
ANSYS
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INNOVATION CONFERENCE
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MoJet Tunnel Ventilation – Testing and CFD Analysis

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Introduction to Mosen Ltd

www.mosen.global

Mosen Ltd is an engineering consultancy with expertise in

- tunnel ventilation
- fire safety engineering
- risk management
- tunnel safety
- Computational Fluid Dynamics

We have worked on >100 tunnels worldwide.

Motivation

- Cost and power consumption for tunnel ventilation can be very high
- The MoJet was invented as a sustainable, energy-efficient device, using ANSYS CFX
- Measurements were undertaken to check the real performance

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Agenda

1. What is the MoJet?
2. Model scale tests
3. Full-scale tests
4. Conclusions and outlook

MoJet

- Energy-efficient jetfan
- Uses shaped nozzles
- Reduces the Coanda effect, hence increasing the in-tunnel thrust
- Reduces the in-fan pressure drop, hence reducing the power consumption

Model Scale Testing

Model Scale Testing

- Undertaken at the Institute of Aerodynamics, RWTH University in Aachen
- History of previous research in tunnel aerodynamics with jetfans

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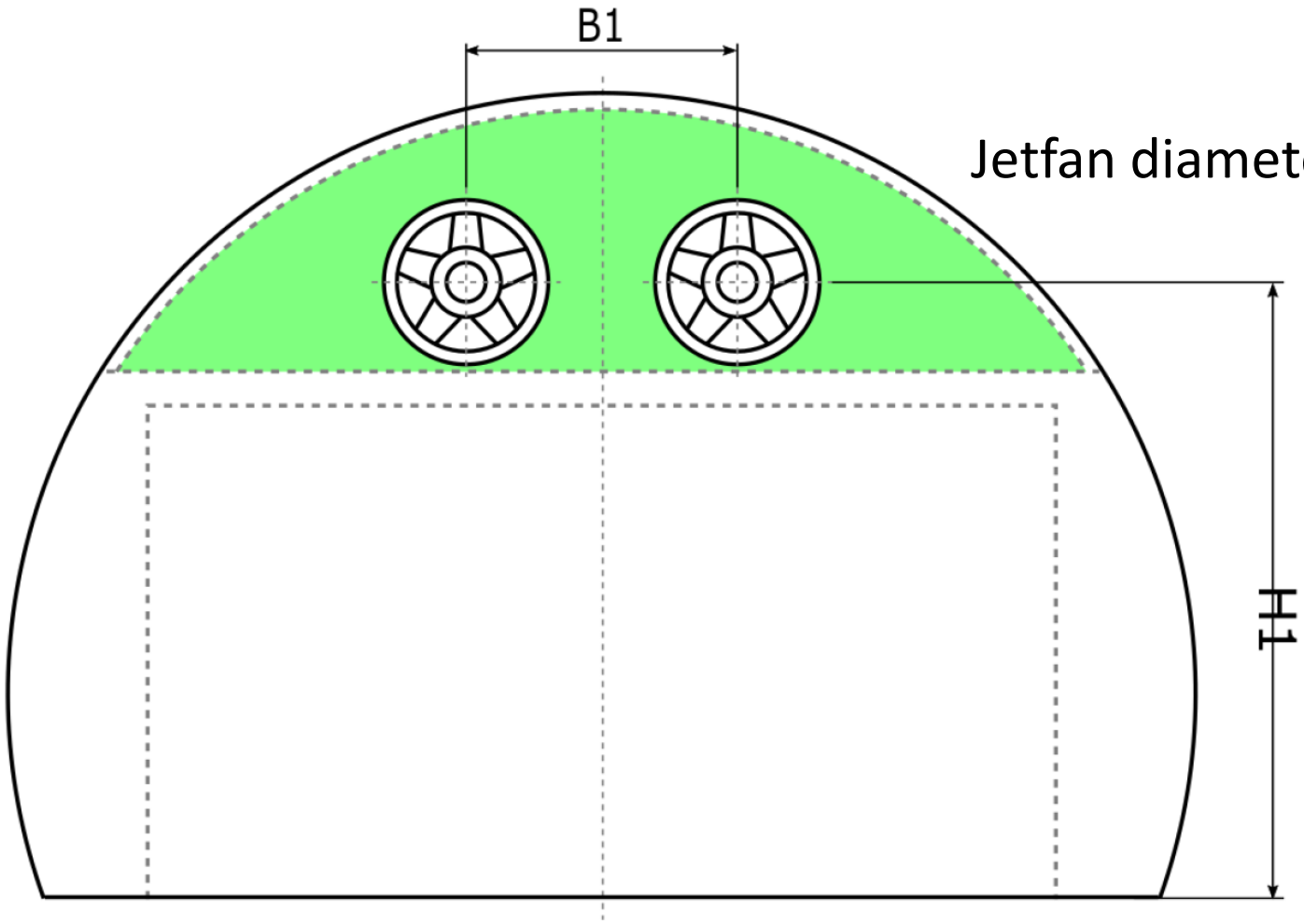
1:18 Model Scale Tests



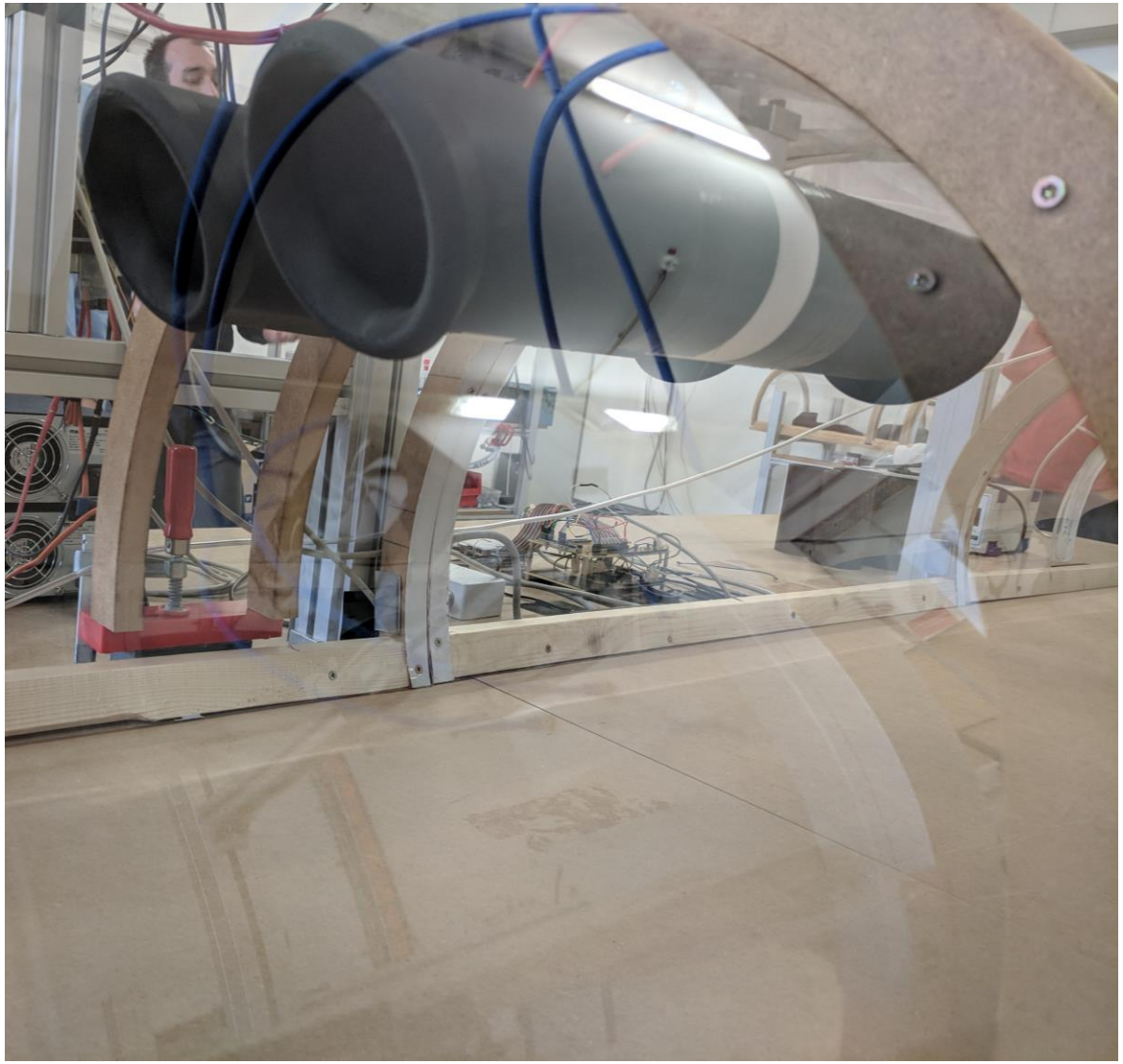
Jetfan diameter = 7 cm

Model-Scale Tunnel

- 10 m long
- Jetfans installed at 2 m from inlet portal
- PIV air velocity measurements undertaken near outlet portal

1:18 Model Scale Tests

MoJet Installation



Flow Discharge from MoJet

Results from Model Scale Tests

	Value
Reynolds Number (Real to Model Scale)	x 18
Tunnel friction drag (MoJet to conventional)	-20%
Jetfan thrust/power ratio (MoJet to conventional)	+10%

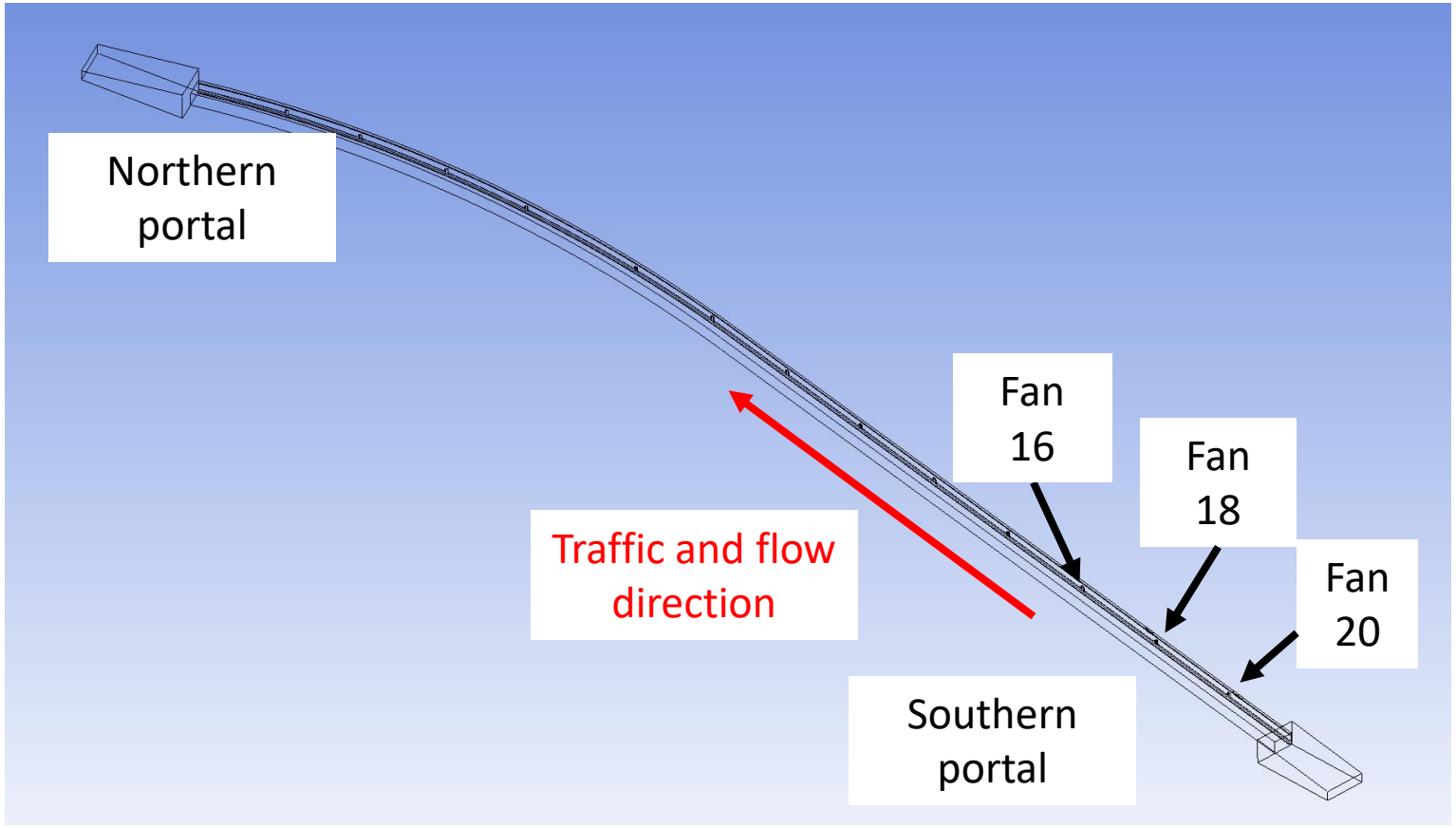
Full-Scale Testing

Montgomery Tunnel, Brussels

Full-Scale Jetfan Testing

- 500 m long tunnel
- 10 jetfans in each tunnel bore; mixture of 550 mm and 630 mm internal diameter
- 3 jetfans to be replaced for test
- Conventional jetfan and MoJet comparison (in-tunnel thrust and power consumption)
- Test scheduled in 2019

Tunnel Geometry



Case configuration

- The simulations were run in CFX 19.2 with the following conditions:
  - Fan rotational speed of 2900rpm
  - Non-buoyant model
  - 1 atm Reference Pressure
  - Total Energy with Viscous Work Term
  - Turbulence Model SST

CASE SET-UP

Case Set-Up

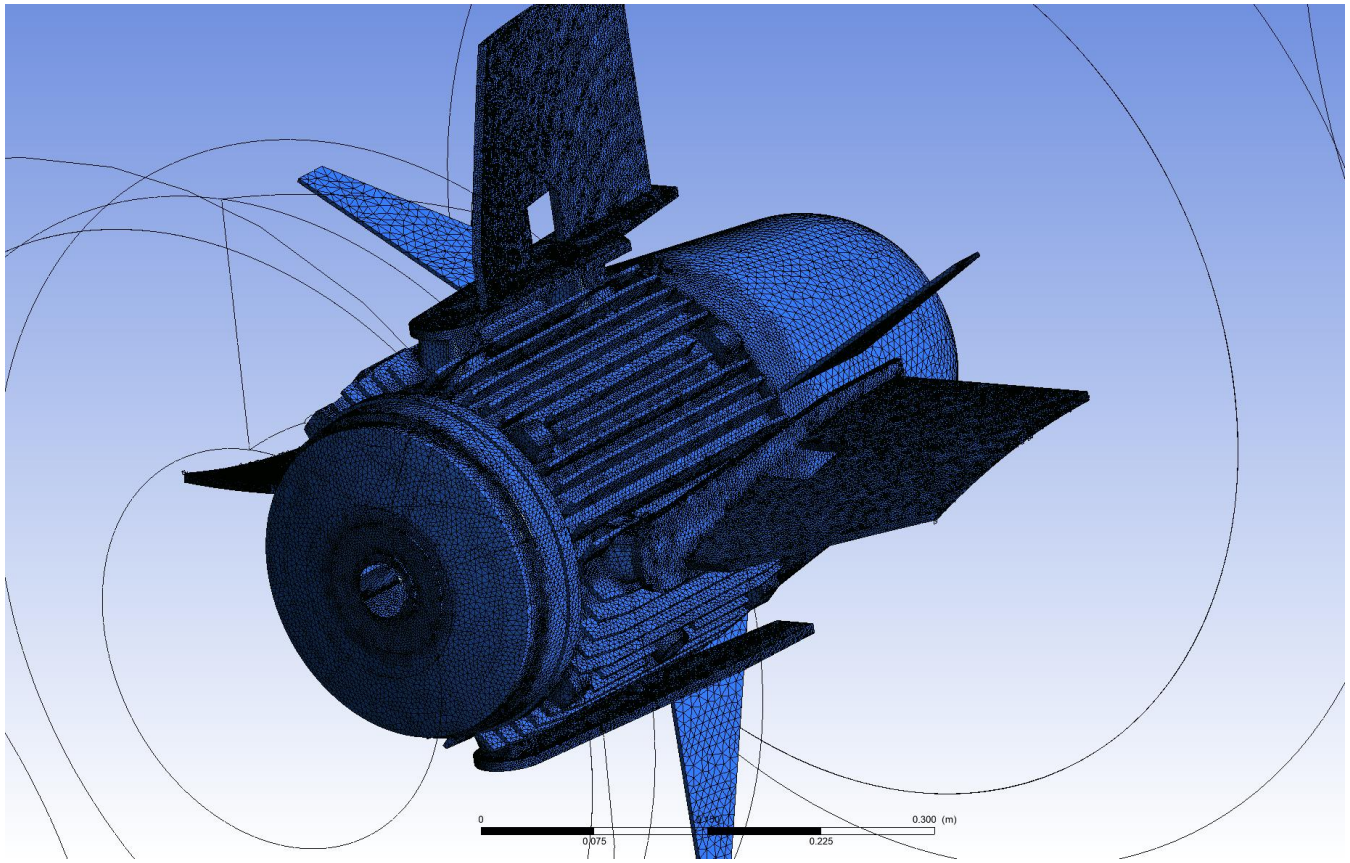
- The conventional jetfan and MoJet (exhaust silencer only) were compared in the following CFD simulations:
  - Bench thrust (jetfans in isolation).
  - Three fans running in the Southernmost locations (16, 18, 20) of the Northbound tunnel (flow direction going from South to North).

Case configuration

BENCH THRUST SIMULATIONS

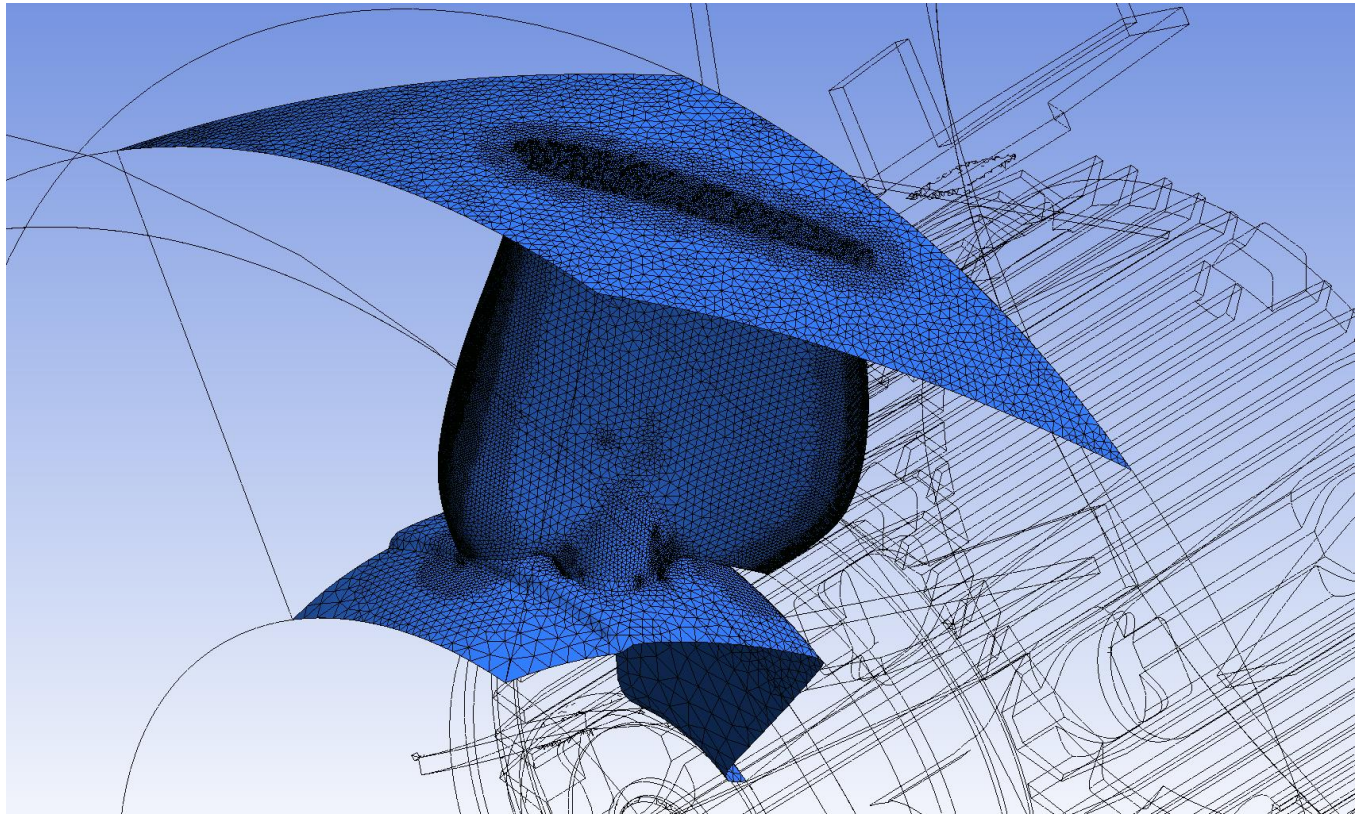
Case configuration

- Motor mesh



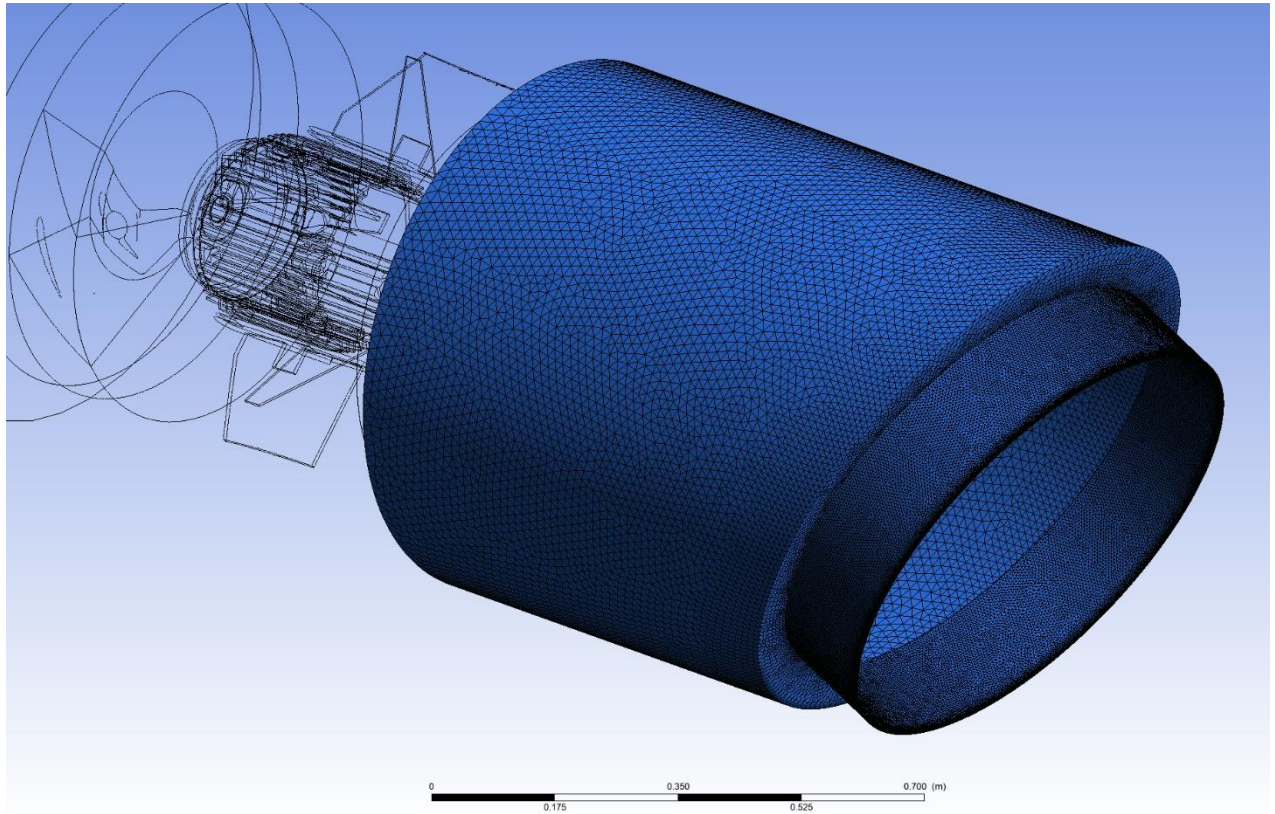
Case configuration

- Blade mesh



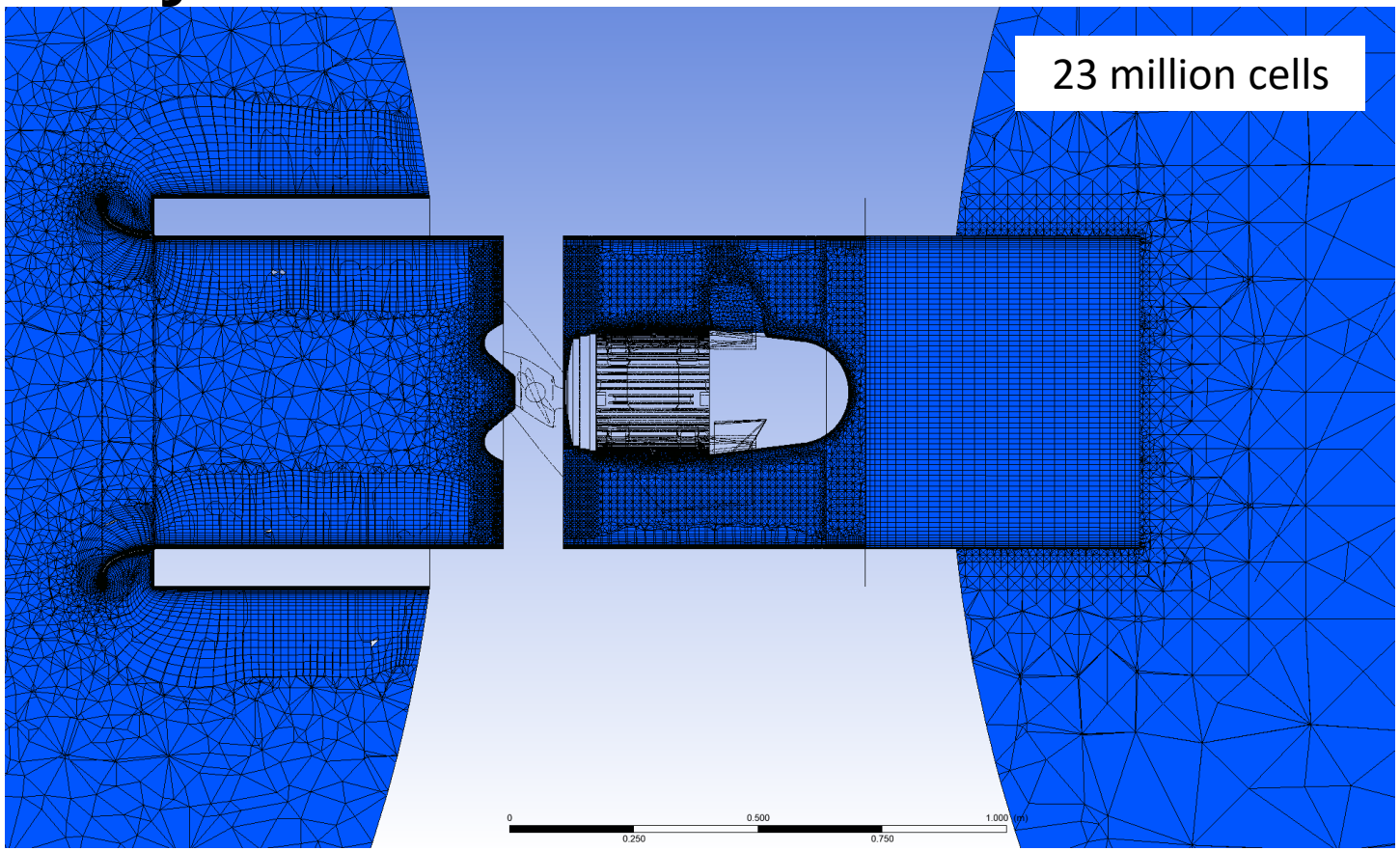
Case configuration

- Silencer mesh



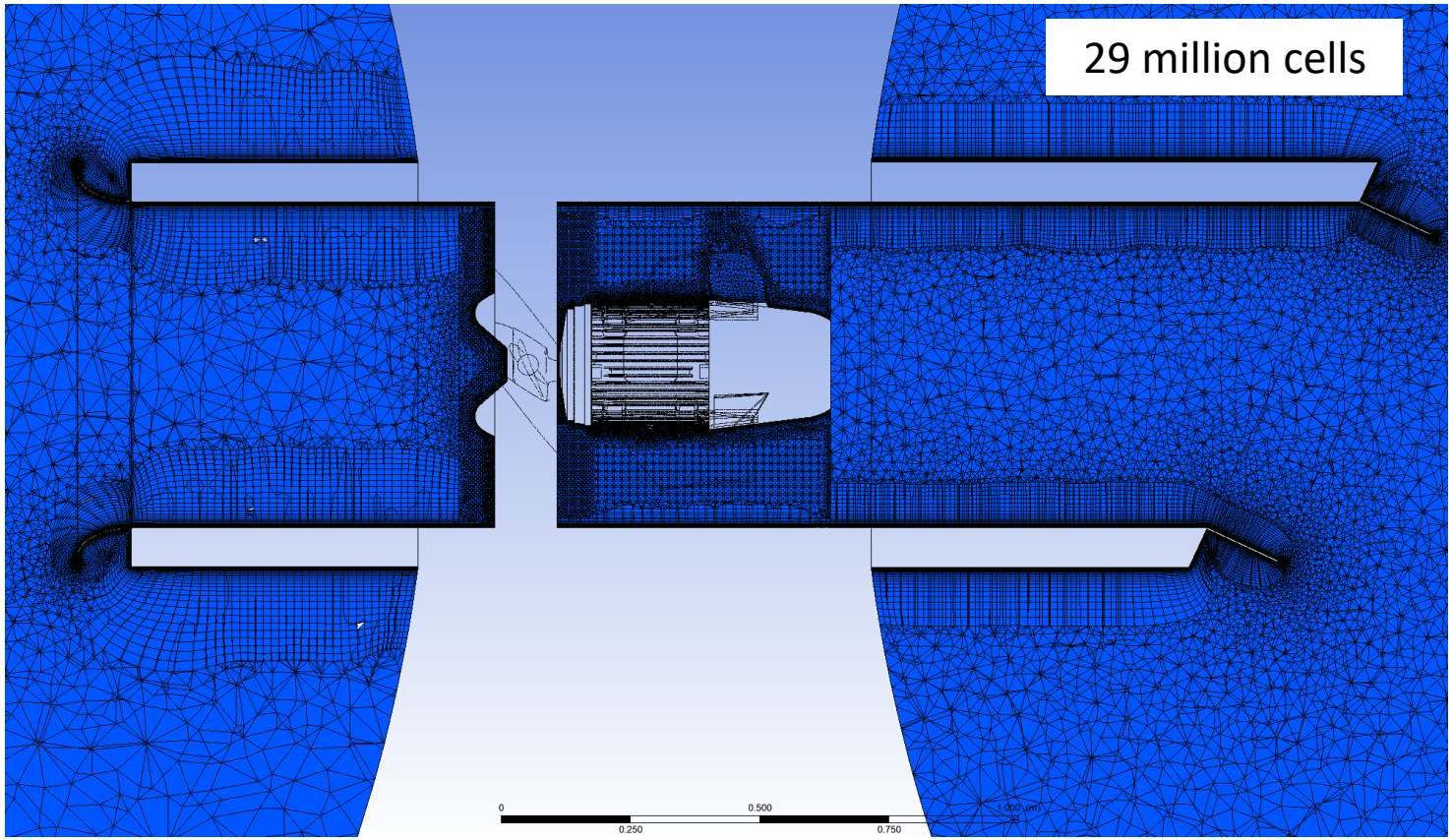
Case configuration

- Conventional jetfan volume mesh



Case configuration

- MoJet volume mesh



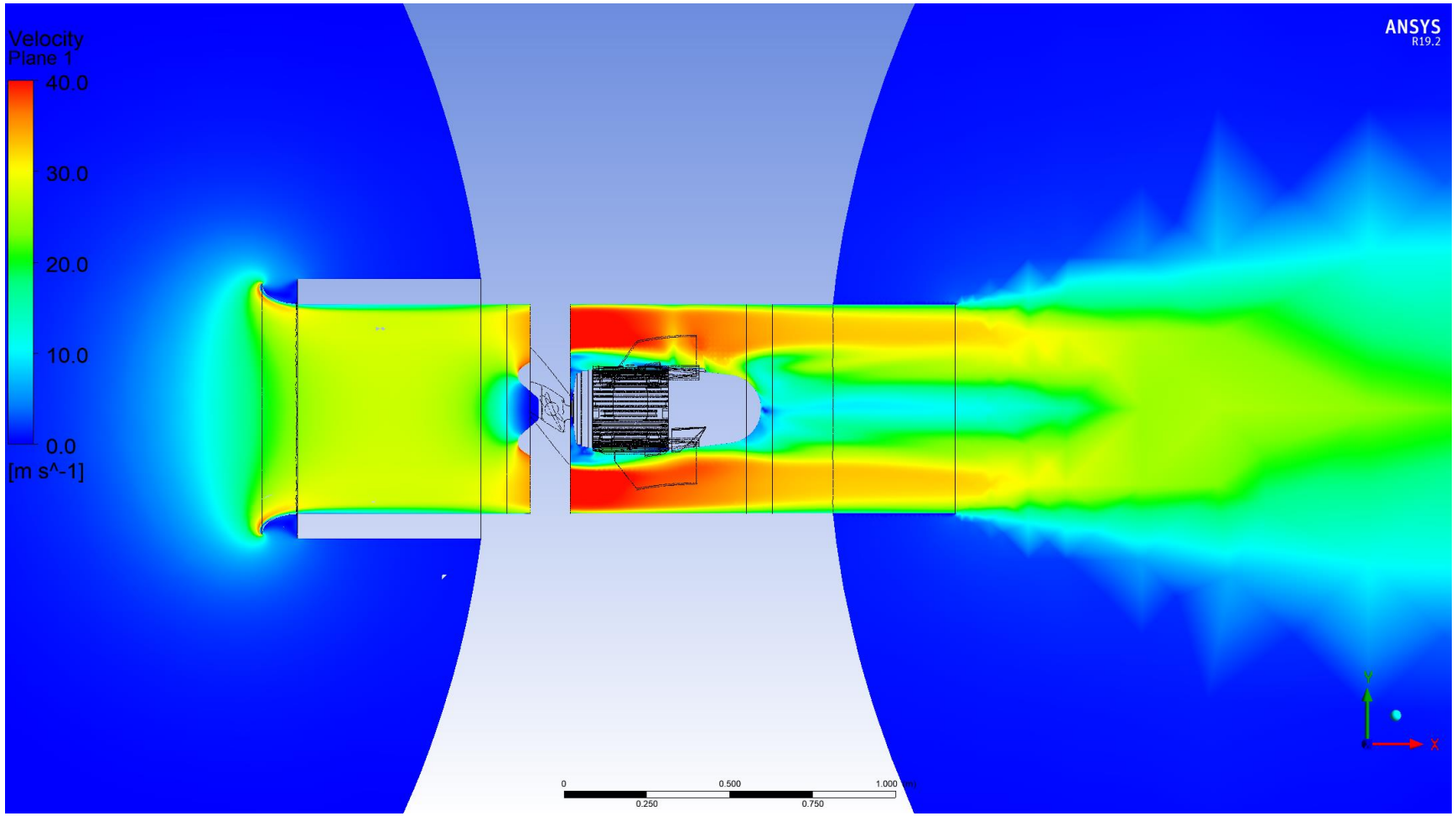
Case results

BENCH THRUST SIMULATIONS

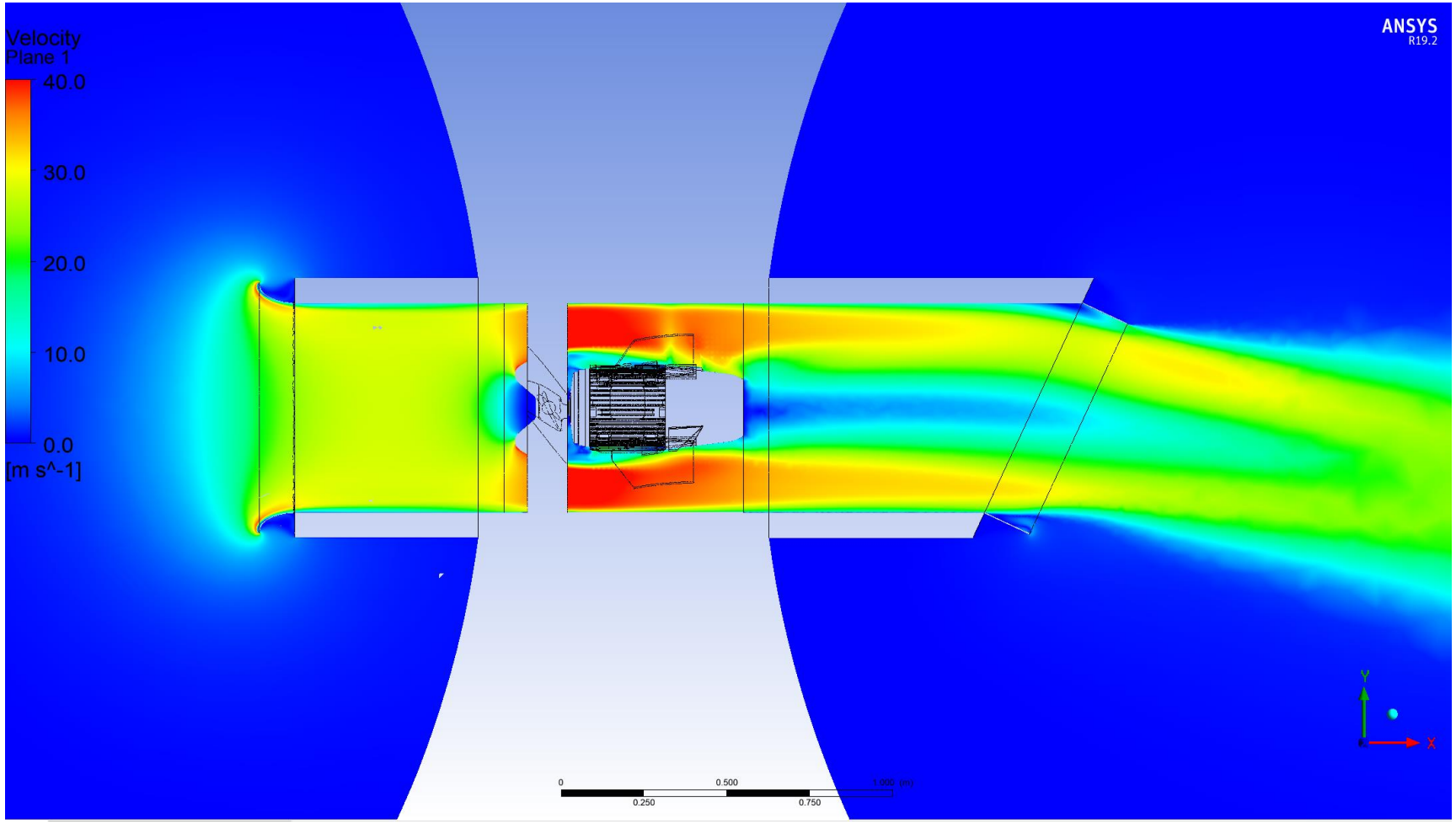
Case results

- Experimental results:
  - Ux 30.5 m/s (21° pitch angle)
- Conventional jetfan
  - Ux 27.5 m/s (mass flow average)
  - VFR 8.21 m^3/s
- MoJet
  - Ux 30.8 m/s (mass flow average)
  - VFR 8.27 m^3/s

Velocity Contours

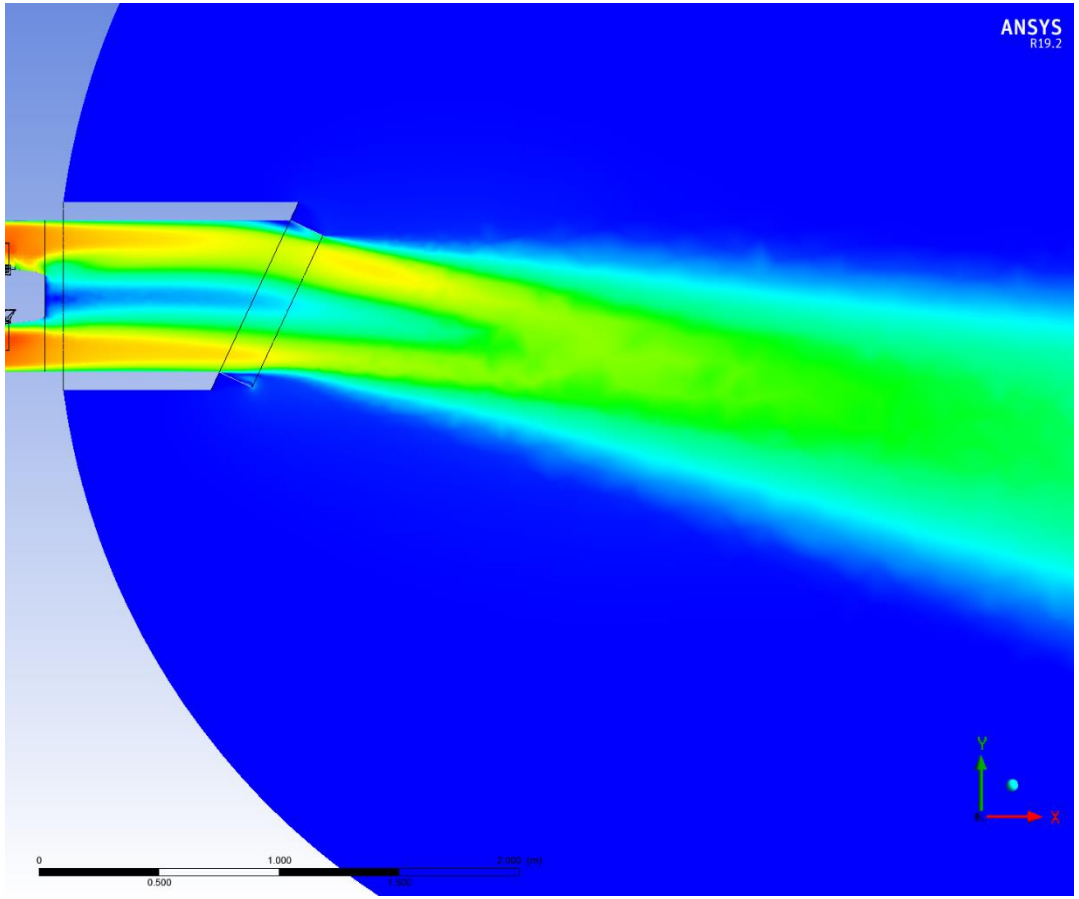


Velocity Contours



Flow Deflection

- The MoJet achieved a deflection angle of 11° from the horizontal axis.

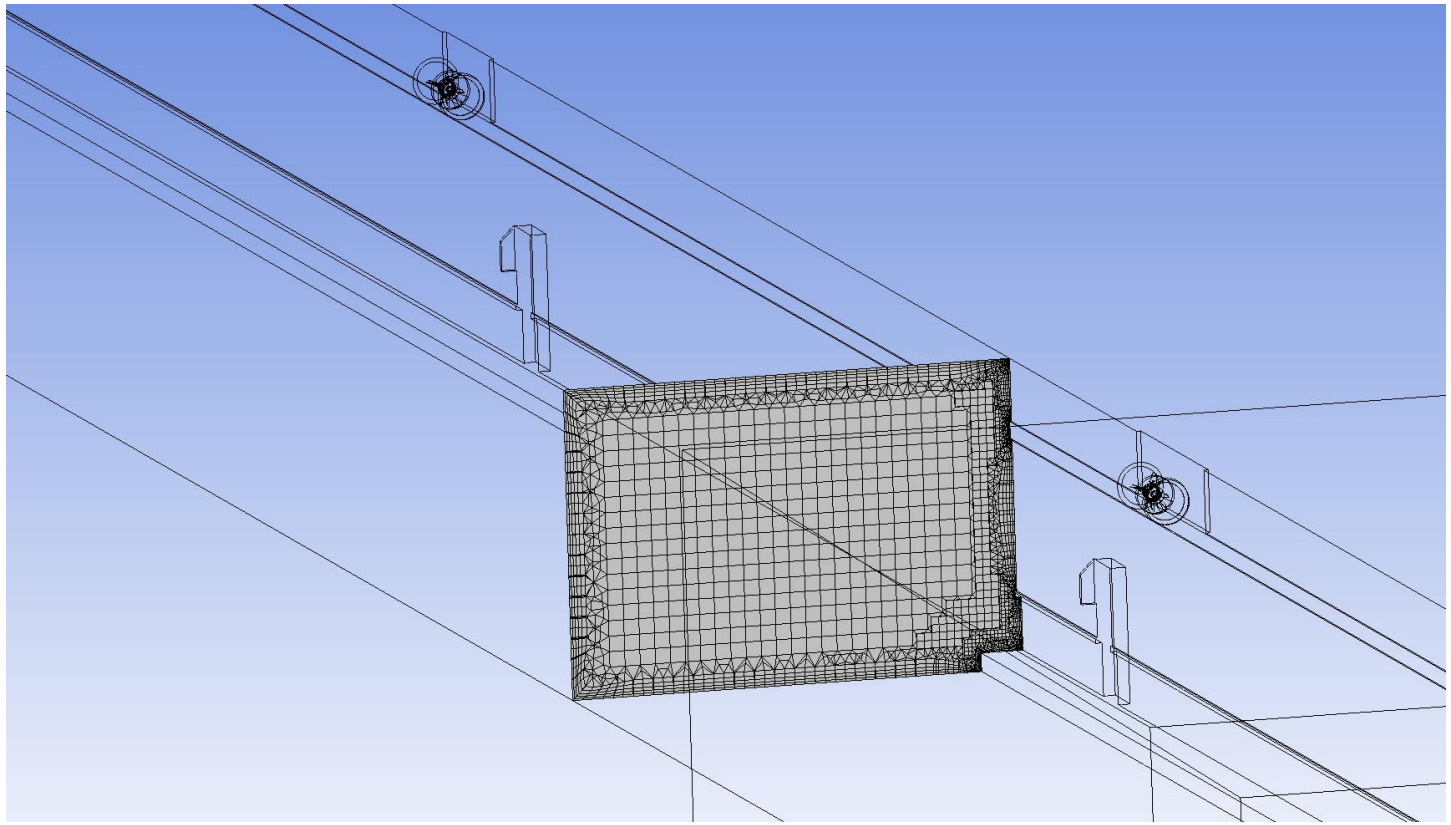


Case configuration

TUNNEL SIMULATIONS

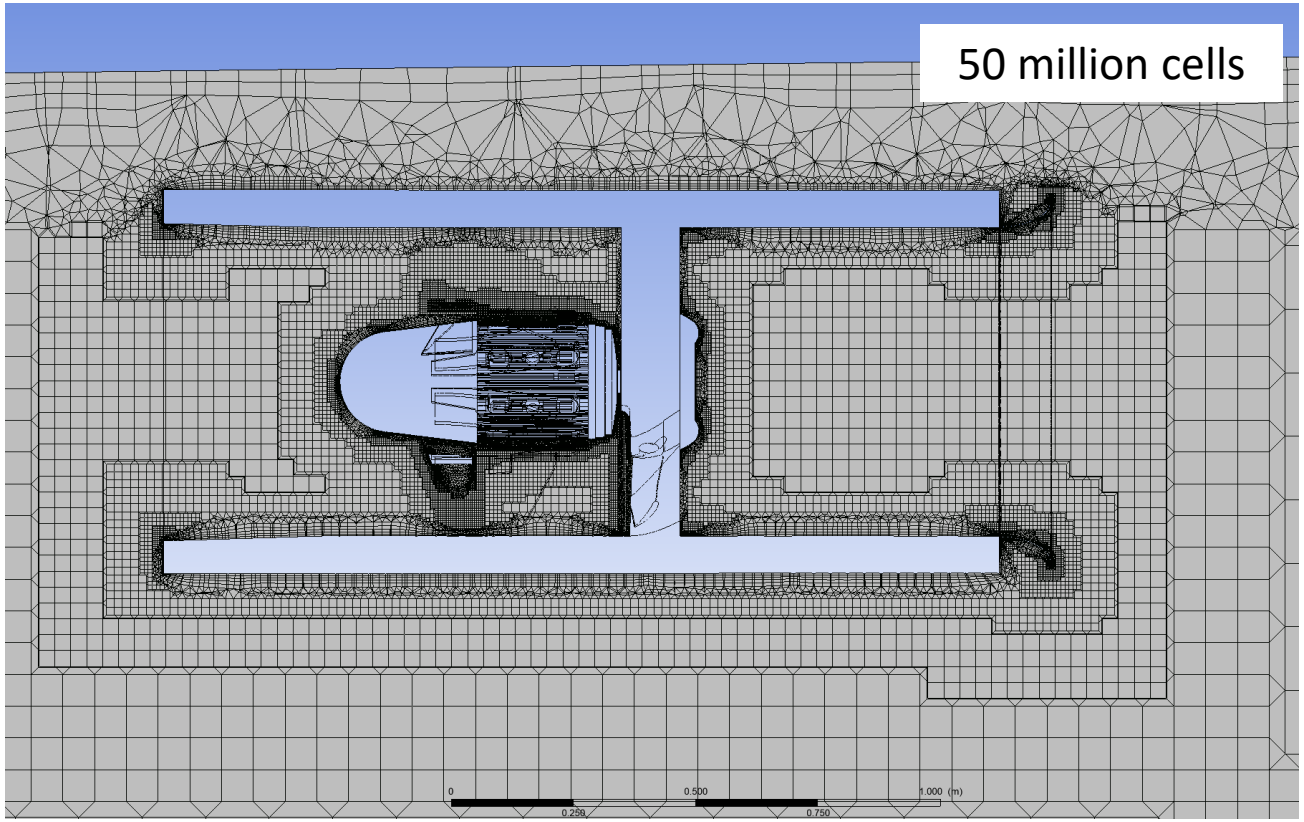
Case configuration

- Tunnel volume mesh



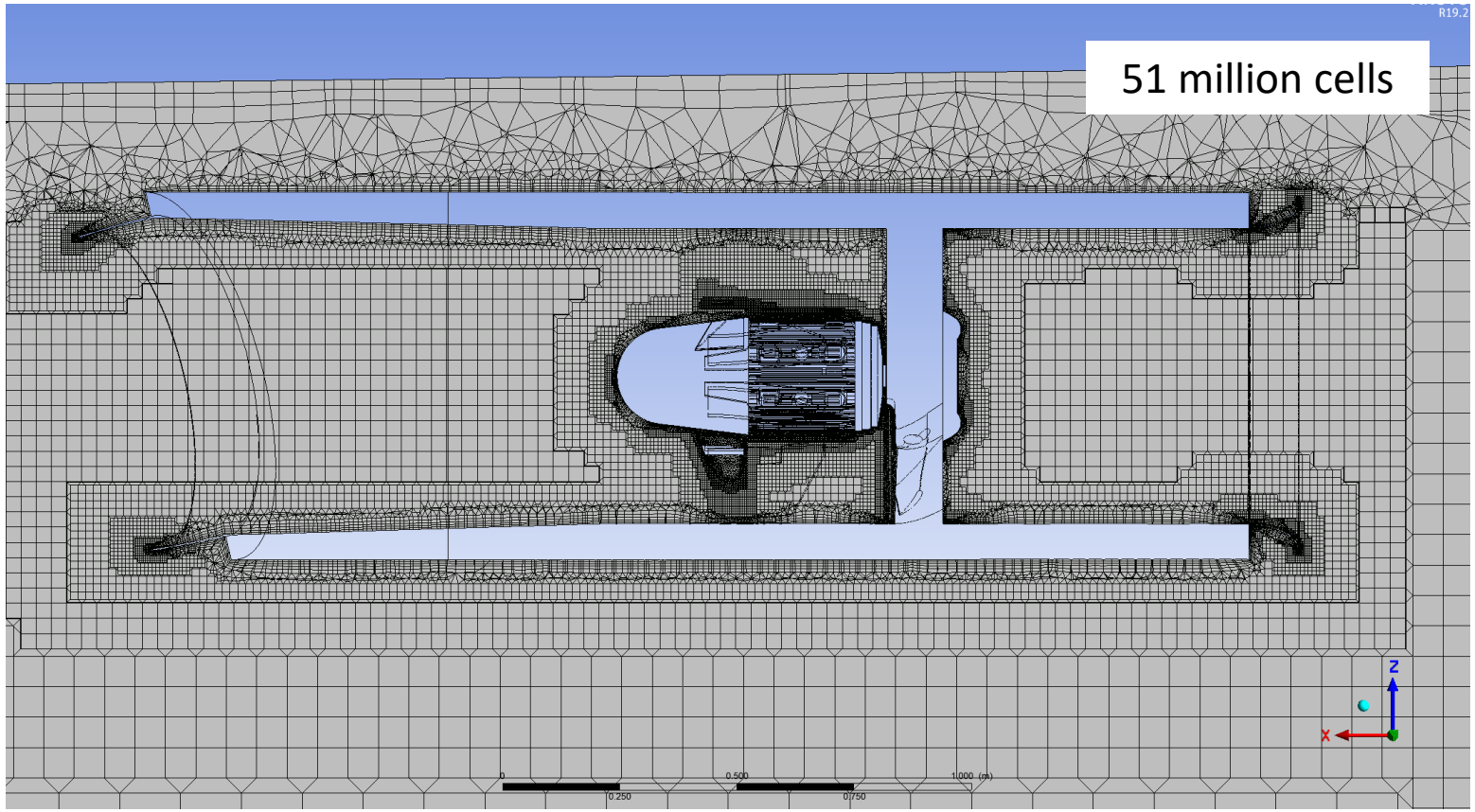
Case configuration

- Conventional jetfan volume mesh



Case configuration

- MoJet volume mesh

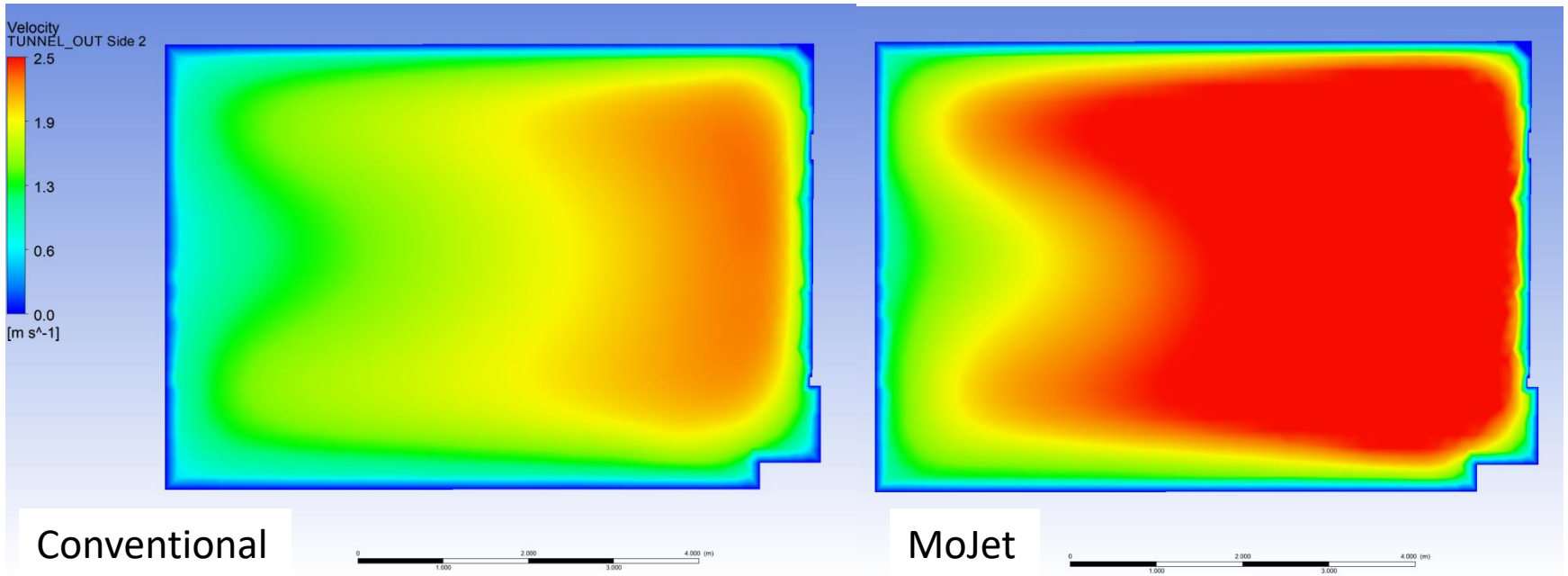


Case results

TUNNEL SIMULATIONS

Case results

- Contour plot of velocity at the Northern portal outlet.



Case results

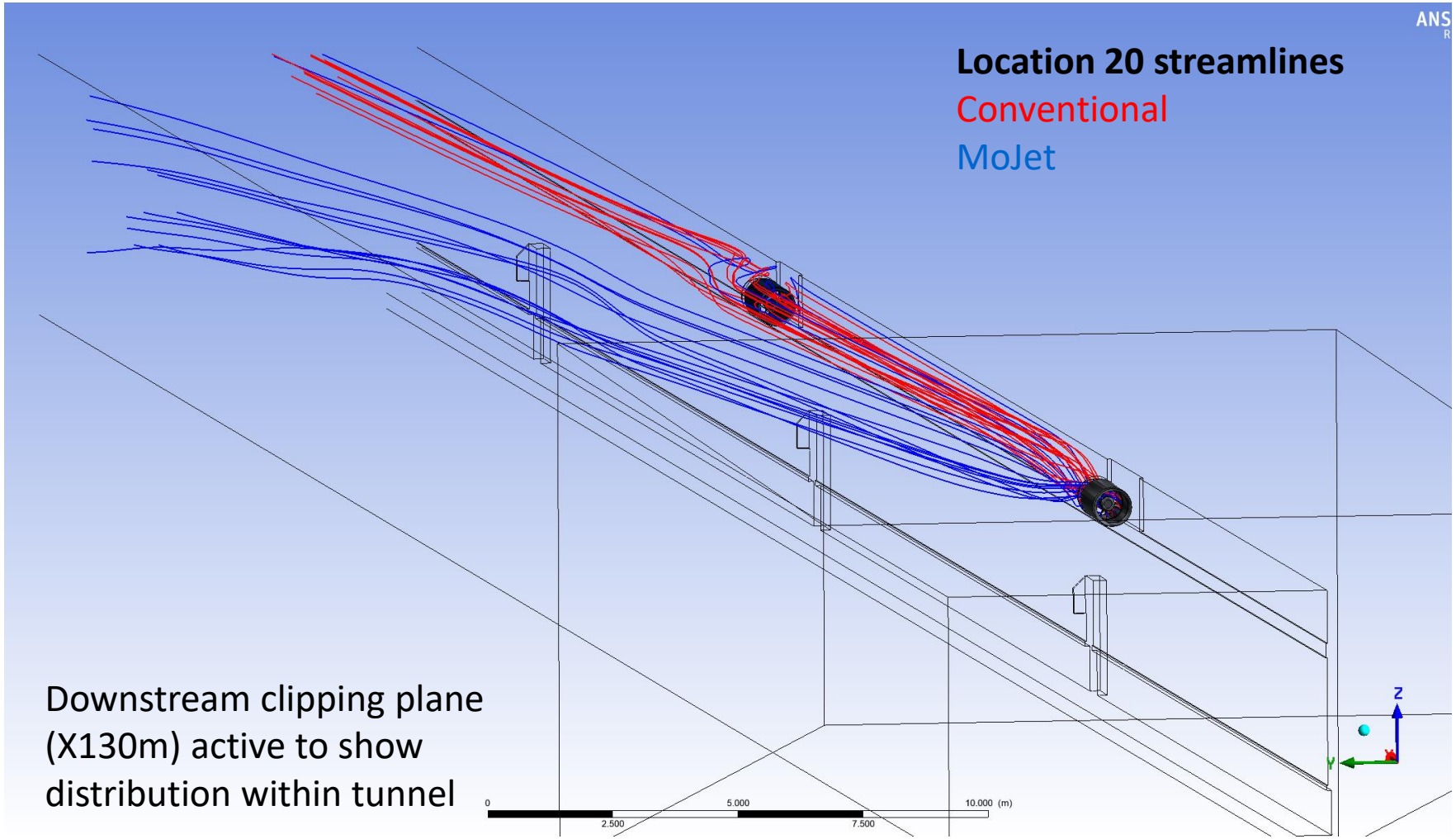
- The volumetric flow rate (m^3/s) is shown below :
-

	Conventional	MoJet
– Location 20	8.30	8.36
– Location 18	8.32	8.35
– Location 16	8.32	8.35

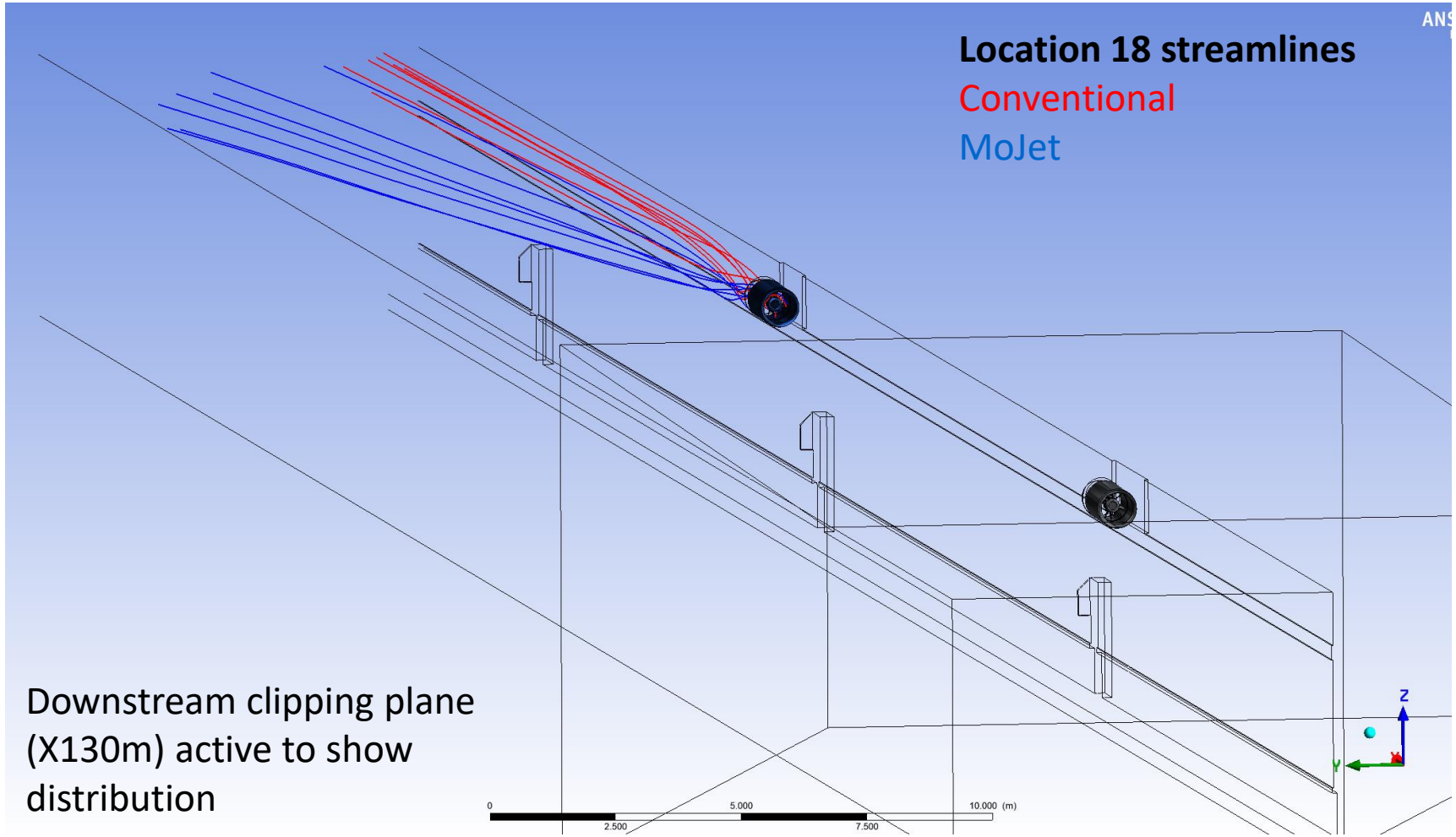
Case results

- Applying the volumetric flow rates from the tunnel simulations to 1D CFD (using IDA RTV) produces the following installation factors :
  - Conventional 0.25
  - MoJet 0.53 (+112%)

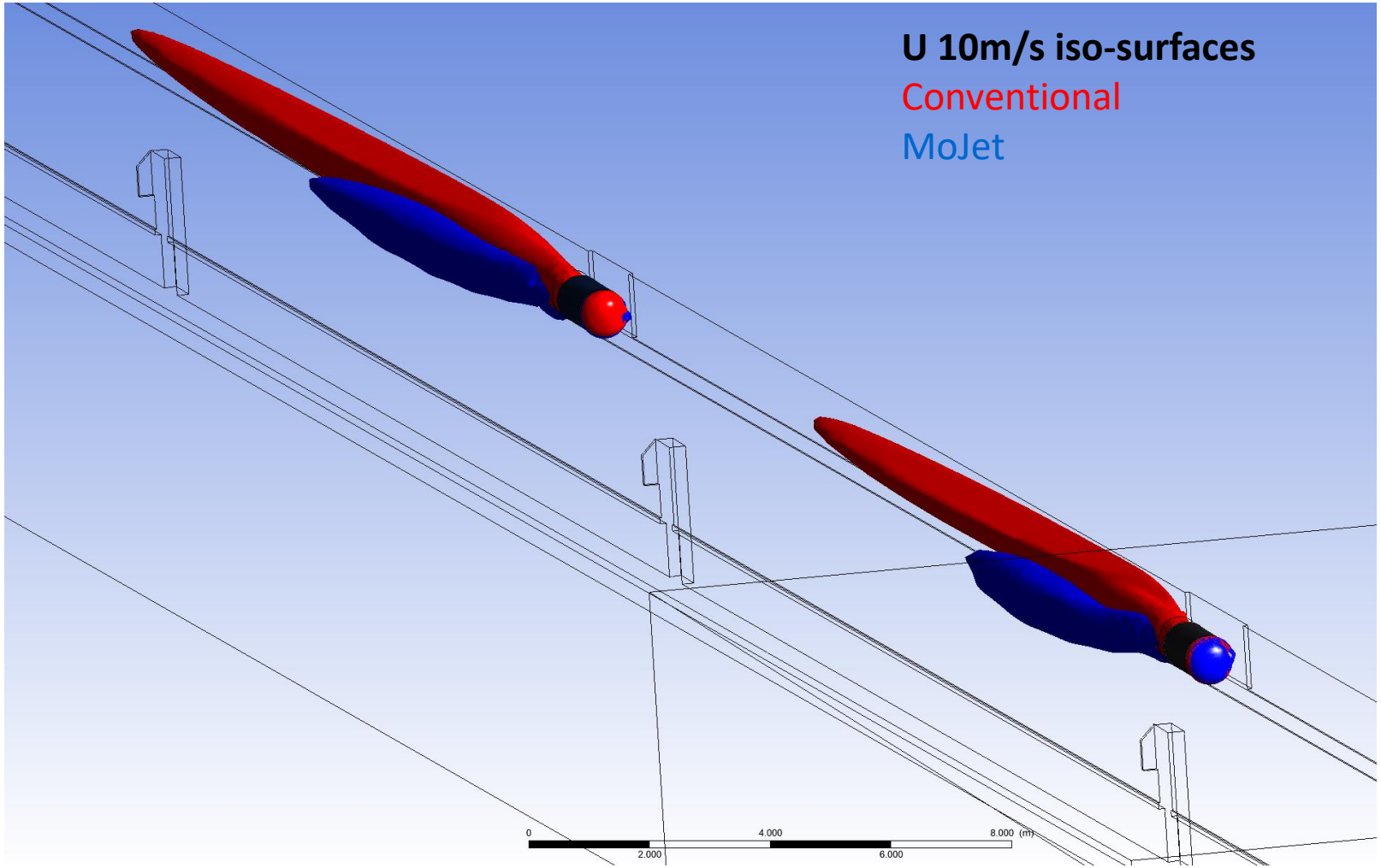
Velocity Streamline Comparison



Velocity Streamline Comparison

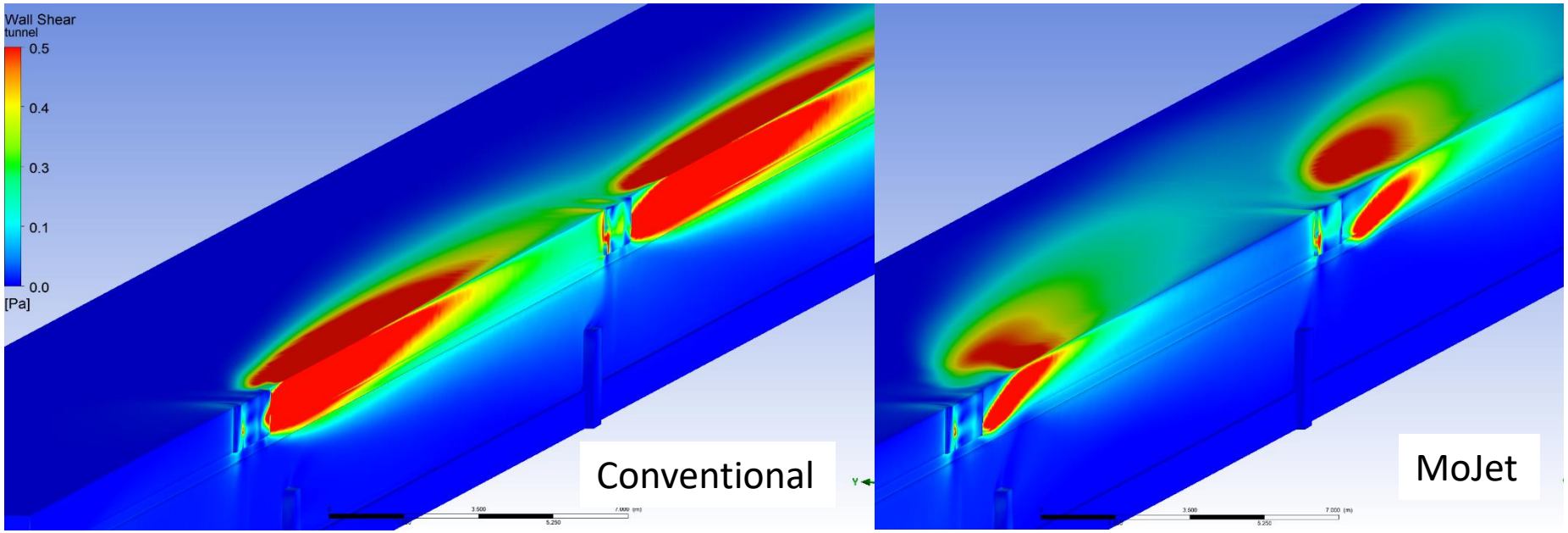


Velocity Iso-surface Comparison



Case results

- As expected a decrease in shear stress on the tunnel walls is noted with the MoJet.



Flow Distribution

- A comparison of the flow leaving the first fan (location 20) shows the MoJet having better distribution within the tunnel.
- The flow from the conventional fan remains attached to the tunnel ceiling and walls, thereby reducing efficiency.
- The flow from the conventional jetfan (at location 20) also gets re-ingested by the downstream fan (location 18).

Velocity & Thrust Comparison

- The average velocity at the Northern portal (outlet) was:
  - Conventional
    - Flow speed 1.59 m/s
  - MoJet
    - Flow speed 2.28 m/s (+44%)
    - Thrust increase above conventional jetfan +106%

Conclusions and Outlook

- ANSYS CFX has been used to develop a patented new product for tunnel ventilation – the MoJet
- Significant reduction in the number of jetfans required in a tunnel
- Model-scale tests have confirmed the potential benefits of the MoJet
- Full-scale tests planned for 2019

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Thank You and Questions