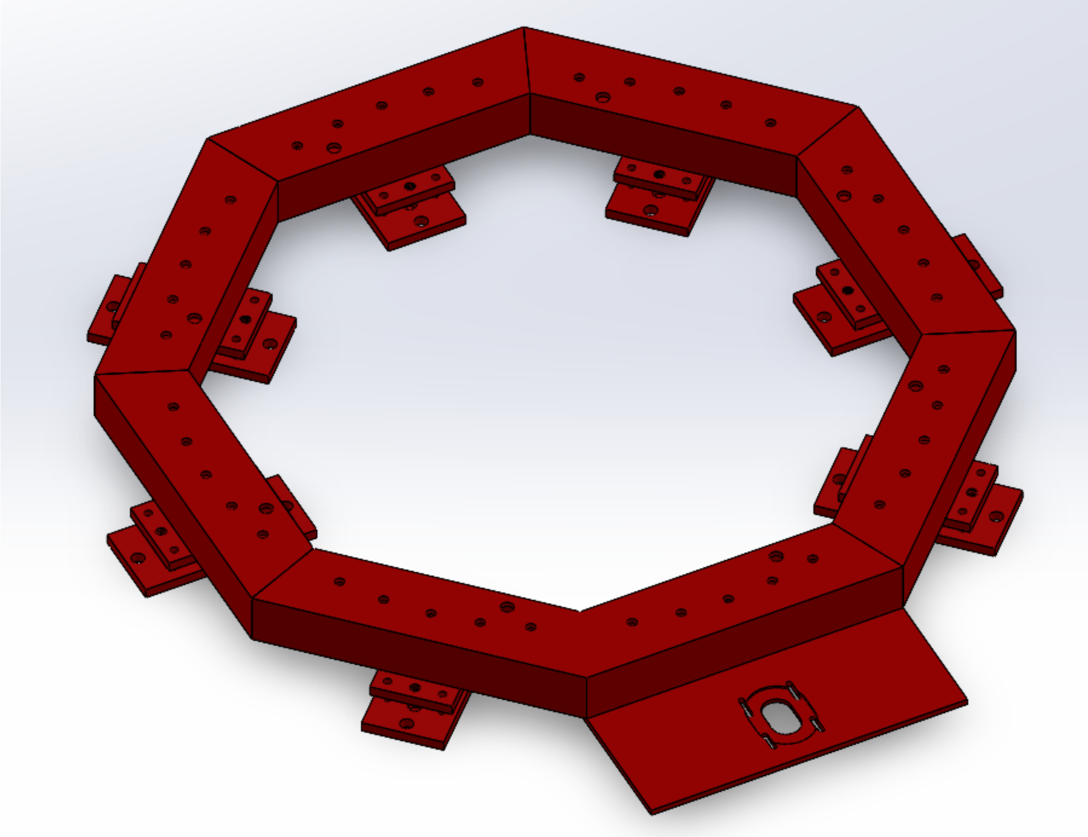
Motivations

1. Investigate how to effectively treat the half model symmetry plane
2. Reynolds number dependence testing and comparison to other wind tunnels tests of the same model
3. Model fidelity
4. Test the suitability of using 3D printed parts
5. ‘Workhorse’ model before the arrival of Boeing 4% ‘gold standard’ model

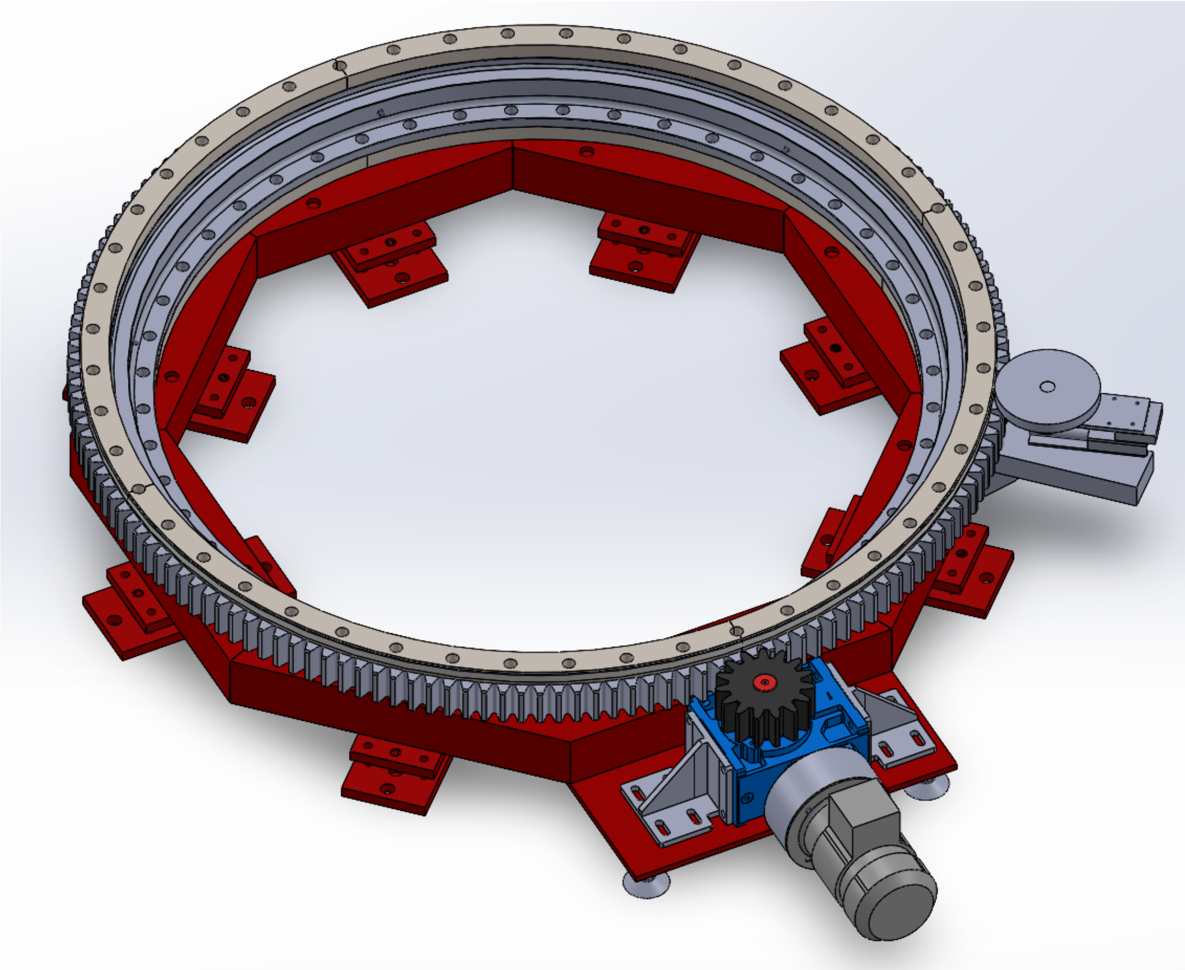
Model Motion System

Design and Build Progress

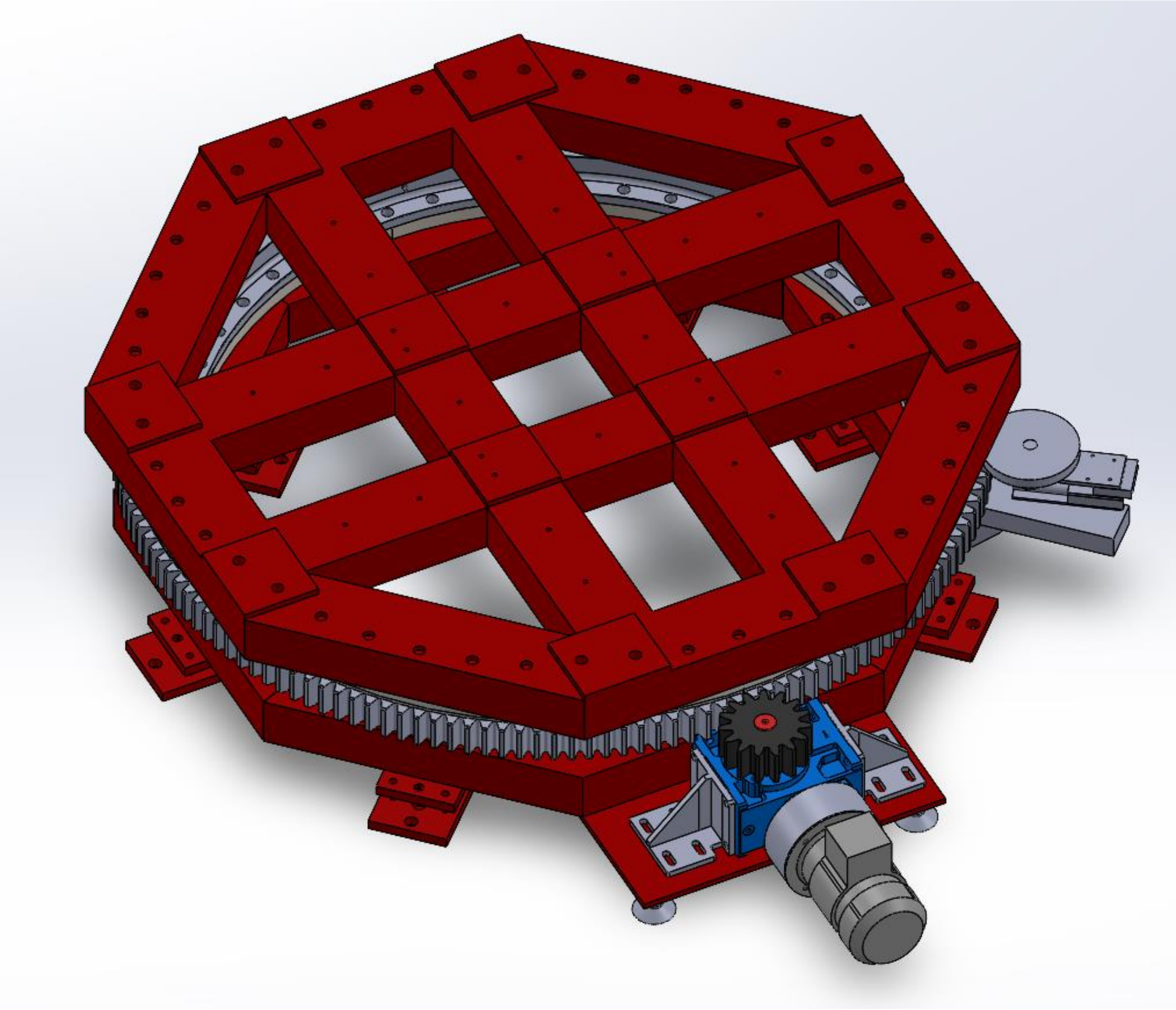
MMS Design



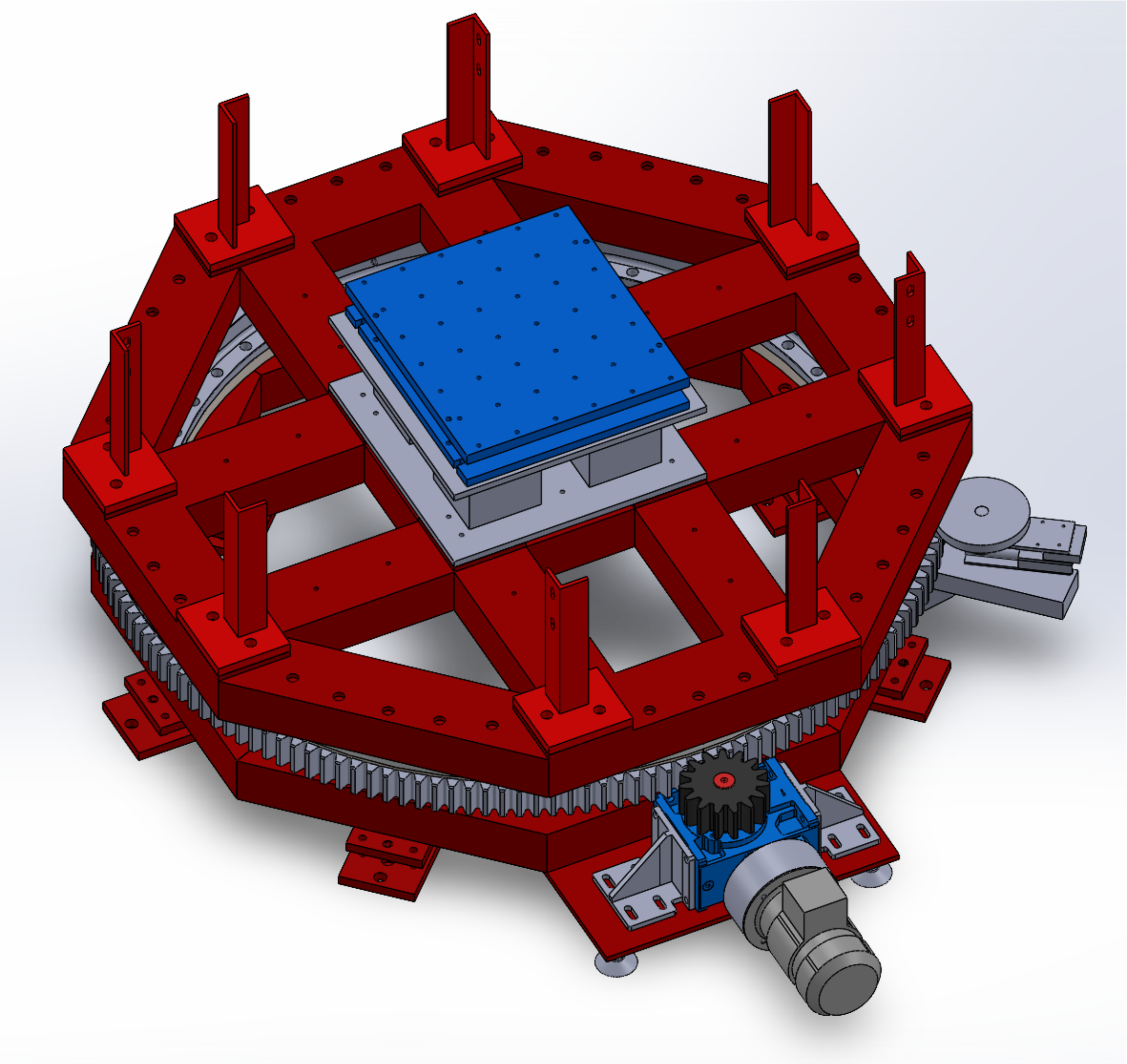
MMS Design



MMS Design



MMS Design



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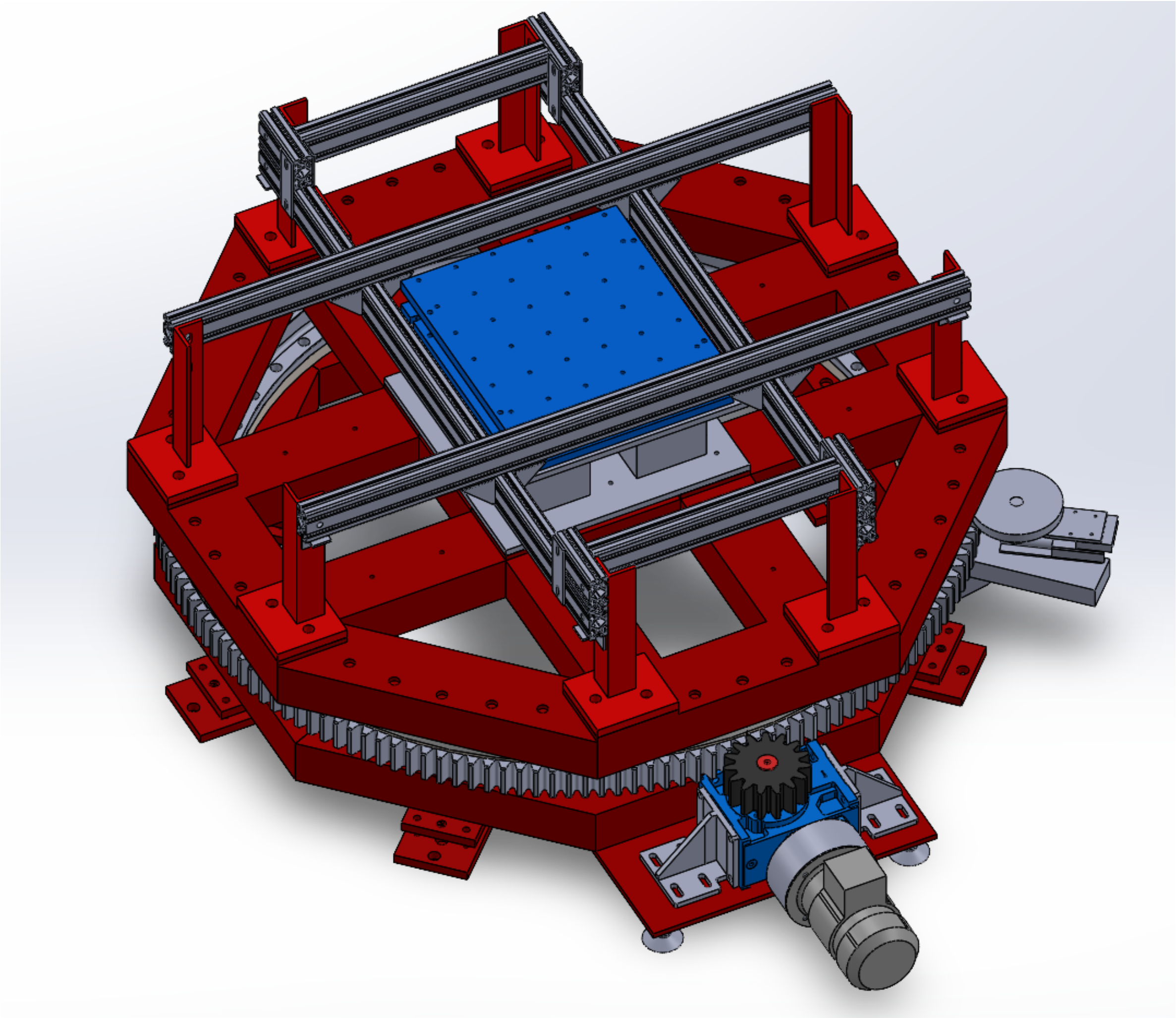

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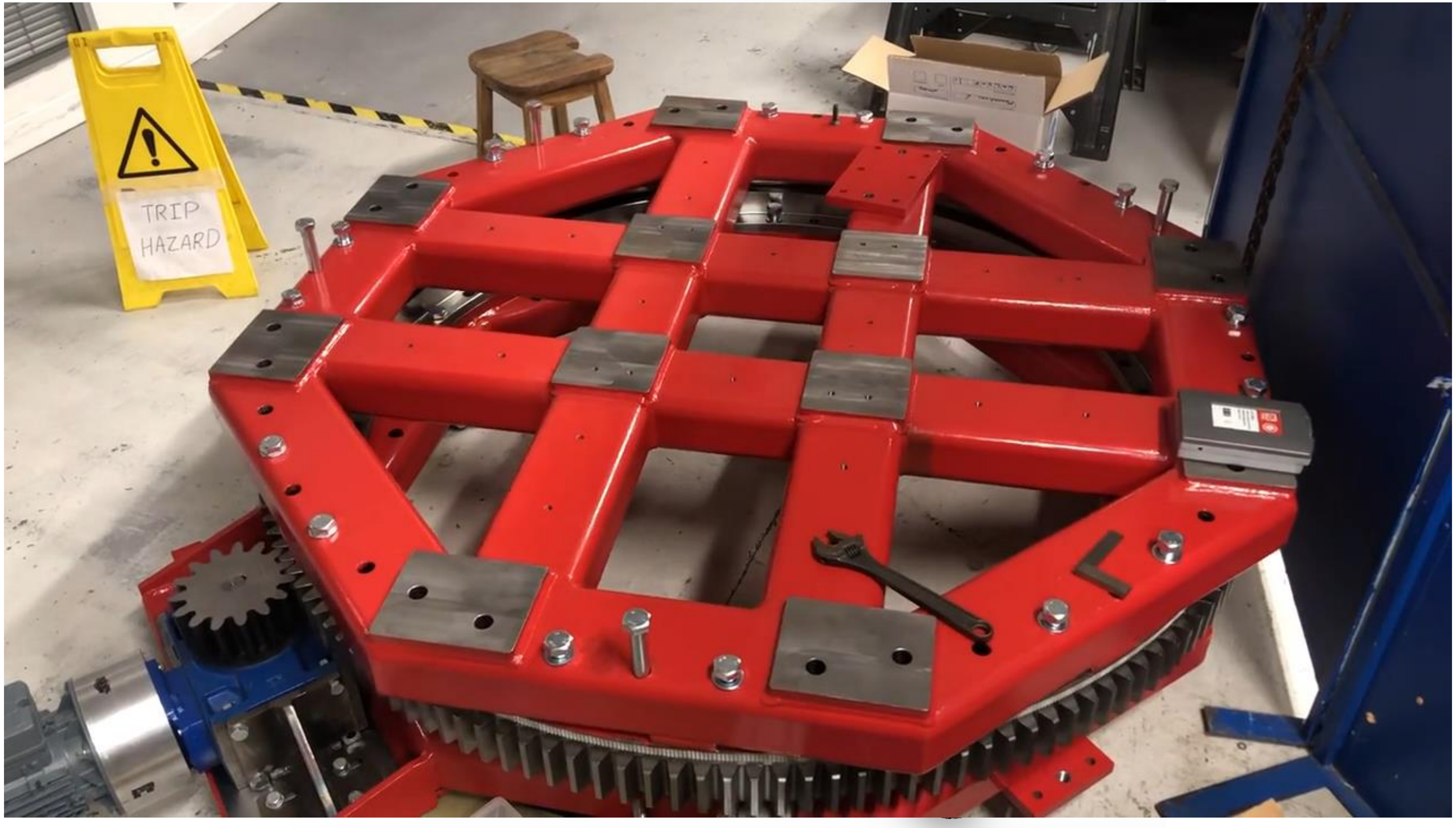
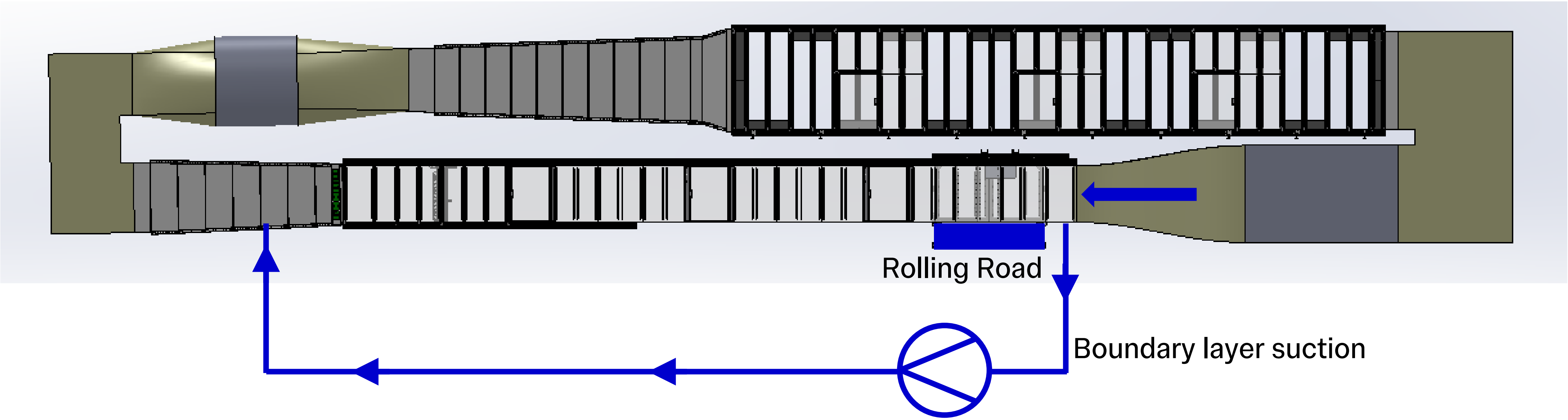


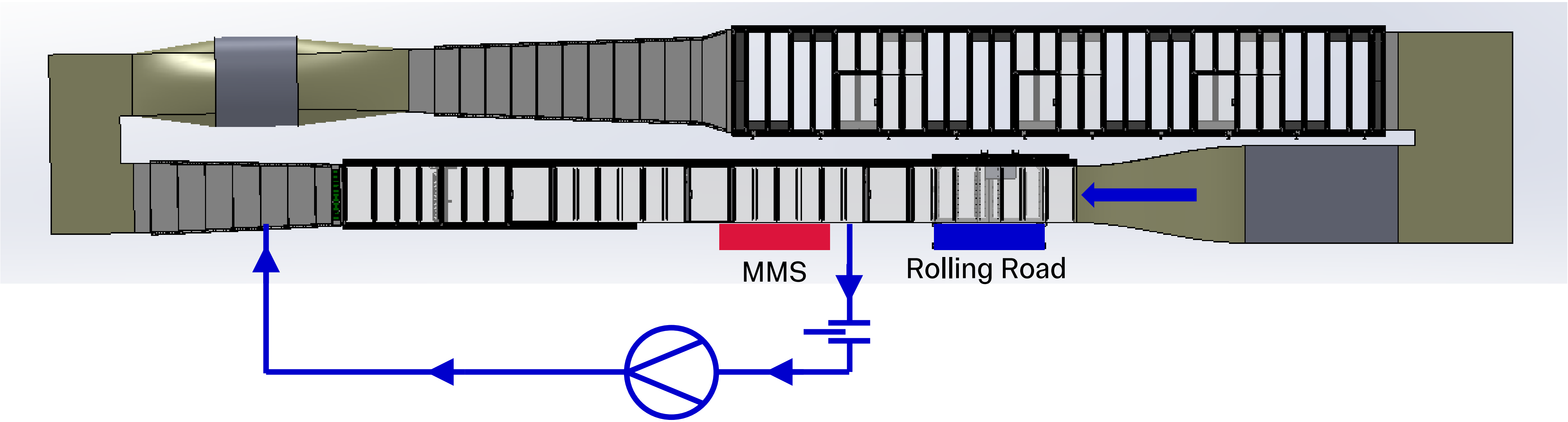
Symmetry Plane Treatment

Boundary Layer Suction

Original suction system ahead of rolling road

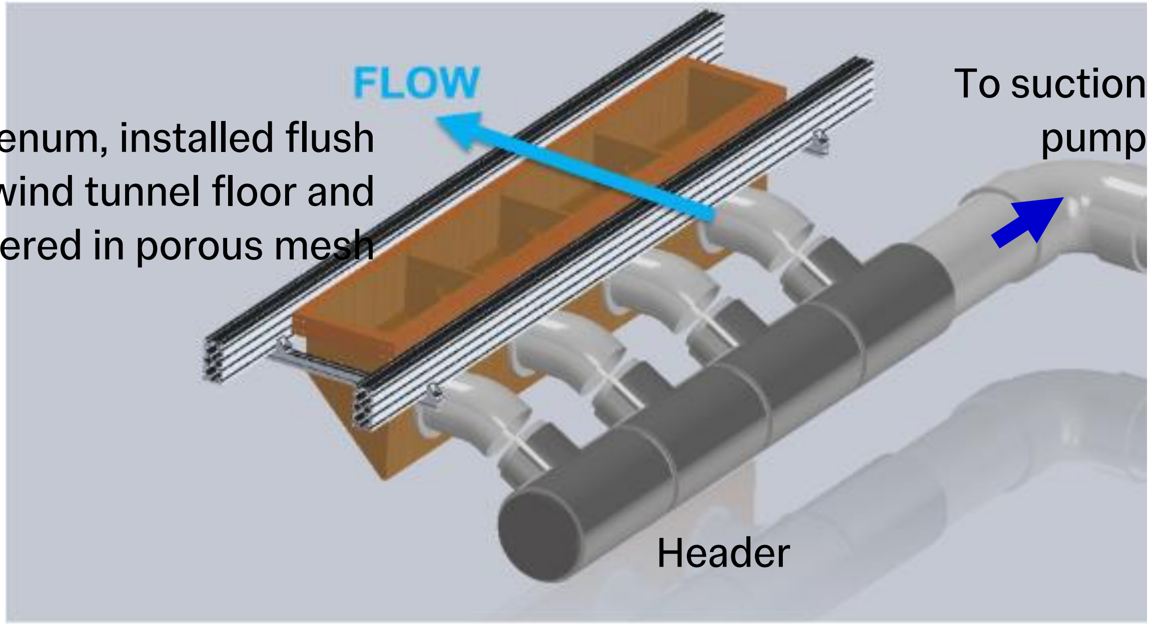


Modified suction system

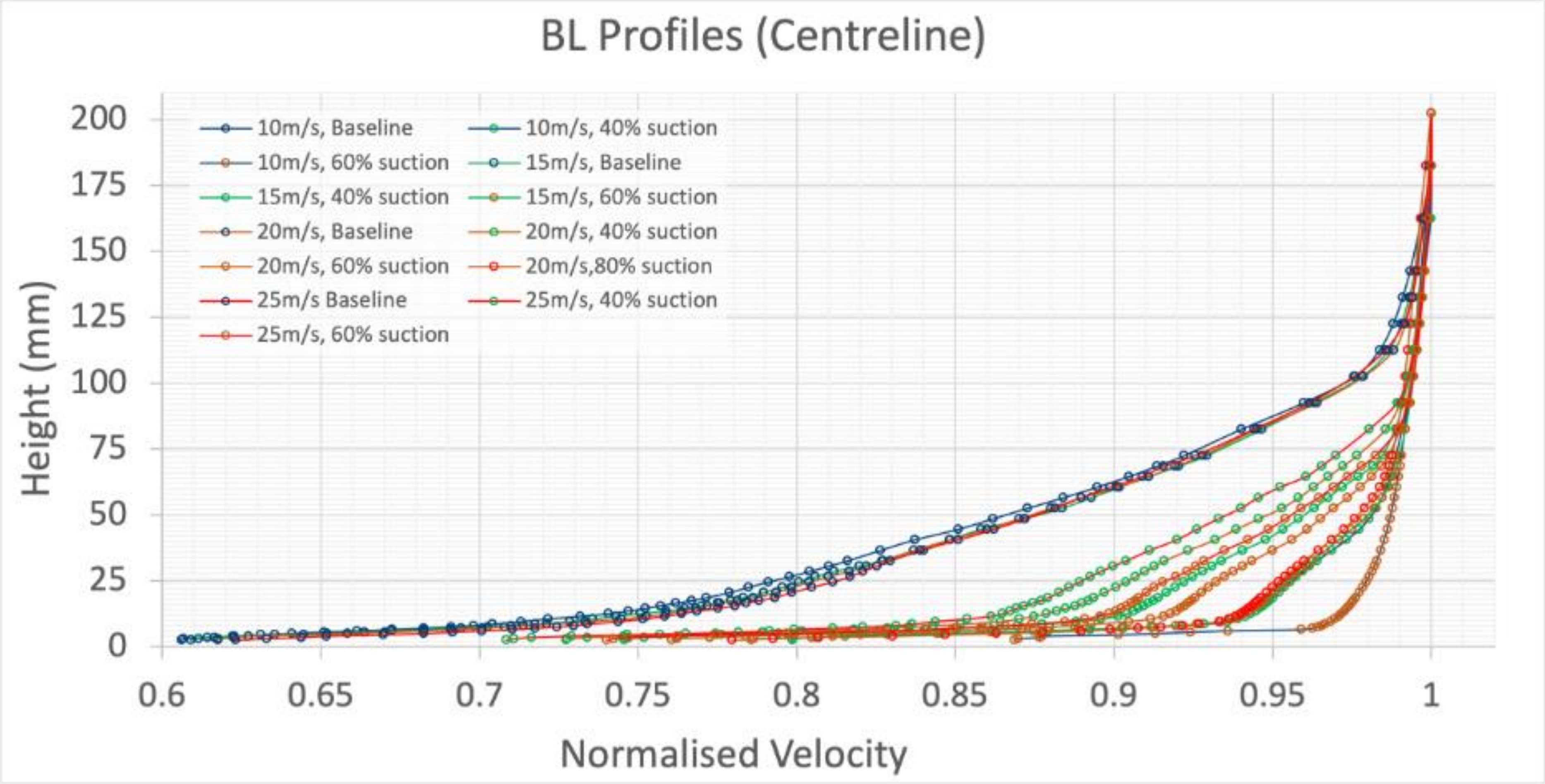


Introduction of suction plenum and porous floor upstream of MMS

First results – Neville Koh, MSc Thesis



Boundary layer modification through suction, Neville Koh, MSc Thesis



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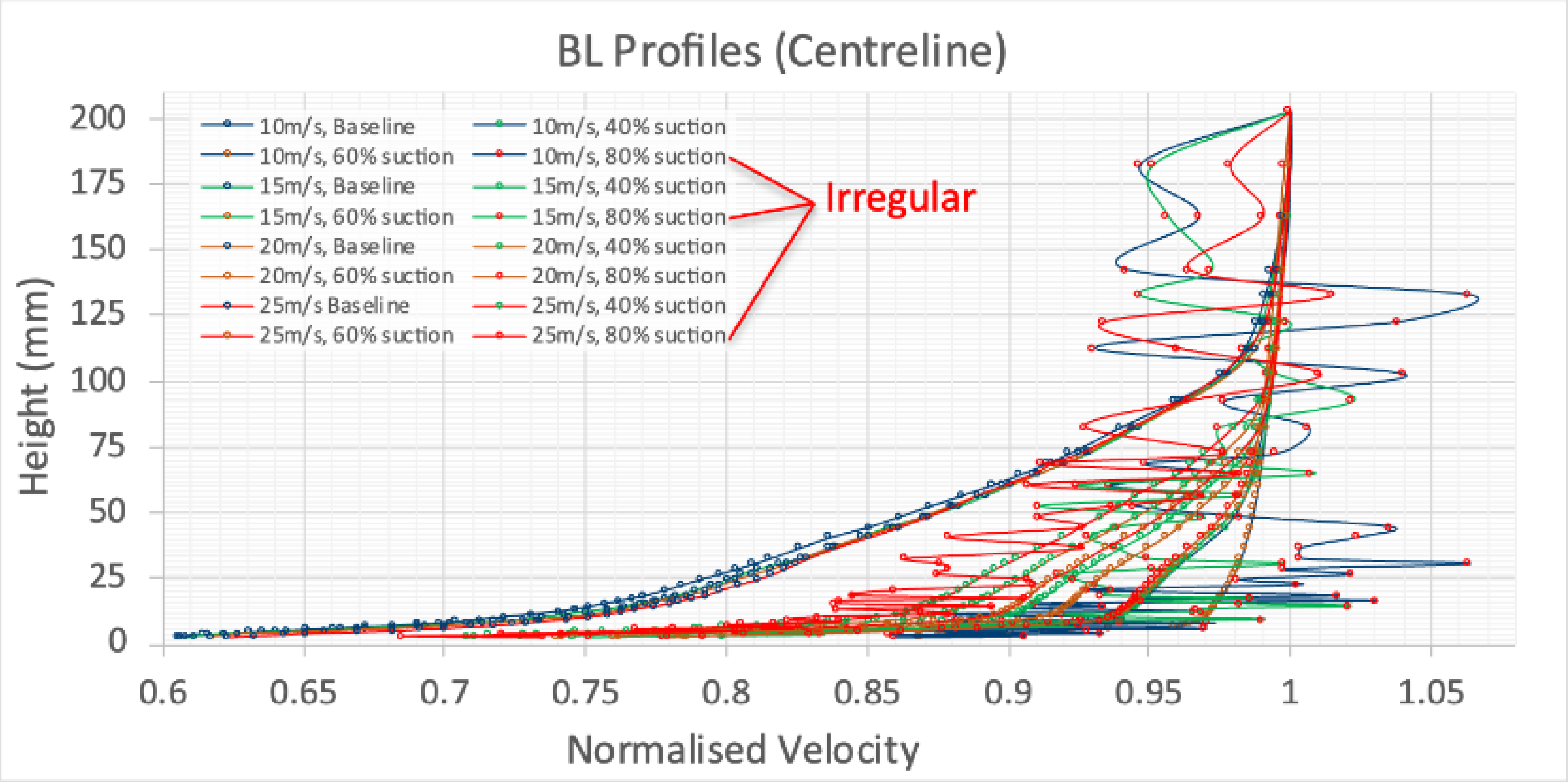
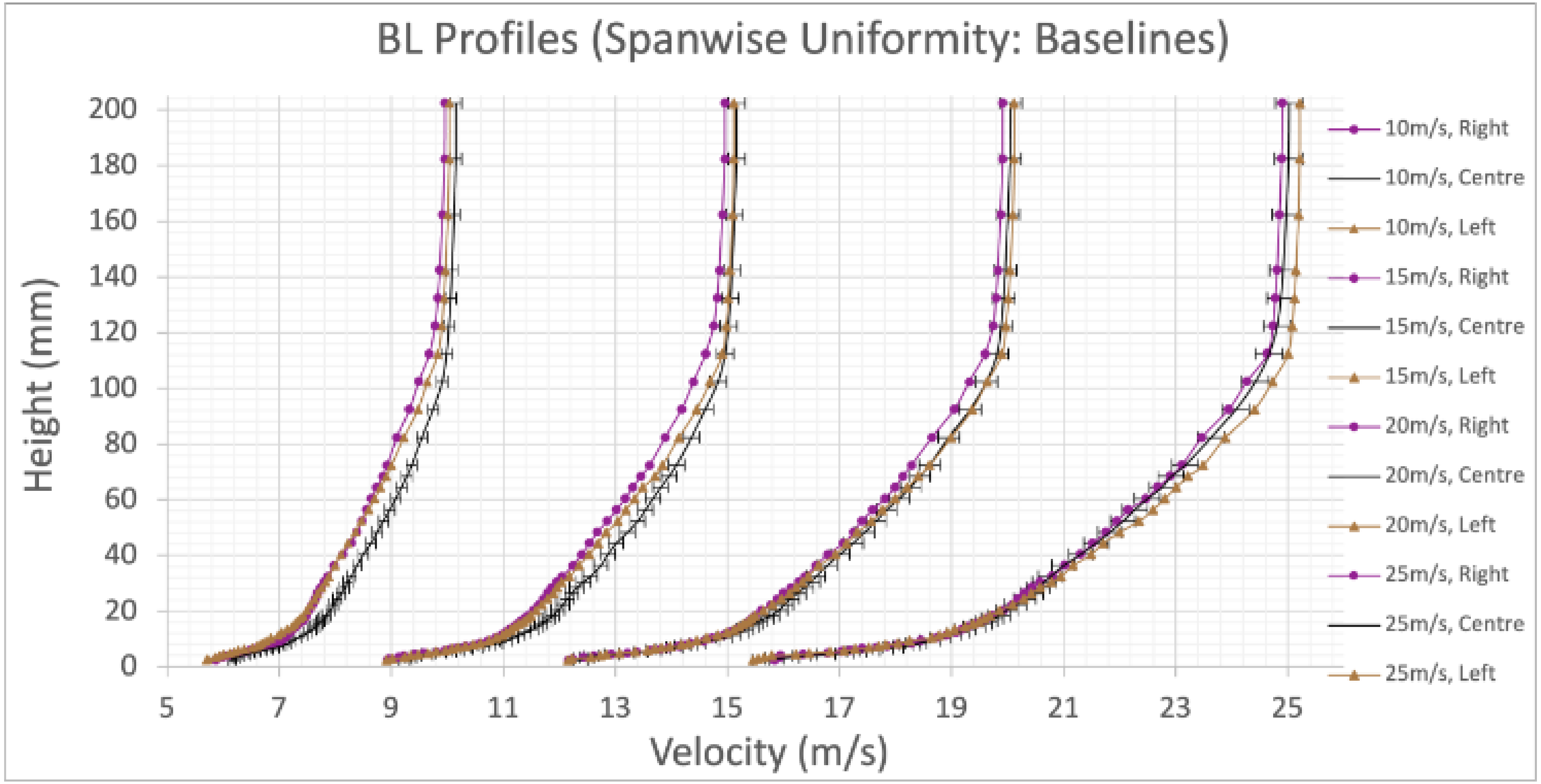
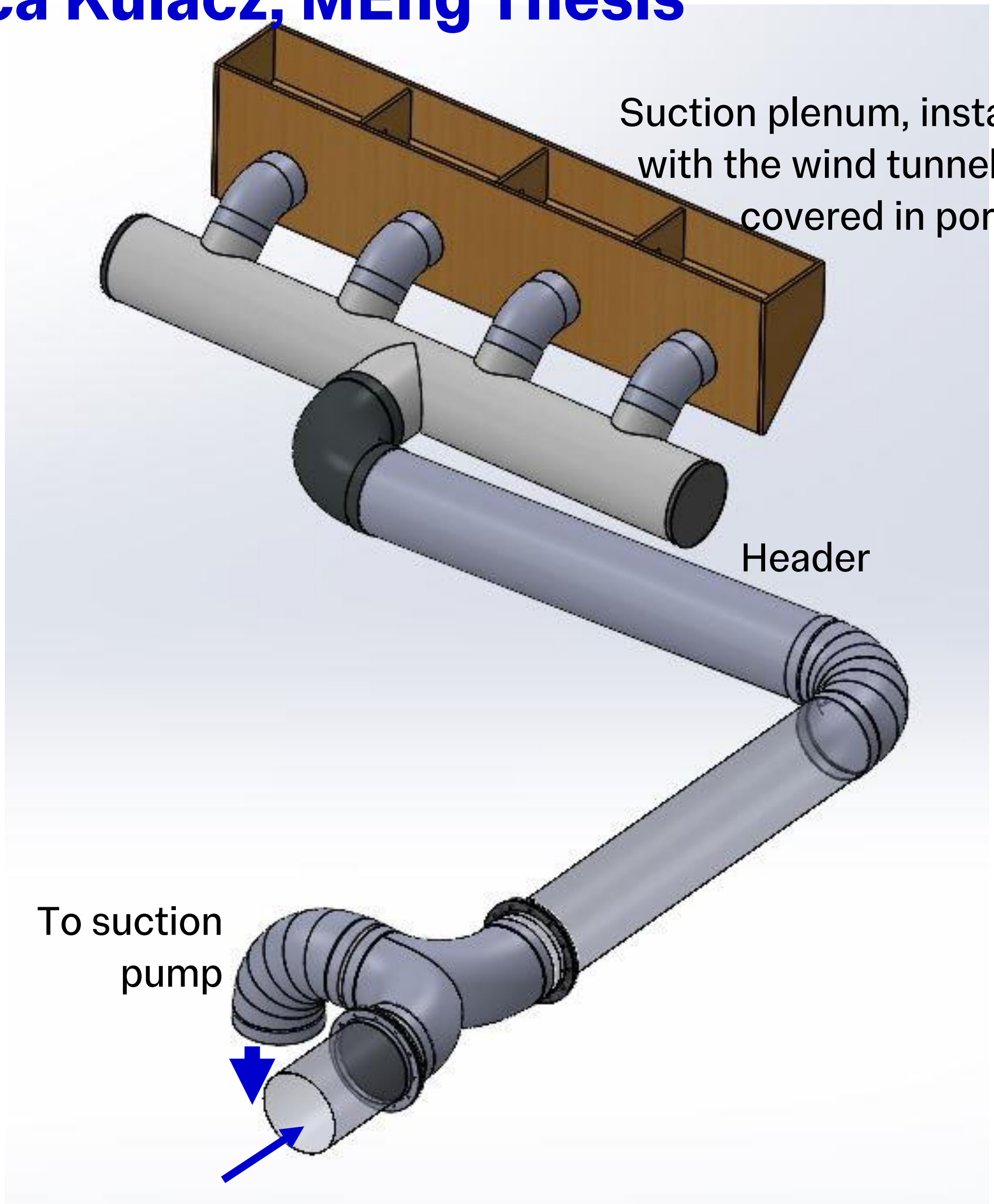


Boundary layer modification through suction, Neville Koh, MSc Thesis



Luca Kulacz, MEng Thesis

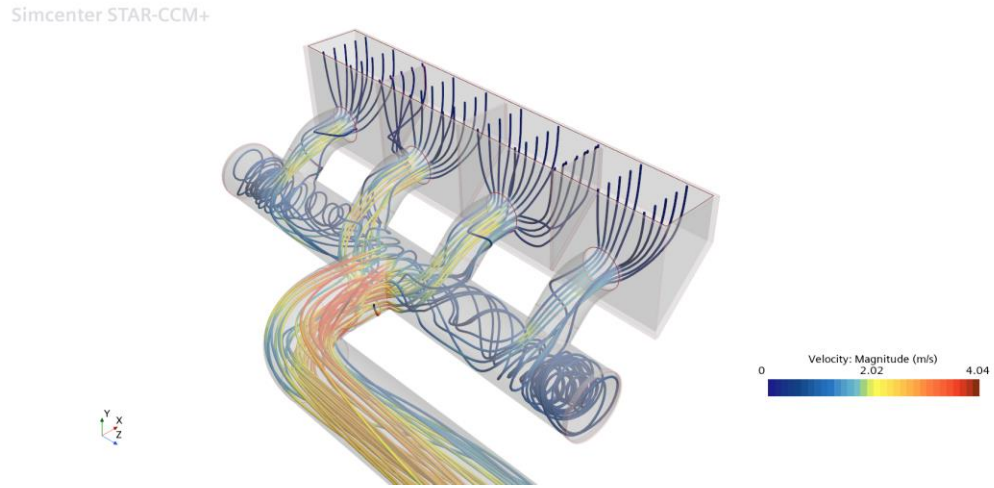


Parameter space

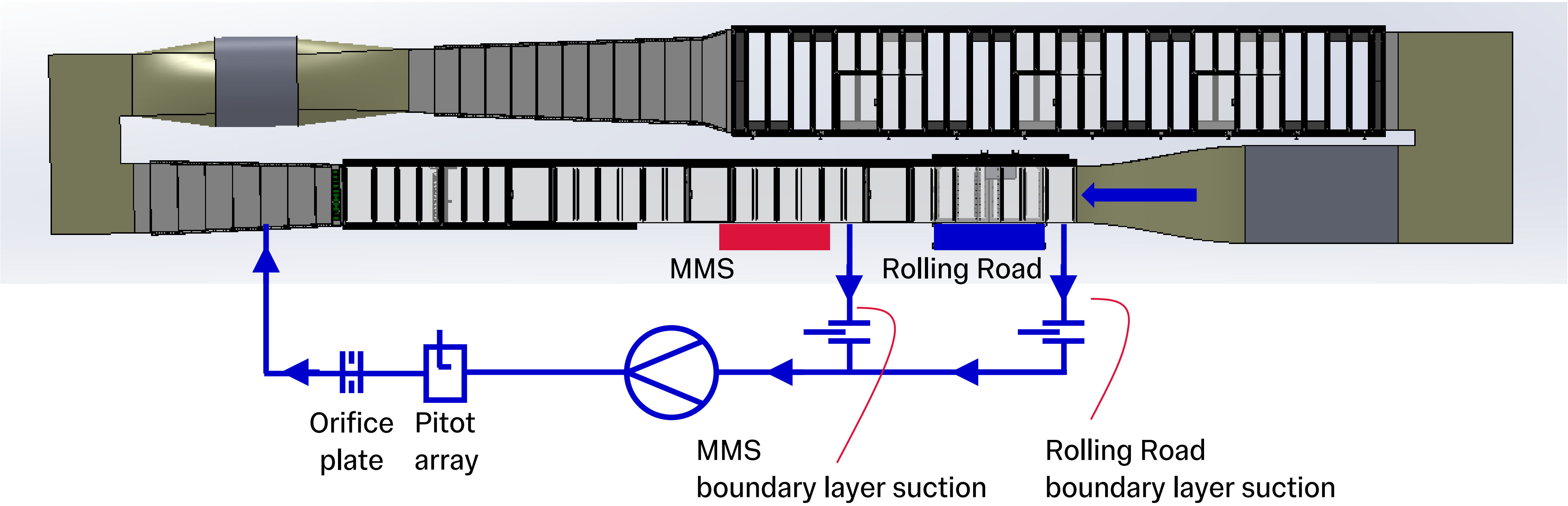
- 2 porosities
- 2 suction widths
- 4 suction levels
- 4 wind speeds
- Floor-normal profiles (25 locations)
- 3 spanwise stations

Data

- Streamwise and vertical velocity from Laser Doppler Anemometer
- Streamwise (floor and wall) static pressure along flow direction
- Flow rate through orifice plate
- Flow rate through Pitot-s array



Modified suction system



Introduction of metering

Introduction of gate valves

Introduction of suction plenum and porous floor upstream of MMS

Static Pressure Monitoring

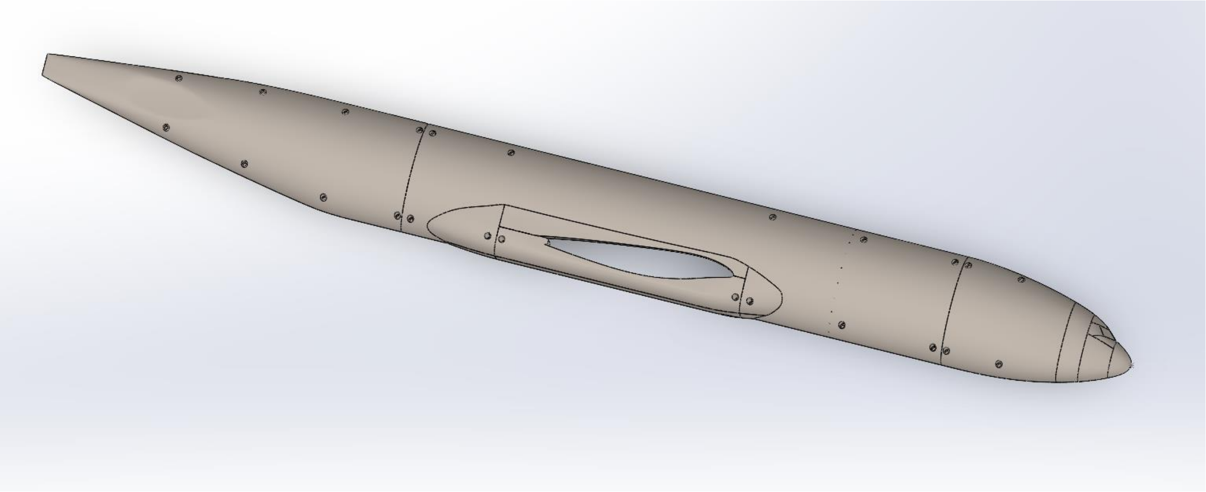
- Taps along the tunnel floor centreline…
- Taps along the wall…
  - Have been introduced to monitor the streamwise evolution of the static pressure, downstream of the suction.
  - This informs the ideal installation location of the MMS disc.

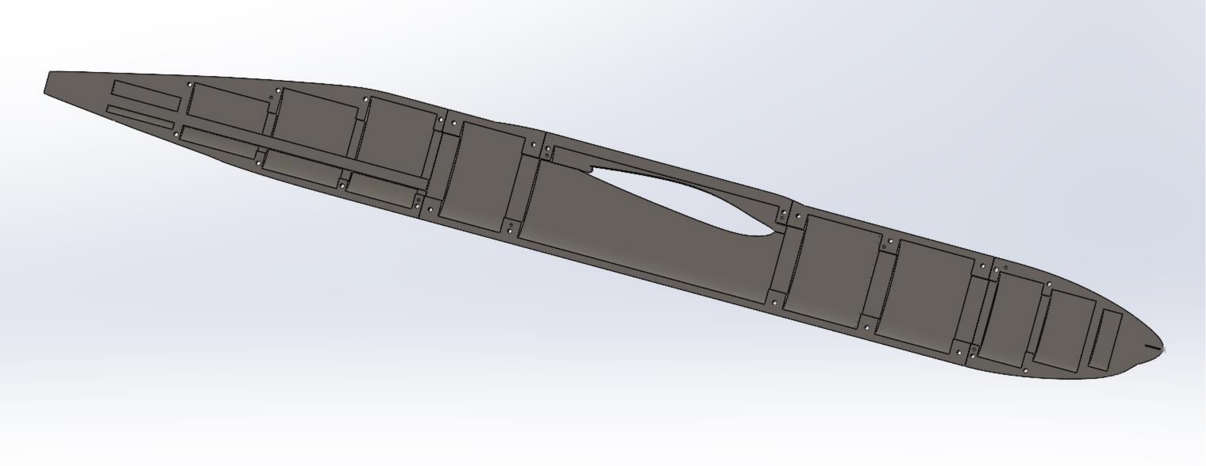
A TE ESP64-HD Pressure scanner acquires the pressures

NASA Common Research Model (CRM-HL)

Design and Manufacture – 4% scale

CRM-HL Design



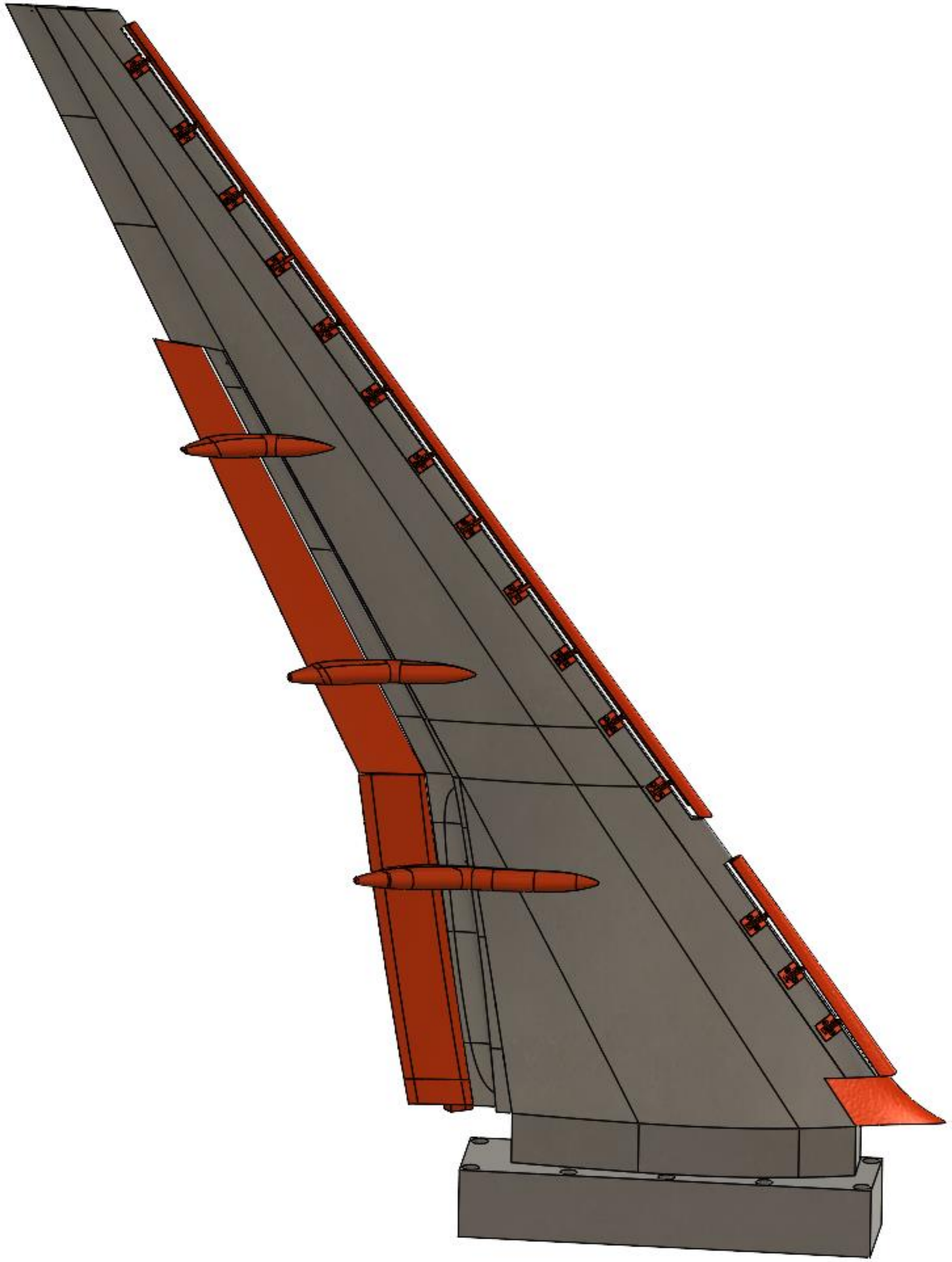


- The fuselage, largely hollowed, will be 3D printed.
- Pressure taps to be included, replicating locations existing in the Boeing UK 6% model, or the NASA 10% model (tested at QinetiQ in 2019).
- Peniche/Standoff design on going

CRM-HL Design

- We’re planning two wings:
  - A lower cost, training, version with
    - 3D printed leading edge slats
    - 3D printed flaps on fairings
    - 3D printed trailing edge
    - 3D printed tip.
    - A core machined out of solid hard foam or hard wood.
      - It will have a small sample of taps.

  - A carbon-fibre, hollow version, with
    - 6-10 belts of pressure taps
    - Same 3D printed components as the lower cost version



CRM-HL Design

- We're planning two wings:
  - A lower cost, training, version with
    - 3D printed leading edge slats
    - 3D printed flaps on fairings
    - 3D printed trailing edge
    - A core machined out of solid hard foam or hard wood.
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  - A carbon-fibre, hollow version, with
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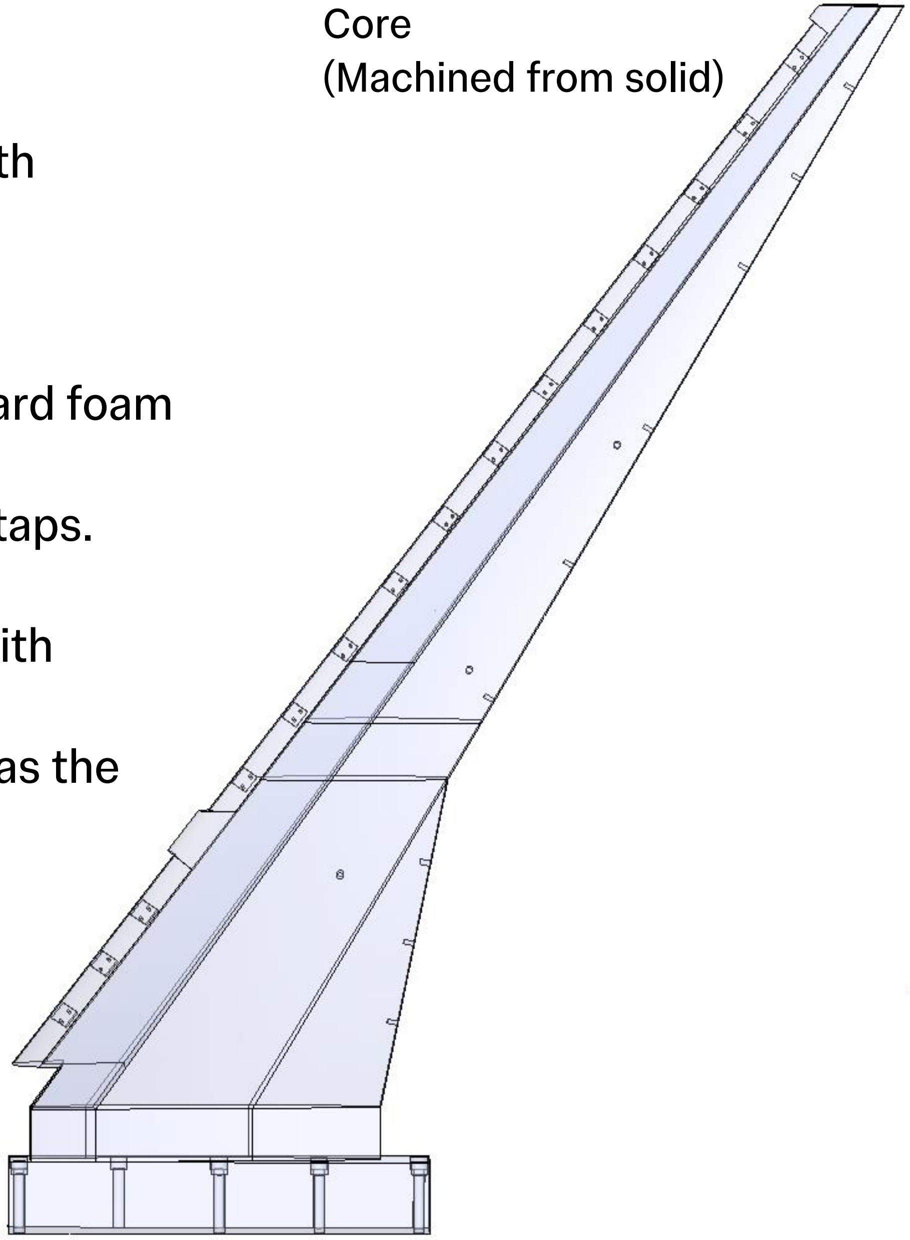
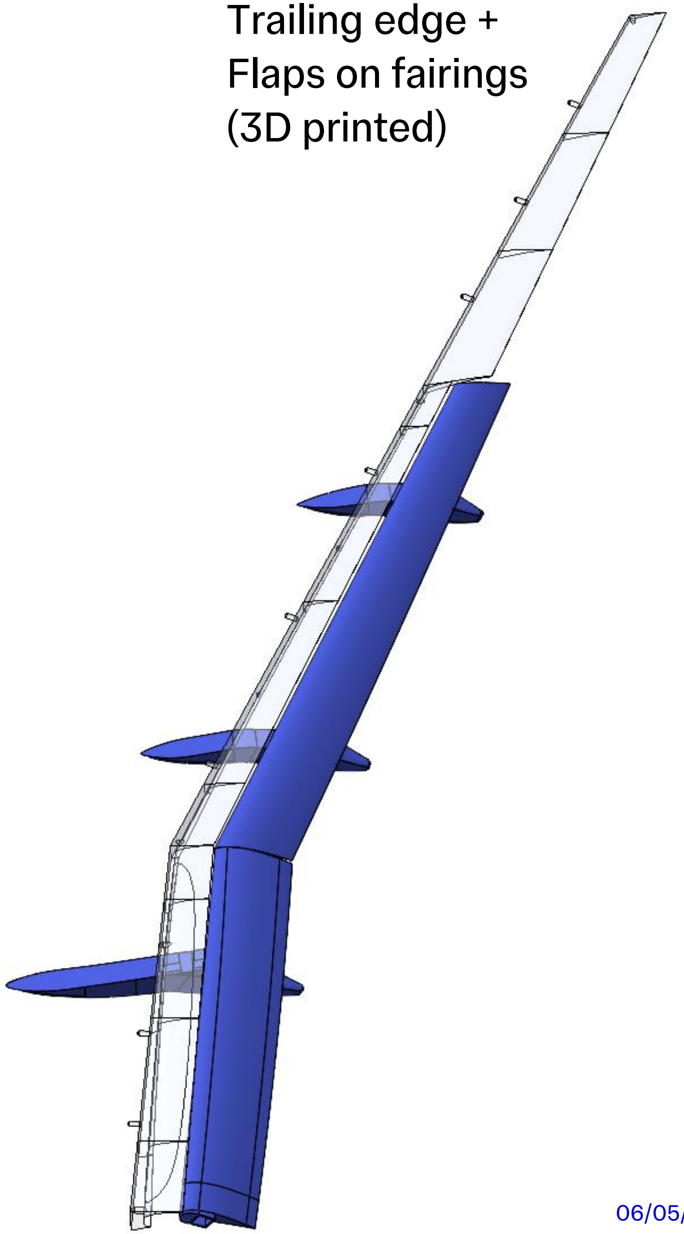
Core
(Machined from solid)



Trailing edge +
Flaps on fairings
(3D printed)

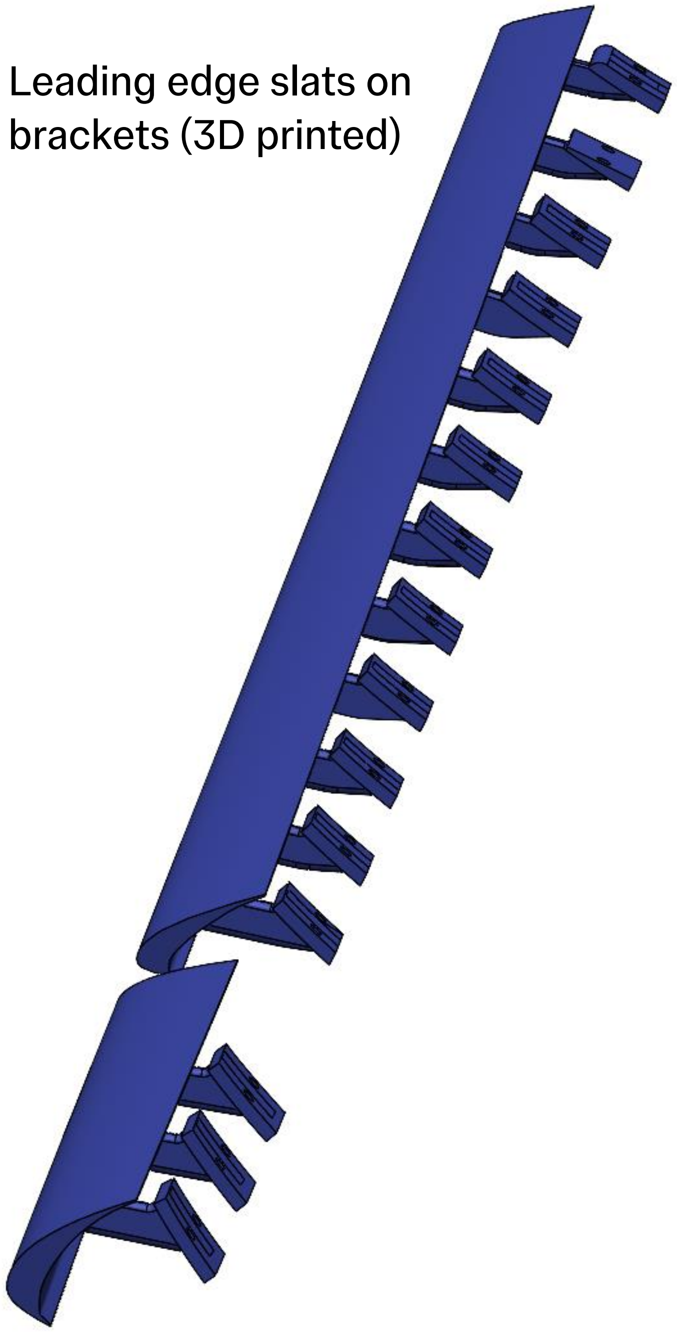


CRM-HL Design

- The wing has leading edge slats, and trailing edge deployed flaps.
- We're planning two wings:
  - A lower cost, training, version with
    - 3D printed leading edge slats
    - 3D printed flaps on fairings
    - 3D printed trailing edge
    - A core machined out of solid hard foam or hard wood.
      - It will have a small sample of taps.

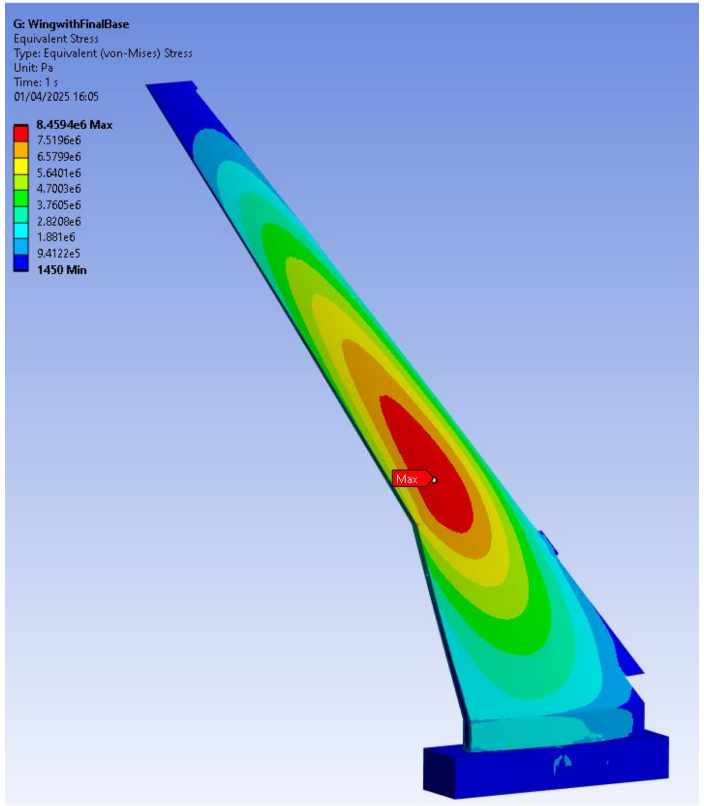
  - A carbon-fibre, hollow version, with
    - 6-10 belts of pressure taps
    - Same 3D printed components as the lower cost version

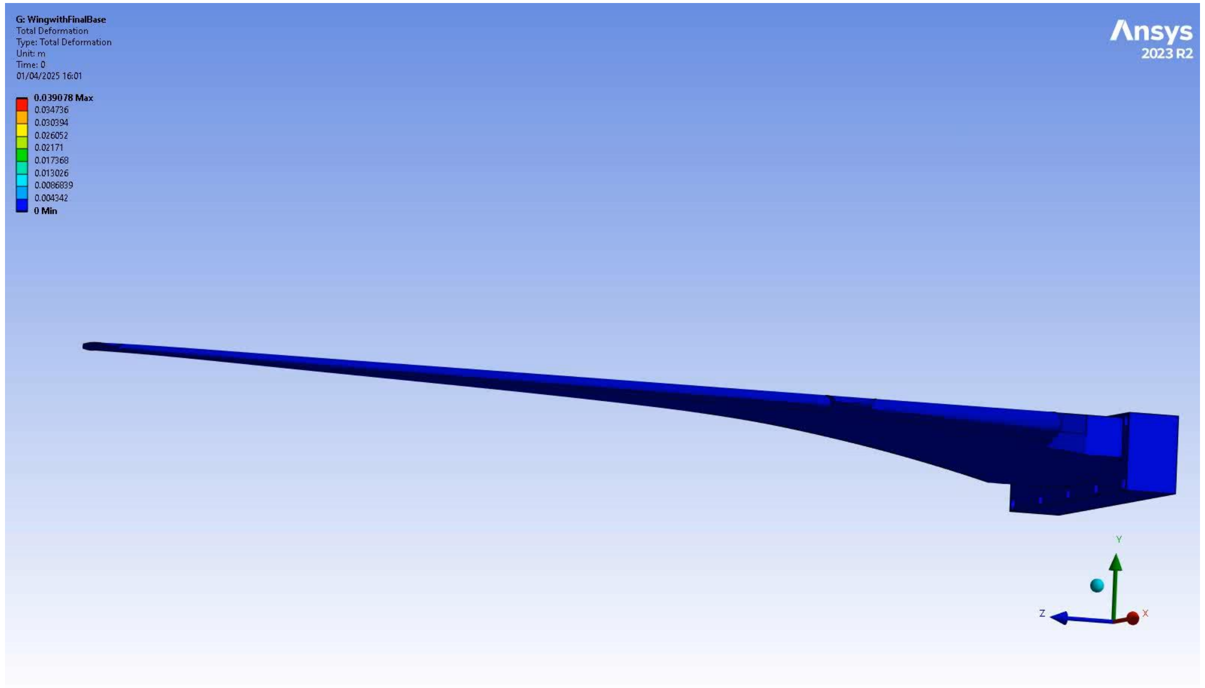
Leading edge slats on brackets (3D printed)



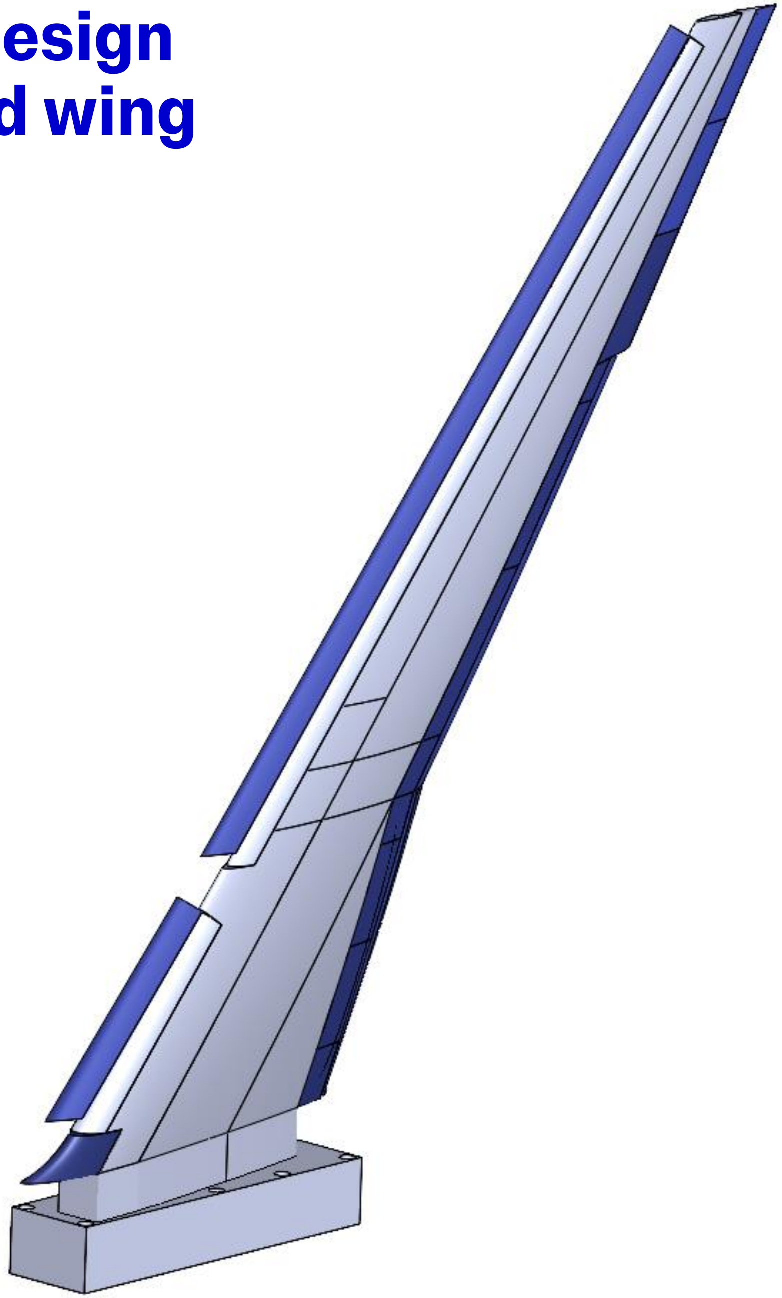
Stress Analysis of the wing

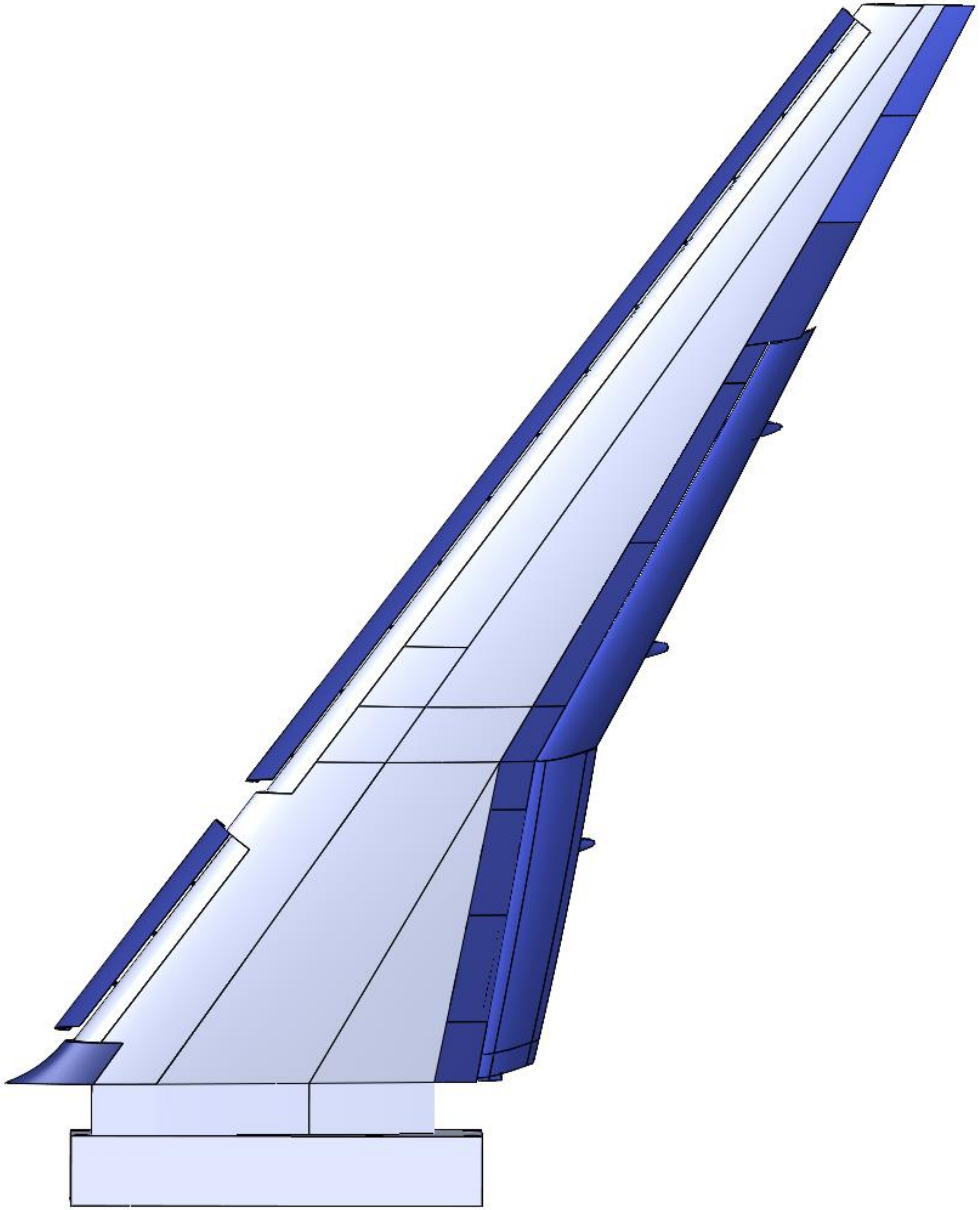
- Material = Modelling Foam
- Distributed load across the half span wing
- Load (Max lift) = 470 N
- Max stress = 8.6 Mpa
- Max Deflection = 40 mm
- Reserve factor 1.8



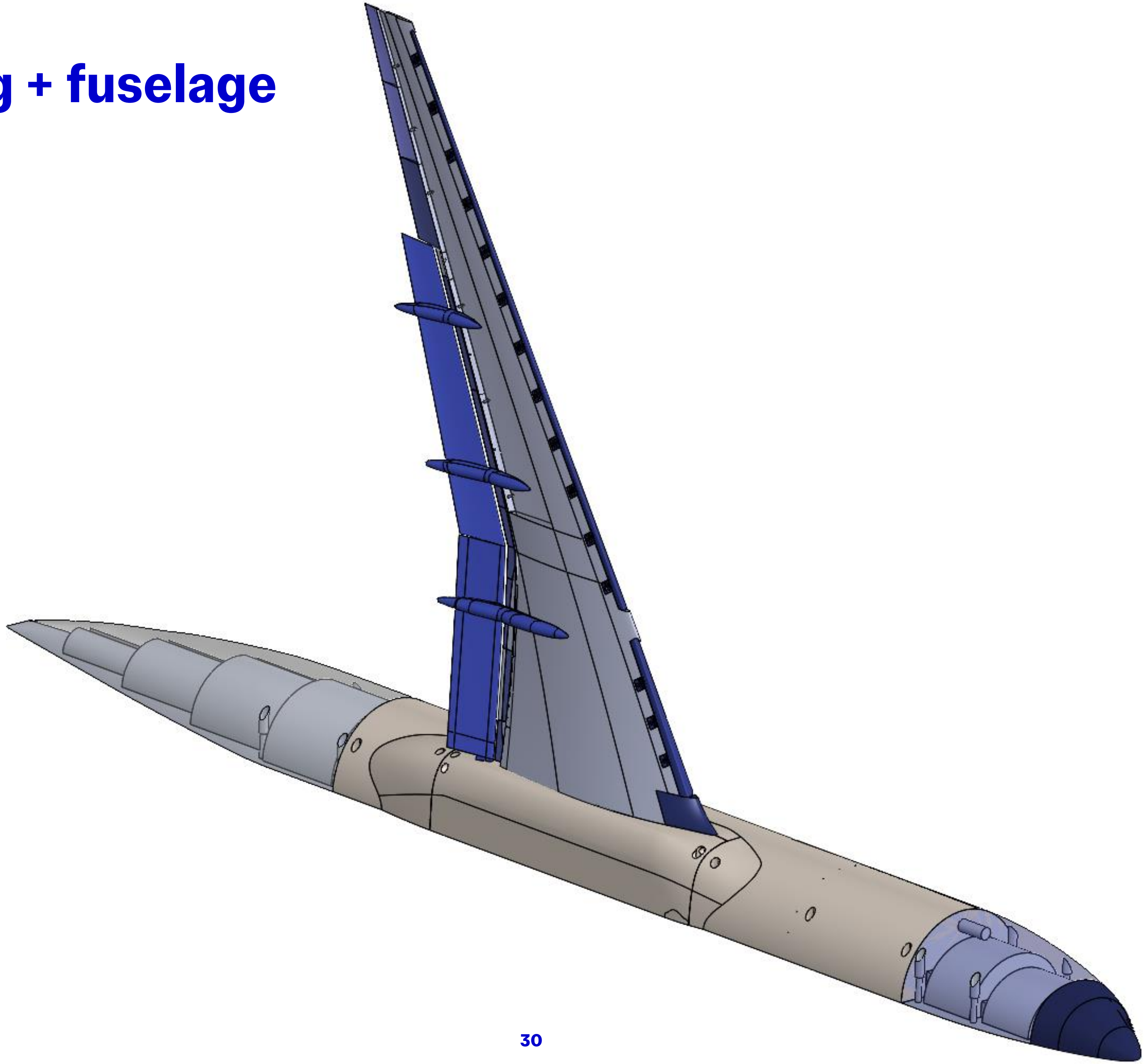


CRM-HL Design
Assembled wing

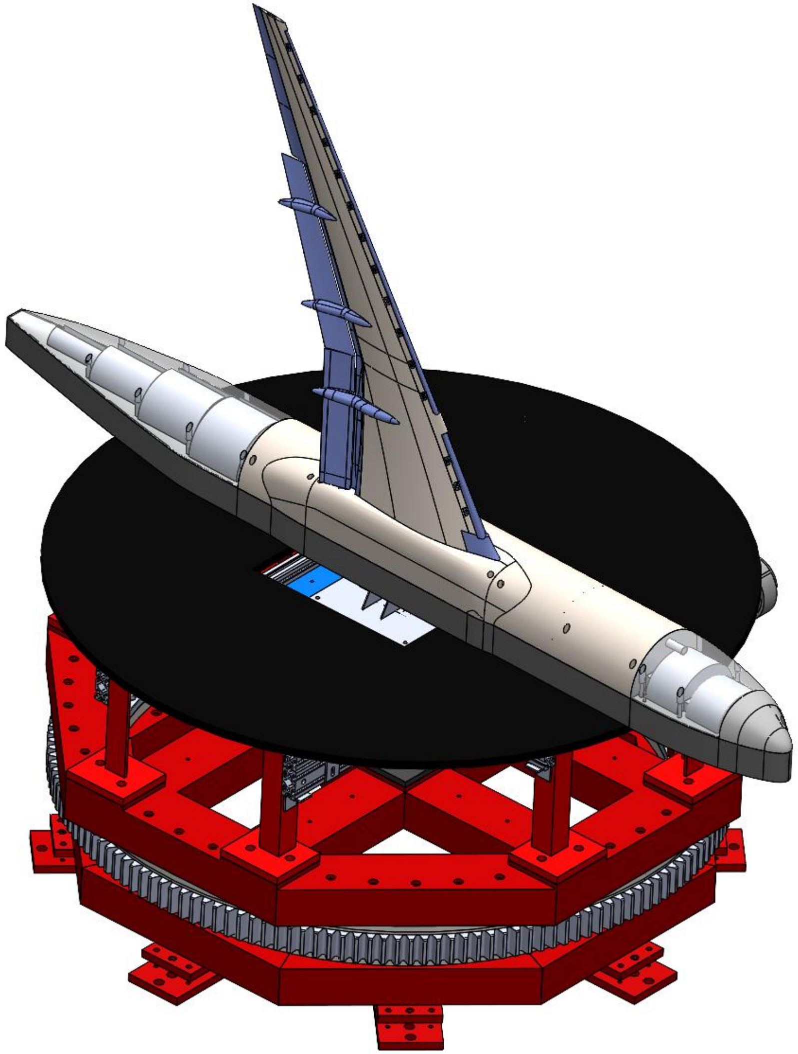


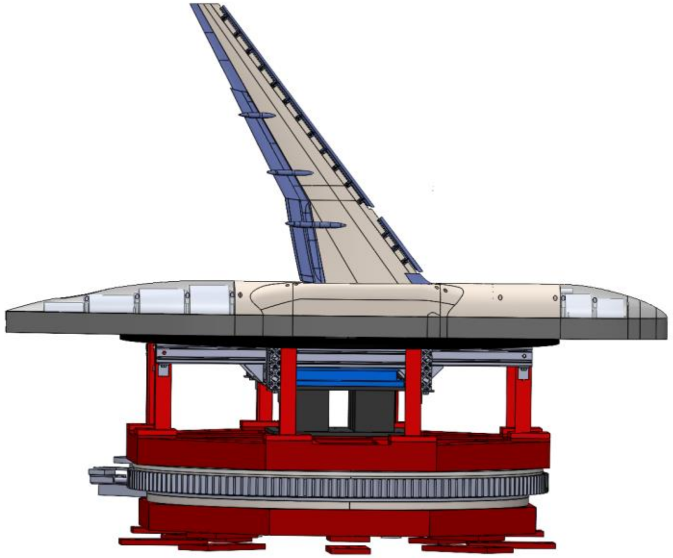


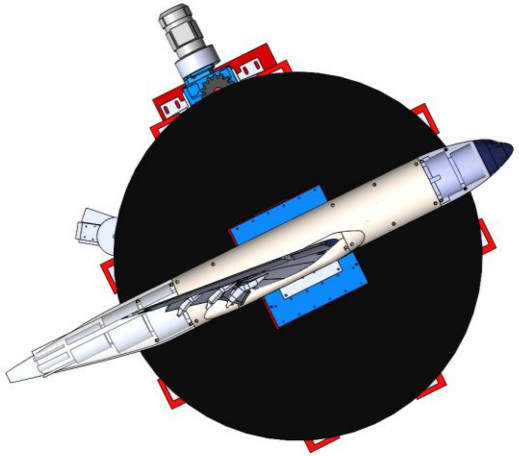
CRM-HL Design
Assembled wing + fuselage



CRM-HL on MMS







CRM-HL Data Sets

Potential Data Sets

Our aim remains to present some of our data, first a taster at SATA, and then at the Lift Prediction Workshop at AIAA. The following are some potential data sets possible using techniques that the lab has extensive experience in.

1. Off-body PIV
2. Off-body and on-body LDA
3. Surface pressures
4. Total loads (6 axes)
5. Pre-testing model scan (FARO arm) – faithfulness to CAD
6. Live non-contact deformation through photogrammetry
7. Off-body hot wire measurements

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Dr. Kevin Gouder (Research Fellow and wind tunnel manager)

Neville Koh (MSc student, now at Boeing UK)

Katya Goodwin (wind tunnel engineer, now studying for a PhD at Imperial)

Alazar Lemma (IROP student from MIT)

Paul Howard (wizard machinist)

Thank you

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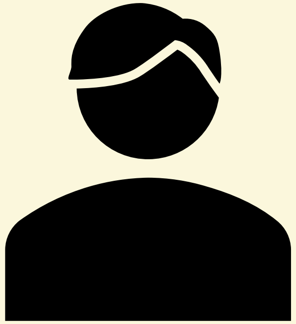

Mark Grant (wizard machinist)

Luca Kulacz (Undergraduate Final Year Student)

Franco Giammaria (Electronics engineer)

Riya Gujarathi (Wind tunnel engineer, now pursuing further studies)

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Questions

Aircraft Half-Model test Capability
03/04/2025