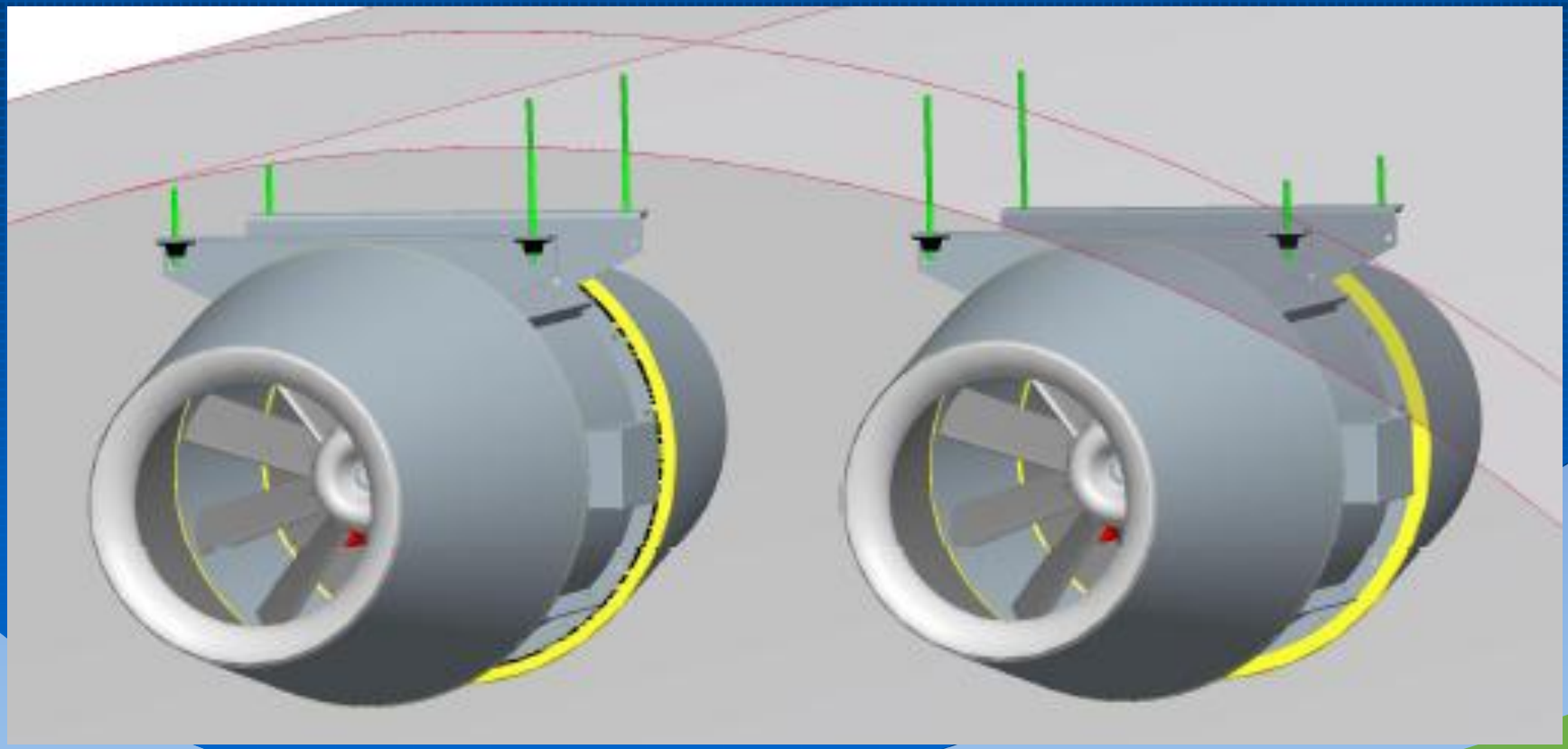
Technical Background to the MoJet®



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Motivation

The motivation behind this presentation is to:

- **Understand the technical terminology used**
- **Be able to appreciate the technical features of jetfans generally, and MoJets® in particular**
- **Realise the advantages and limitations of the MoJet® technology.**

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Agenda

1. Principles of the MoJet®
2. Advantages of the MoJet®
3. Selecting the right MoJet®
4. Projects/Prospects

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1. Principles of the MoJet®

Basic Principles

MoJets® combine the advantages of jetfans and Saccardo nozzles

- Convergent nozzles are installed on one or both sides of a fan
- The accelerated flow leads to an increased thrust
- The nozzle is directed towards the tunnel centreline, enhancing the installation efficiency
- UK patent applications 0902131.2, 0819608.1, 0821278.9, 0819608.1, 0918692.5 apply
- International PCT patent application GB2009/002544 applies

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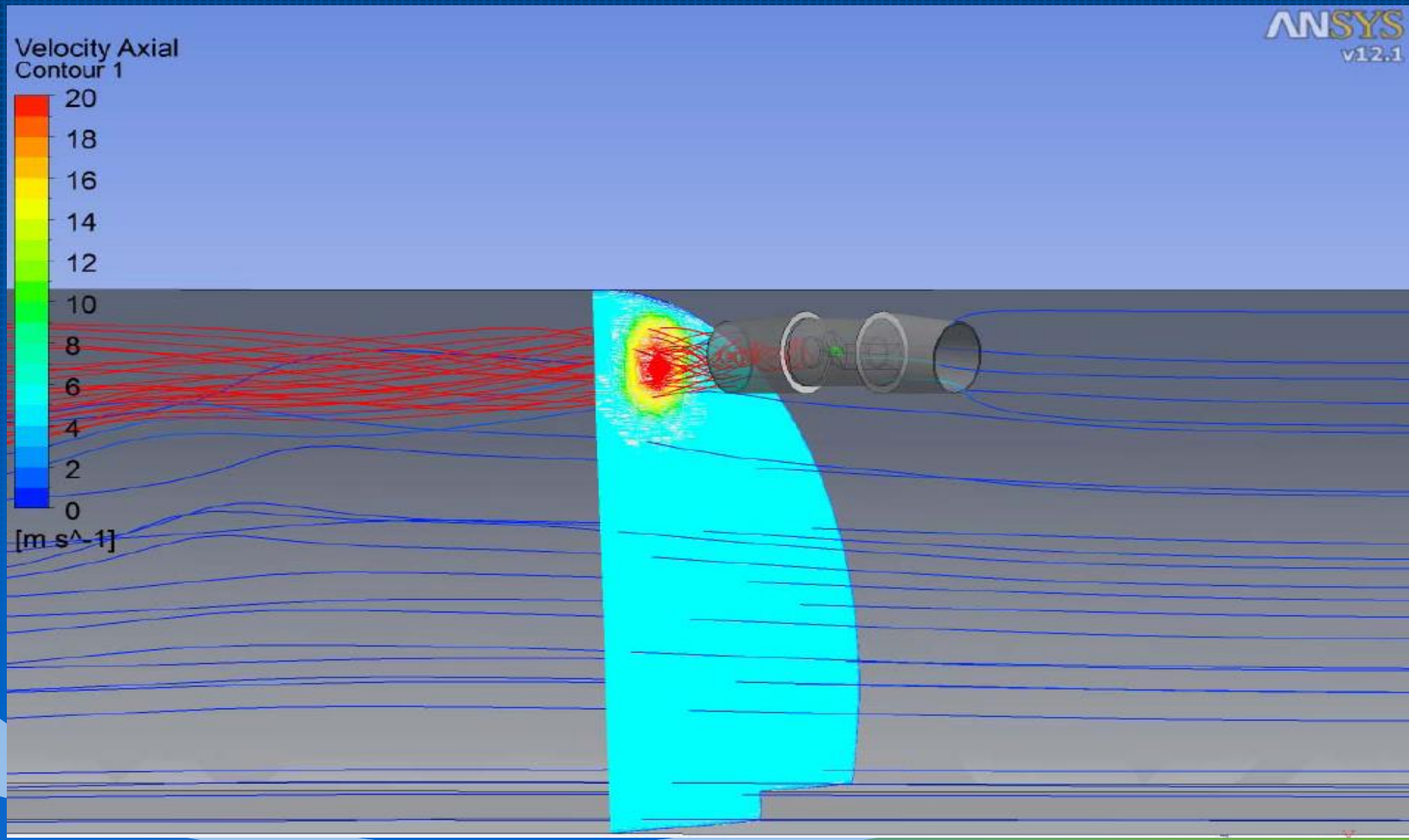
Reduction in Coanda Effect with MoJet®



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Thrust Equation

$$T = \eta_i \rho A V_j (V_j - V_T) \cos(\theta)$$

- T = aerodynamic thrust (N)
- η_i = installation efficiency (-)
- ρ = density (kg/m^3)
- A = jetfan area (m^2)
- V_j = jet velocity (m/s)
- V_T = tunnel velocity (m/s)
- θ = jet angle (-)

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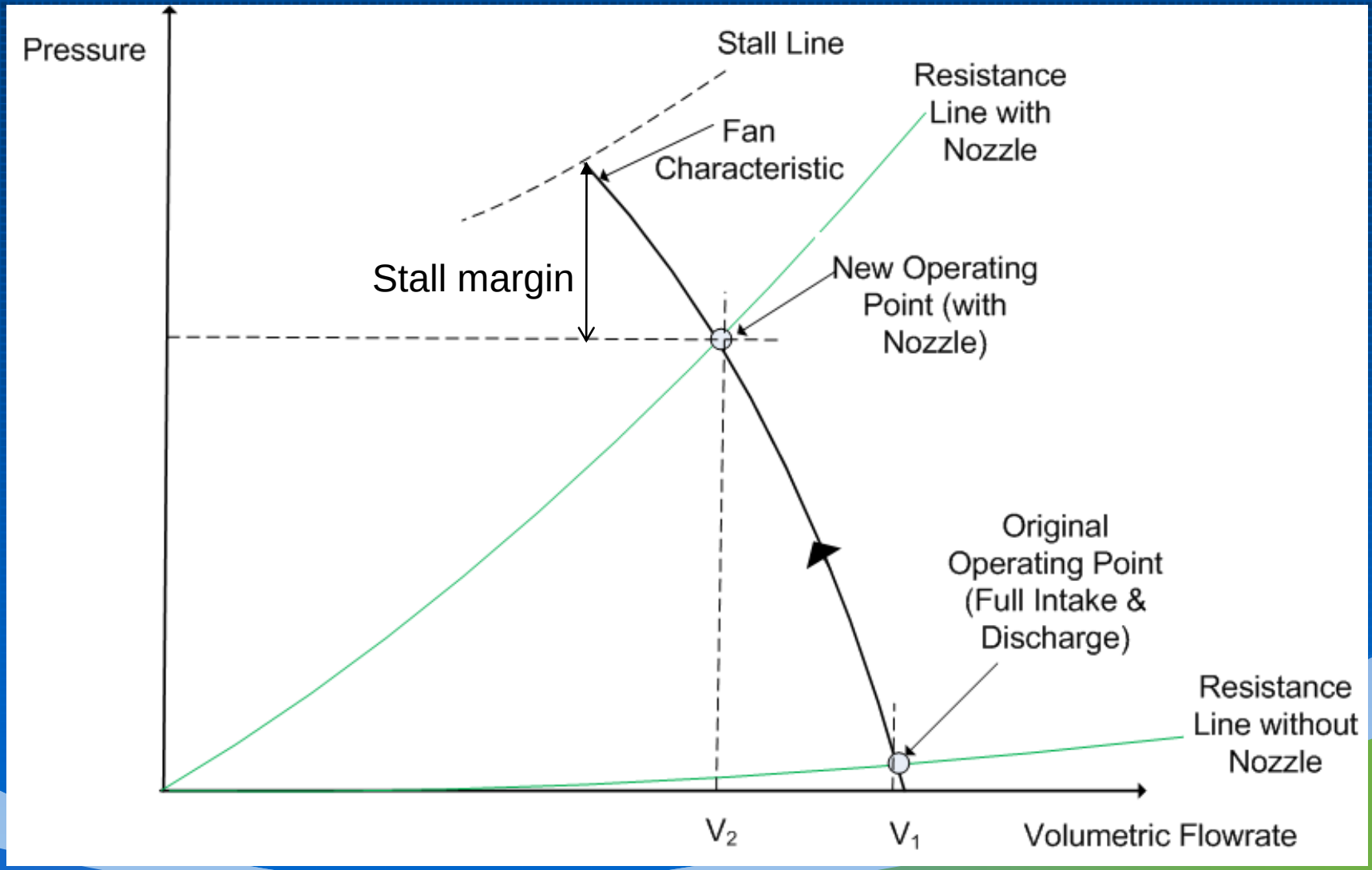
Fan Characteristic



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Characteristic Gradient

- Introducing a nozzle leads to a reduction in mass flow through fan
- Fan characteristic is preferably ‘steep’ enough so that the reduction in mass flow is compensated for by an increase in air velocity

$$-\frac{\partial P}{\partial \dot{V}} > \frac{2\rho V_j^2}{\dot{V}}$$

For a unidirectional MoJet®

$$-\frac{\partial P}{\partial \dot{V}} > \frac{2(1+K_{in})\rho V_j^2}{\dot{V}}$$

For a bidirectional MoJet®

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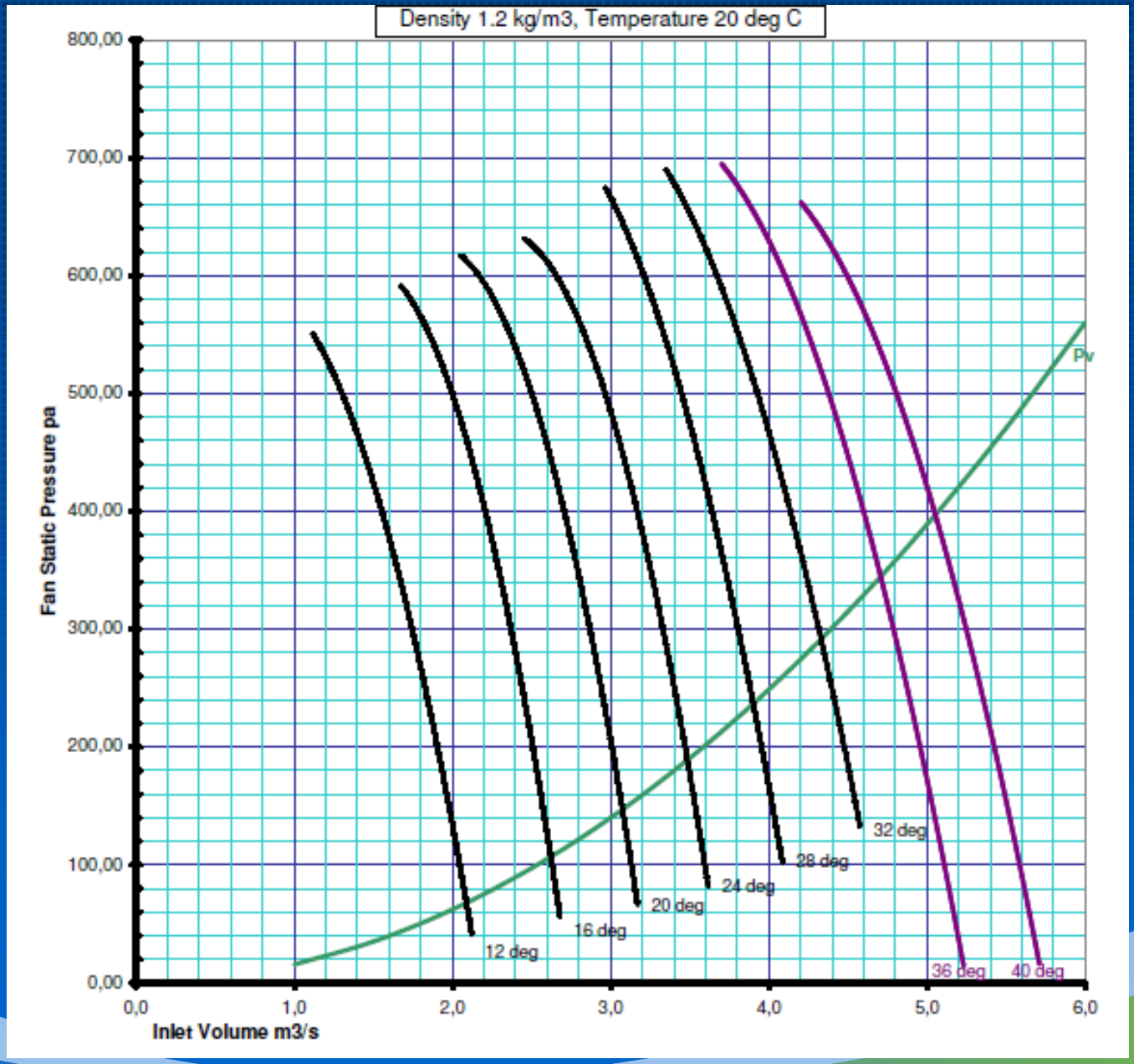
Density 1.2 kg/m3, Temperature 20 deg C
Fan Static Pressure pa
800,00
700,00
600,00
500,00
400,00
300,00
200,00
100,00
0,00
0,0
1,0
2,0
3,0
4,0
5,0
6,0
Inlet Volume m3/s
Pv
12 deg
16 deg
20 deg
24 deg
28 deg
32 deg
36 deg
40 deg

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Unidirectional versus Reversible

- Fan characteristics are ‘steeper’ for unidirectional fans – more velocity and thrust can be generated
- Upstream / downstream guide vanes can be installed in unidirectional fans – more pressure recovery and hence more thrust
- Unidirectional MoJets can be used at portals – reduces cabling lengths

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How Portal-Based MoJets Can Be Arranged

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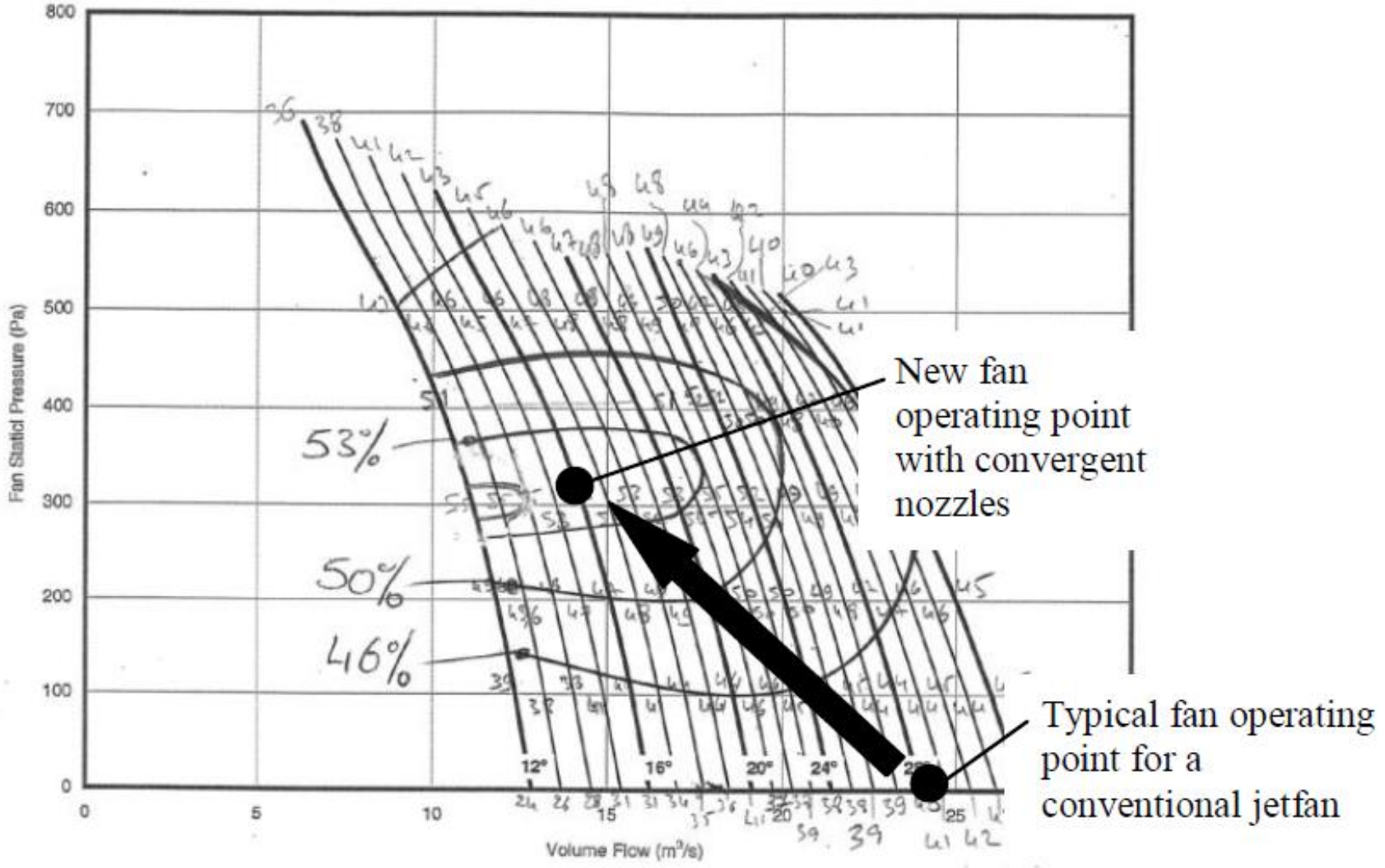
Increase in Fan Efficiency with MoJet®



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Energy Efficiency

The most energy efficient solution:

- Maximise the fan diameter within the available space, and select the lowest discharge velocity for the thrust.
- Maximise the installation efficiency, fan efficiency and motor electrical efficiency.

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Enhancements in Thrust

- With a MoJet®, enhancements in thrust are due to:
  - Increase in jet velocity (typical thrust increase of 7% to 20% available)
  - Improvement in installation efficiency (thrust increase of 18% to 37% available)
- Overall thrust increase is *multiplicative*, i.e. up to 64% thrust increase may be available

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2. Advantages of the MoJet™

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MoJet® Advantages

- Significantly enhanced thrust
- Reduced power requirements
- Smaller diameter fans can be selected for the same installed thrust as conventional jetfans (with about 20% less weight & 15% less installation height)
- No encroachment of traffic envelope
- Can be installed very close to tunnel walls and soffits – reduced space requirements
- Reduced cabling costs using portal-based MoJets® and reduced spacing between fans

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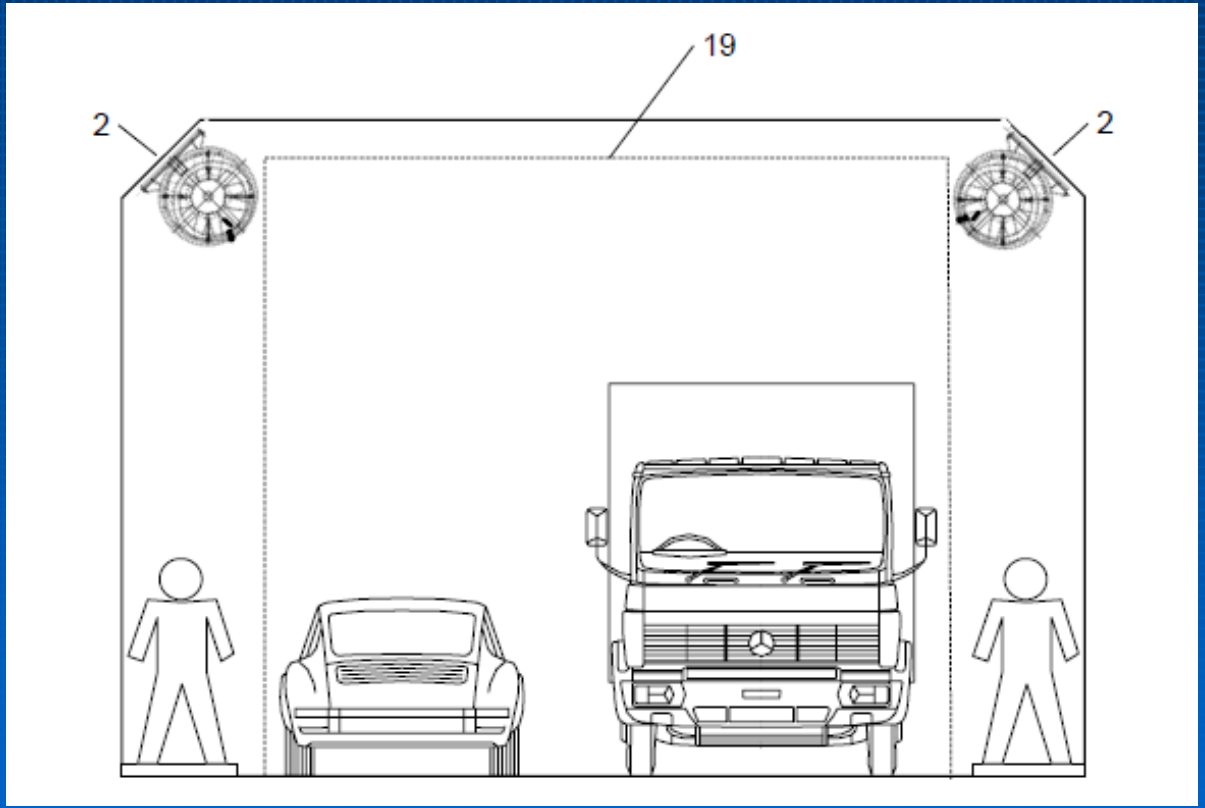
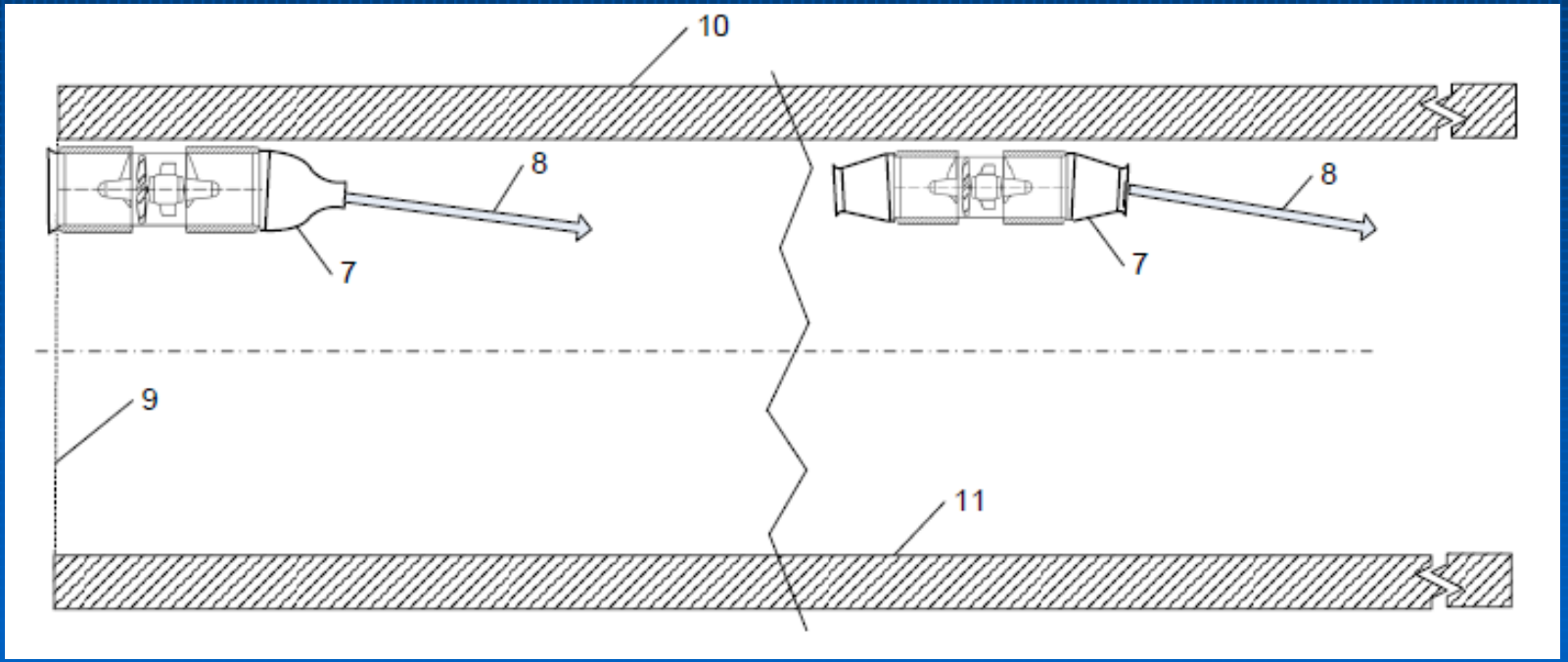
Cut & Cover Tunnel



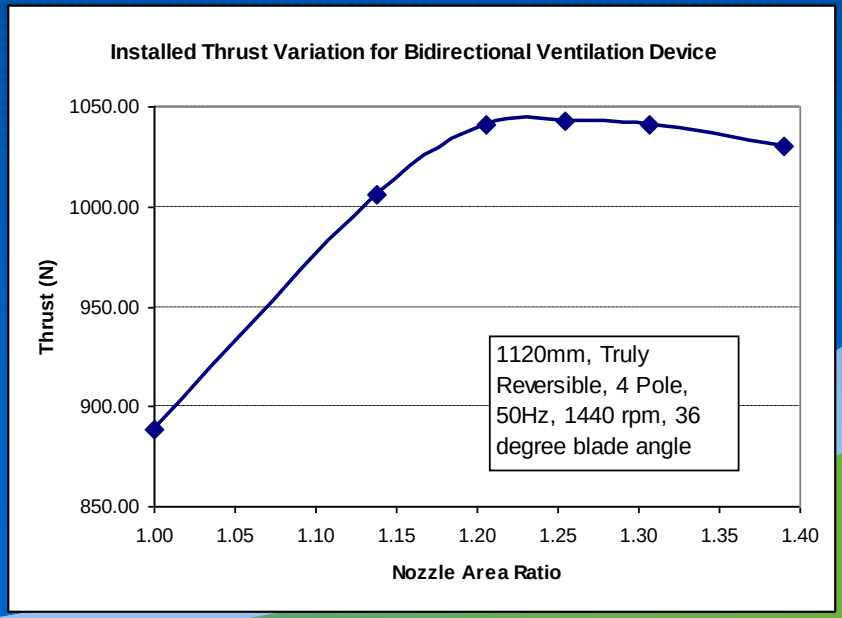
Reduction in Cabling Lengths



3. Selecting the right MoJet®

MoJetSelect™

- Suite of selection tools for selecting the optimum MoJet® for a particular application:
  - Unidirectional MoJets®
  - Bidirectional MoJets®



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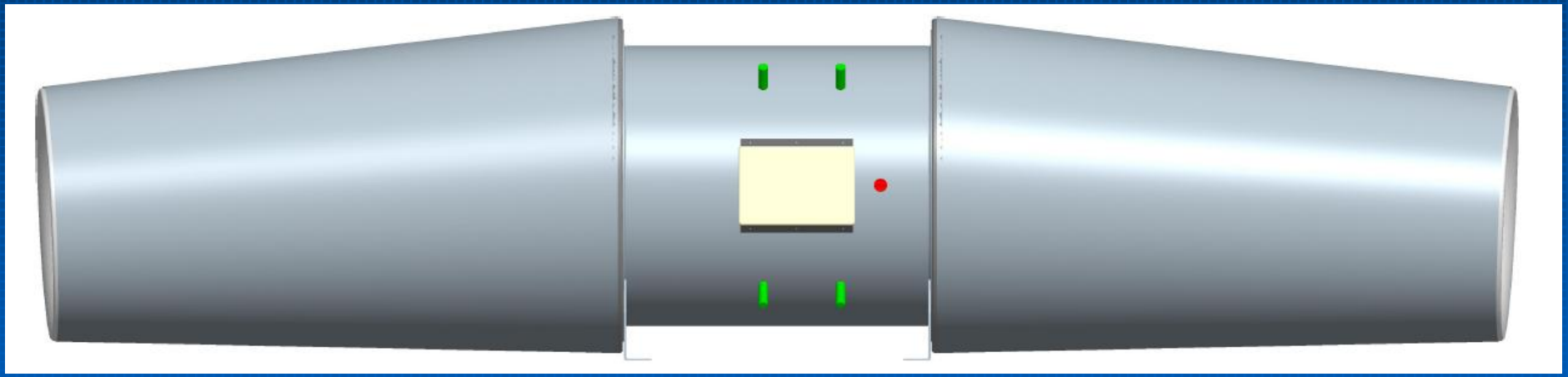
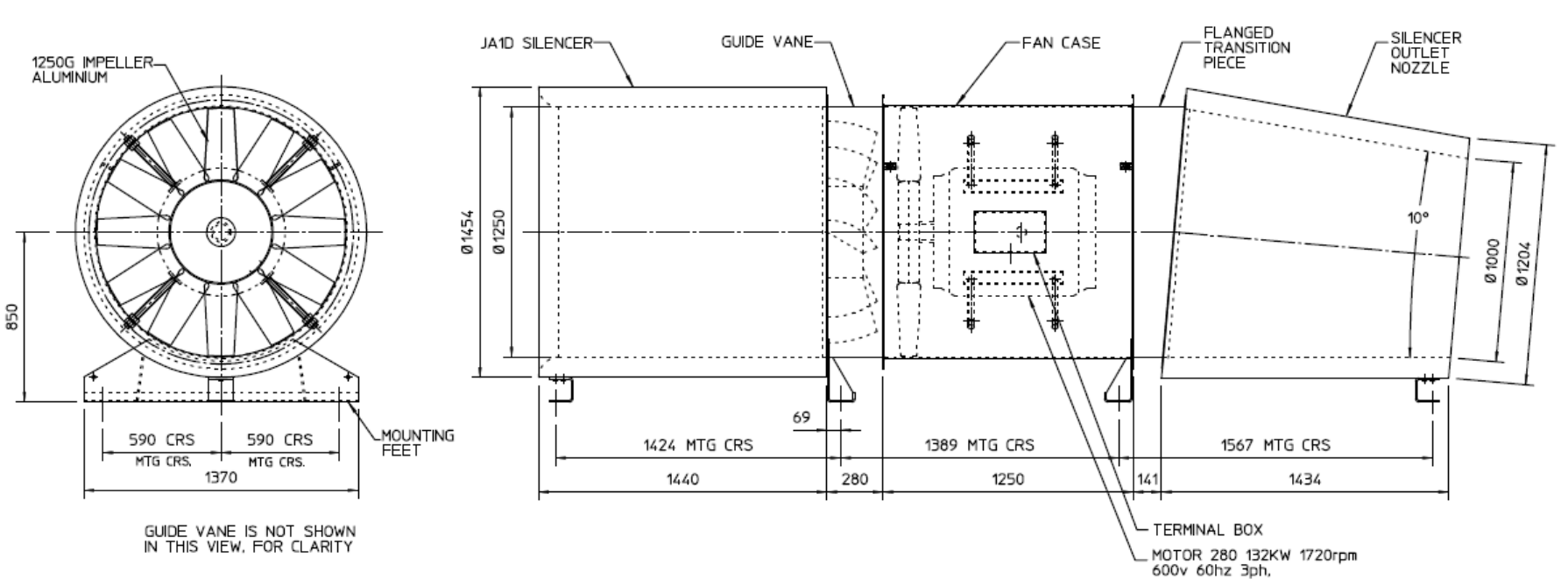
Bi-Directional MoJet®



Unidirectional MoJet®



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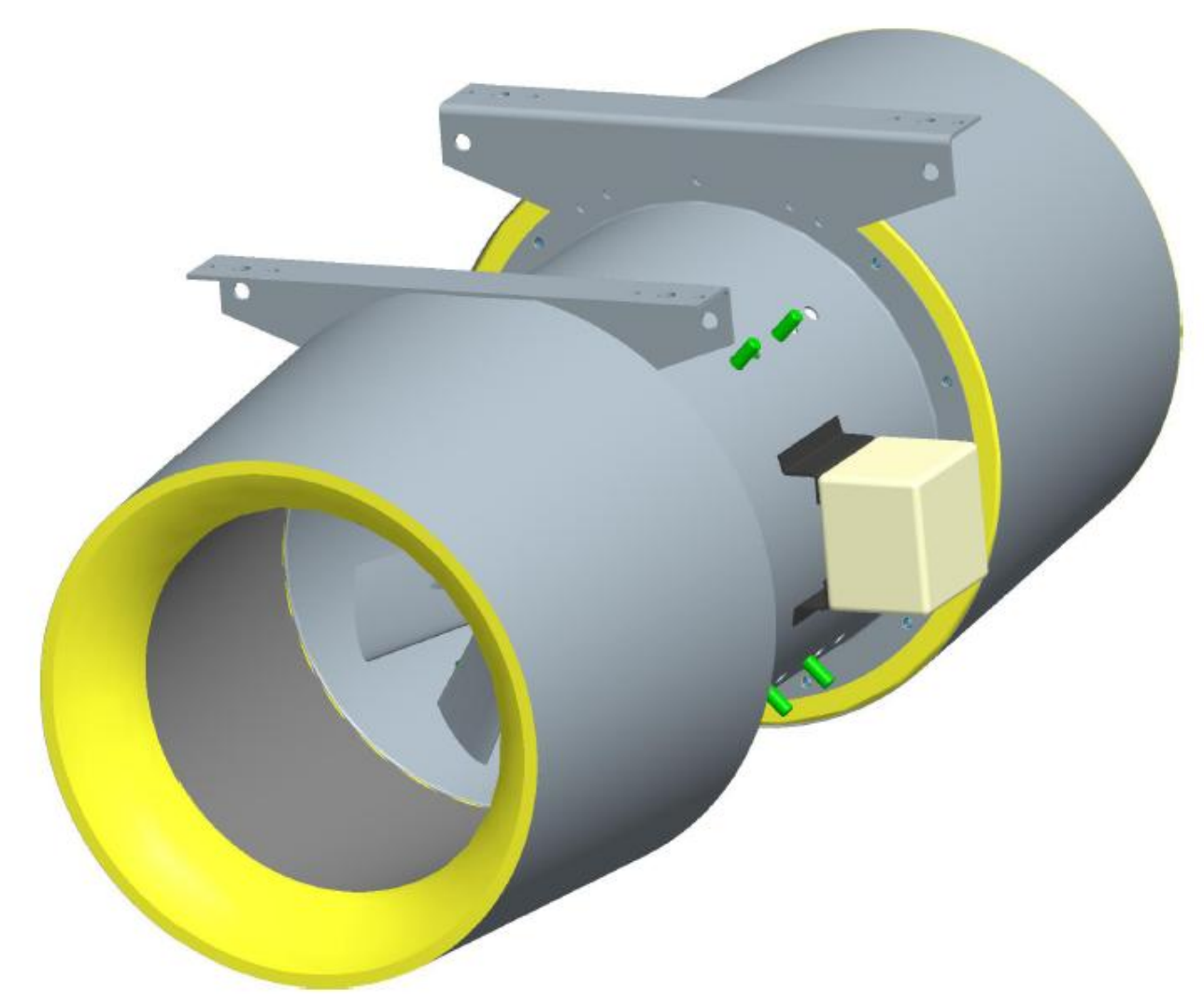
4. Projects/Prospects

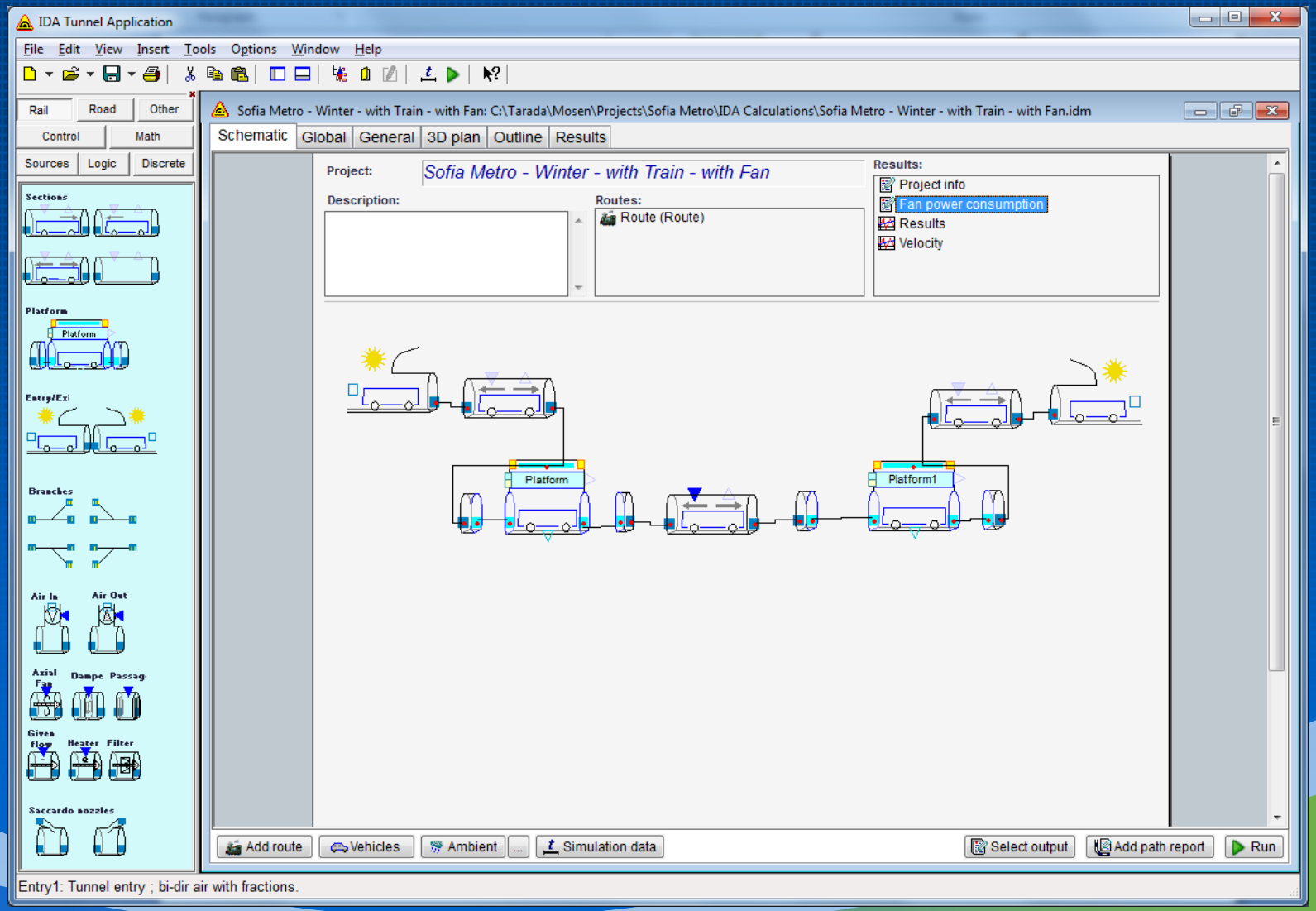
Tunnel Stakeholders

- Tunnel operators
- Regulatory authorities
- Fire authorities
- Consultants
- Mechanical/electrical contractors
- Design/build/operate operators

European Metro Tunnel



European Metro Tunnel



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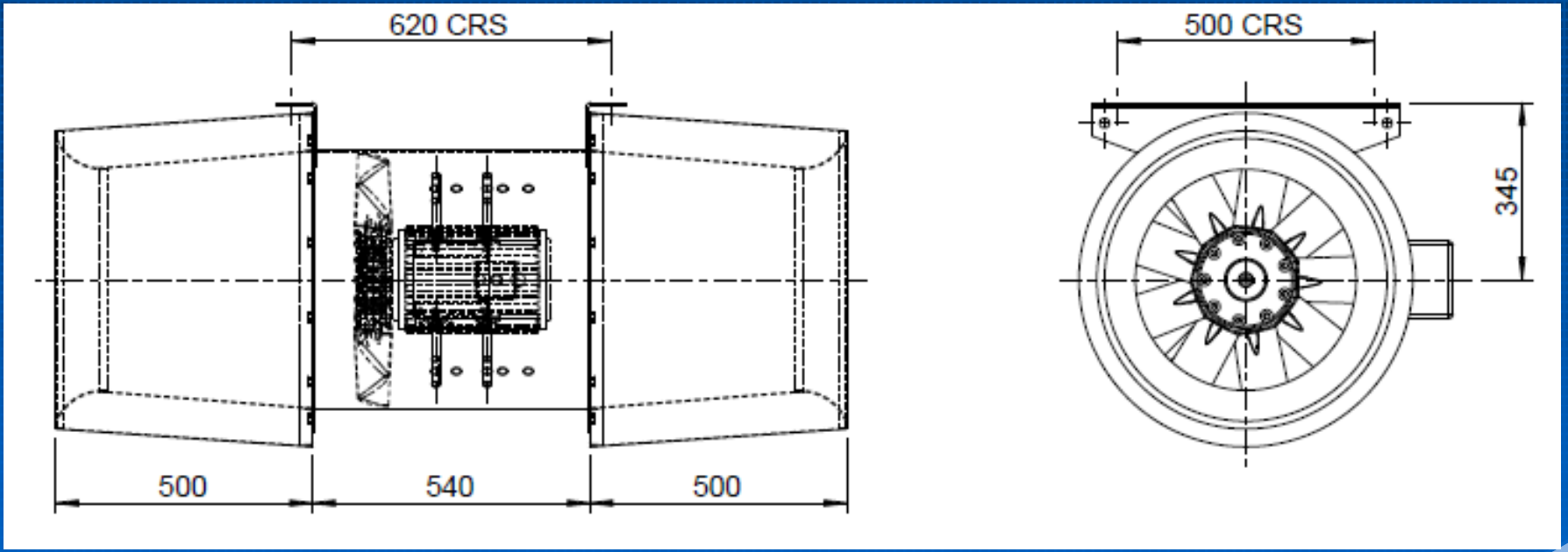
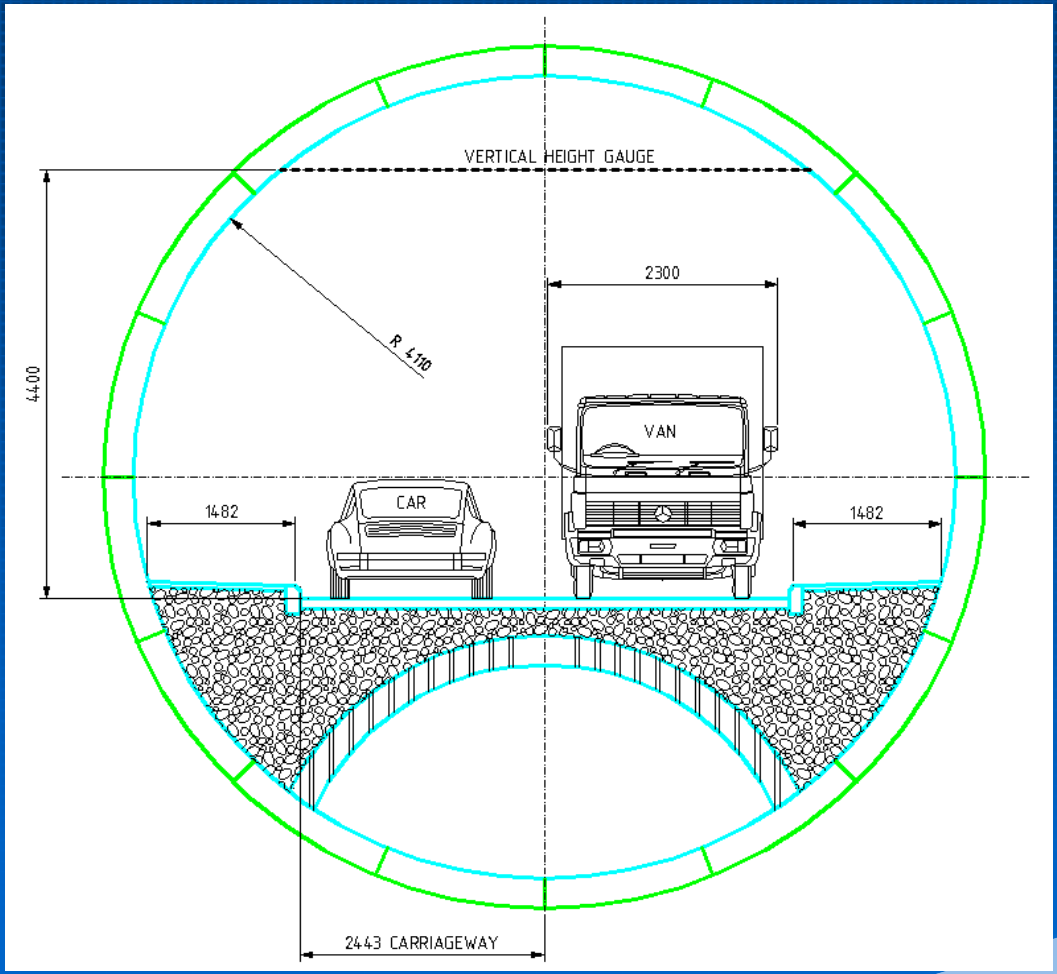
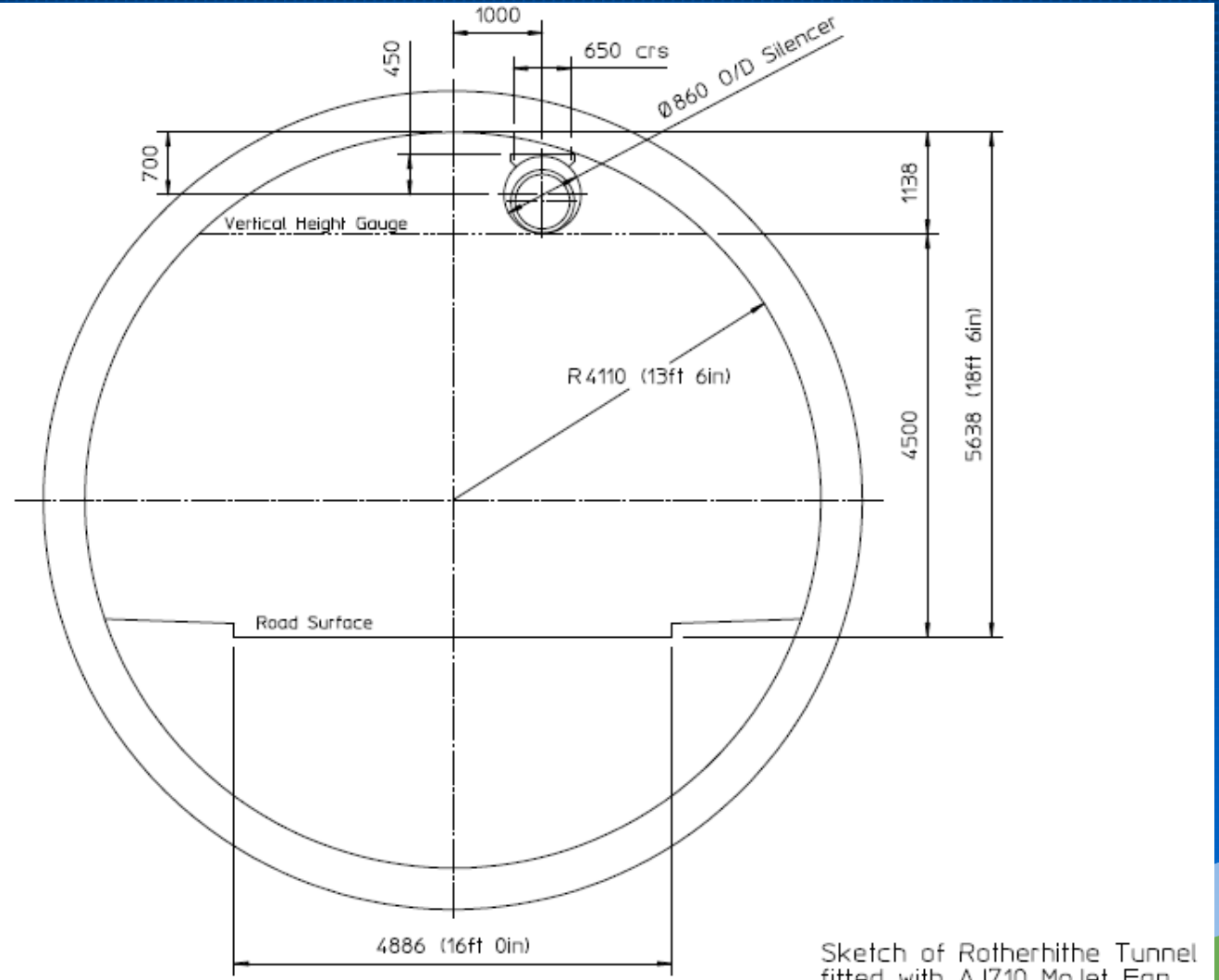
European Metro Tunnel



London Tunnel



London Tunnel



Sketch of Rotherhithe Tunnel fitted with AJ710 MoJet Fan.

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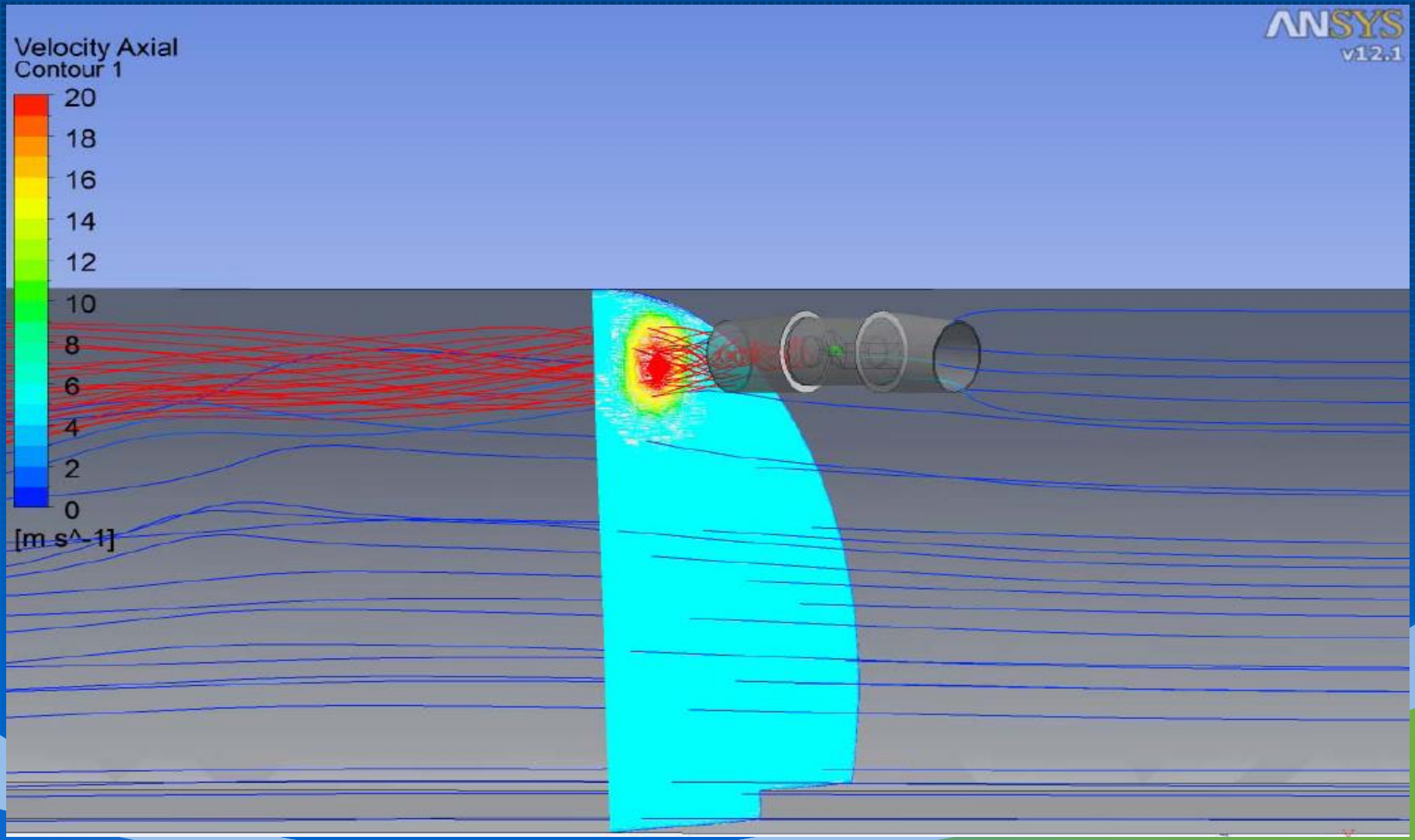
London Tunnel



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La Fontaine Tunnel, Montreal

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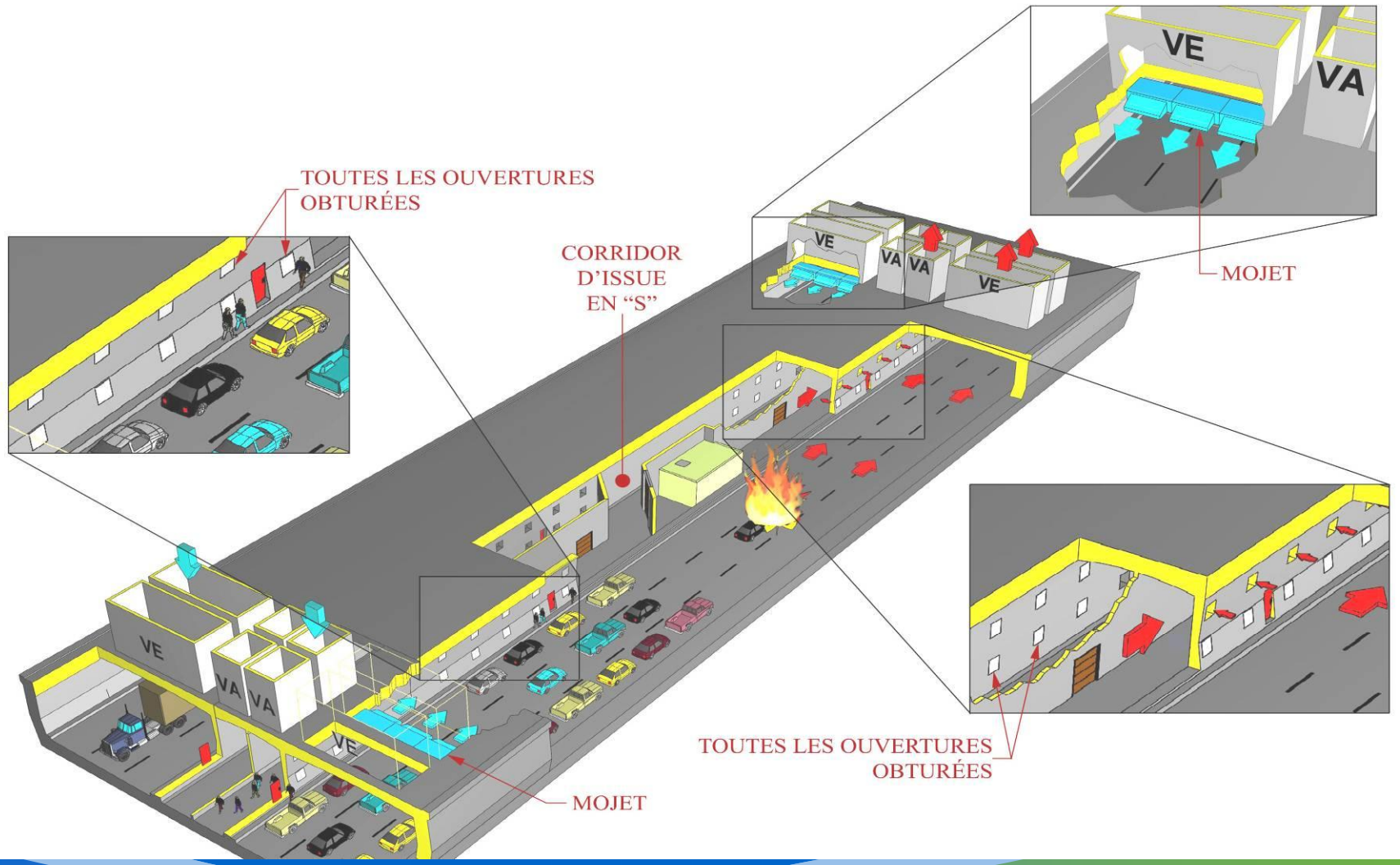
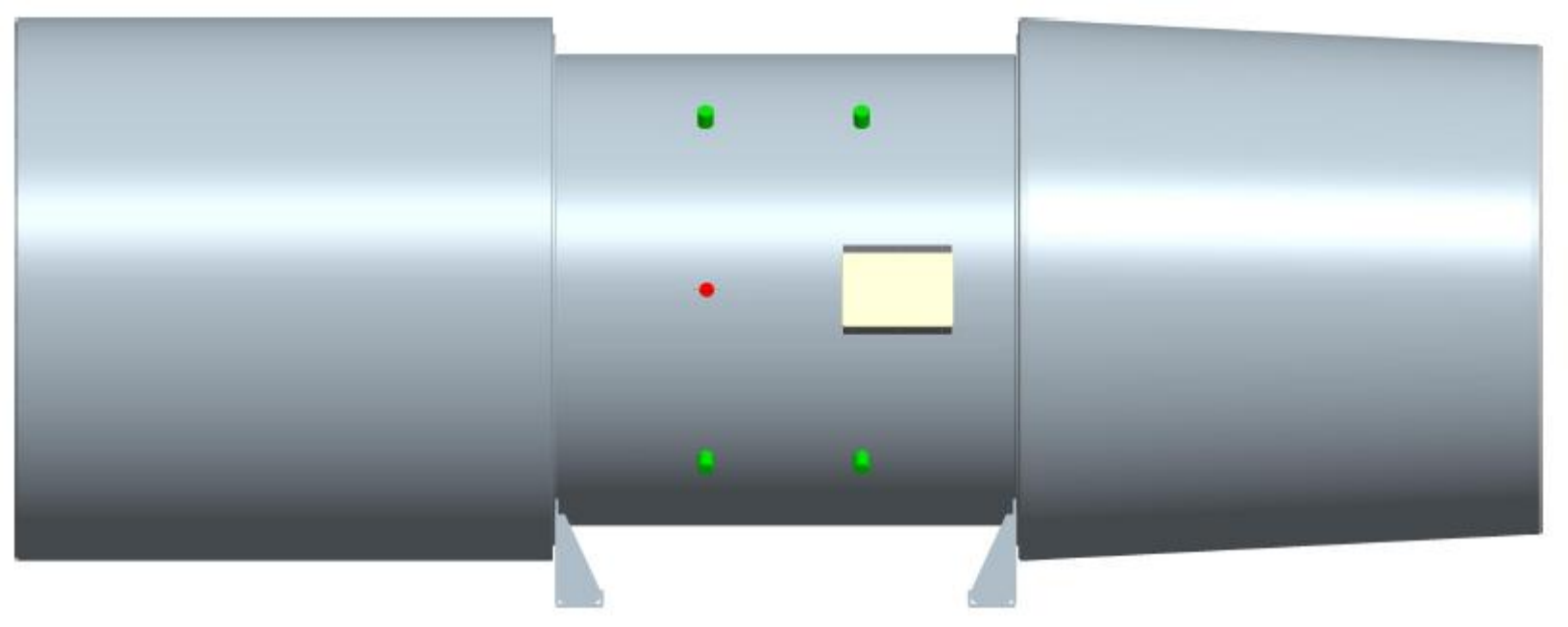
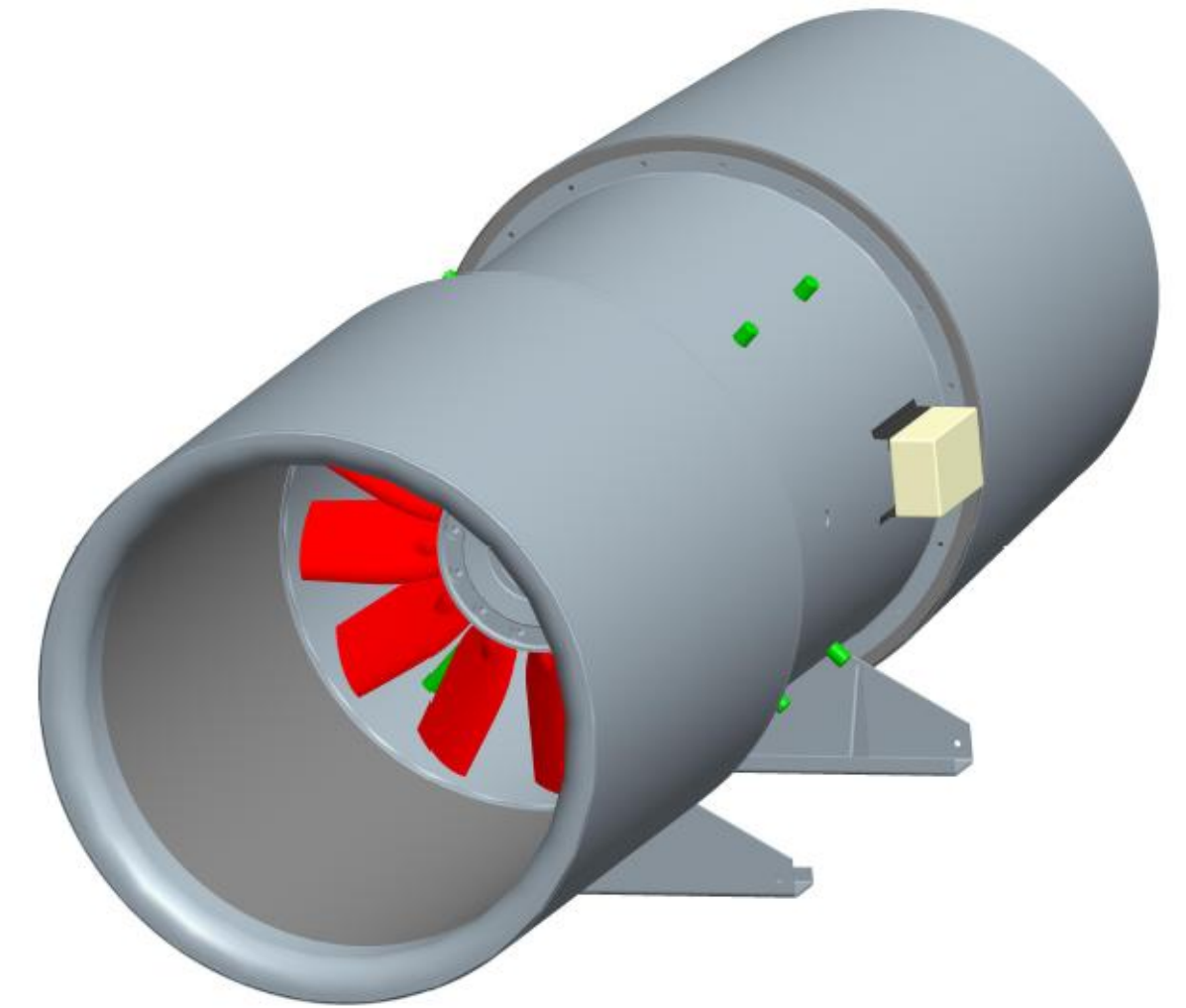
La Fontaine Tunnel



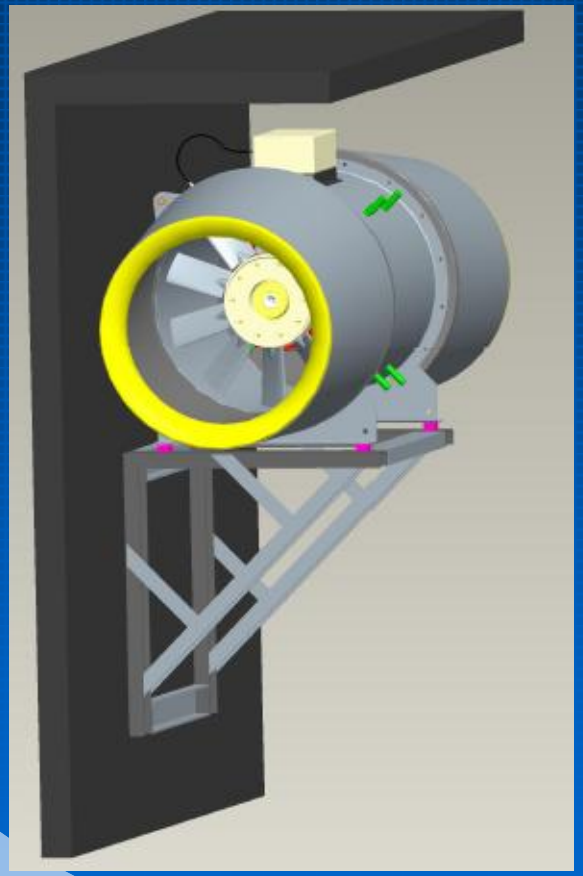
La Fontaine Tunnel

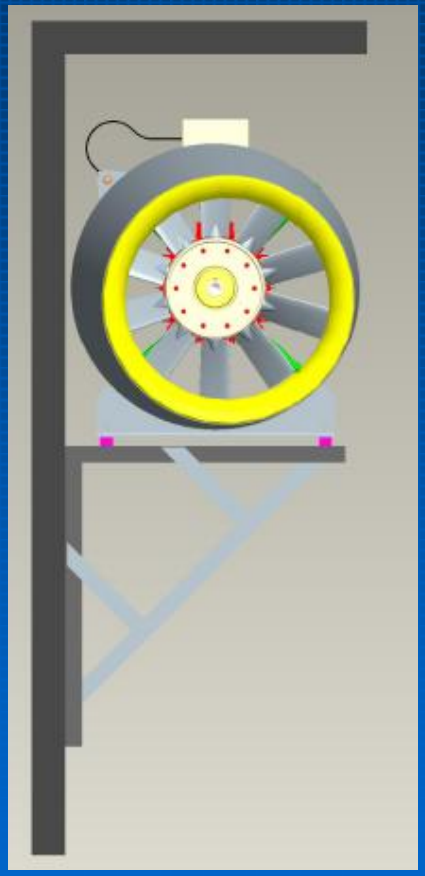


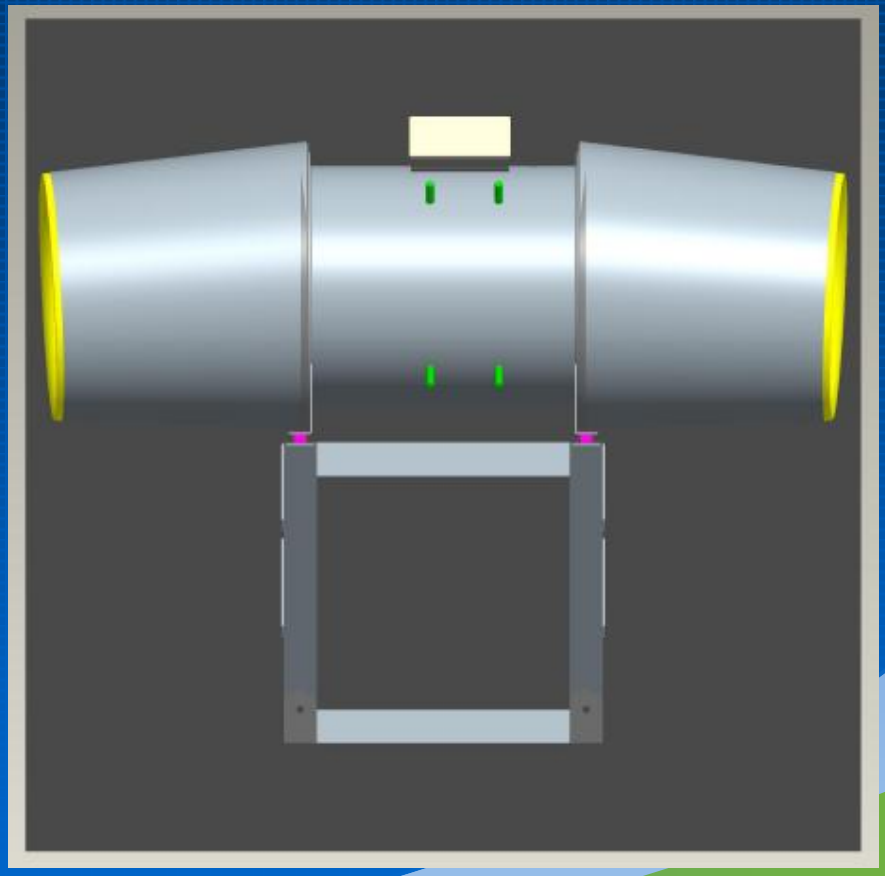
La Fontaine Tunnel



Underground Station, Netherlands







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Underground Station, Netherlands

	Standard Jetfan	MoJet®
Design Thrust Requirement (in Tunnel) incl. velocity factor	22,803 N	
Installation Factor	0.73	0.95
Static Thrust Requirement (N)	31,237	24,003
Maximum Fan size	710mm diameter	

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Power Consumption

	Standard Jetfan	MoJet®
Selected Fan	710TR 2P	710TR 2P
Fan Thrust (N)	822	758
Fan Quantity	38	32
Absorbed Power per Fan (kW)	32.8	28.6
Overall Power Absorbed (kW)	1246.4	915.2

27% reduction in power consumption using MoJet ®

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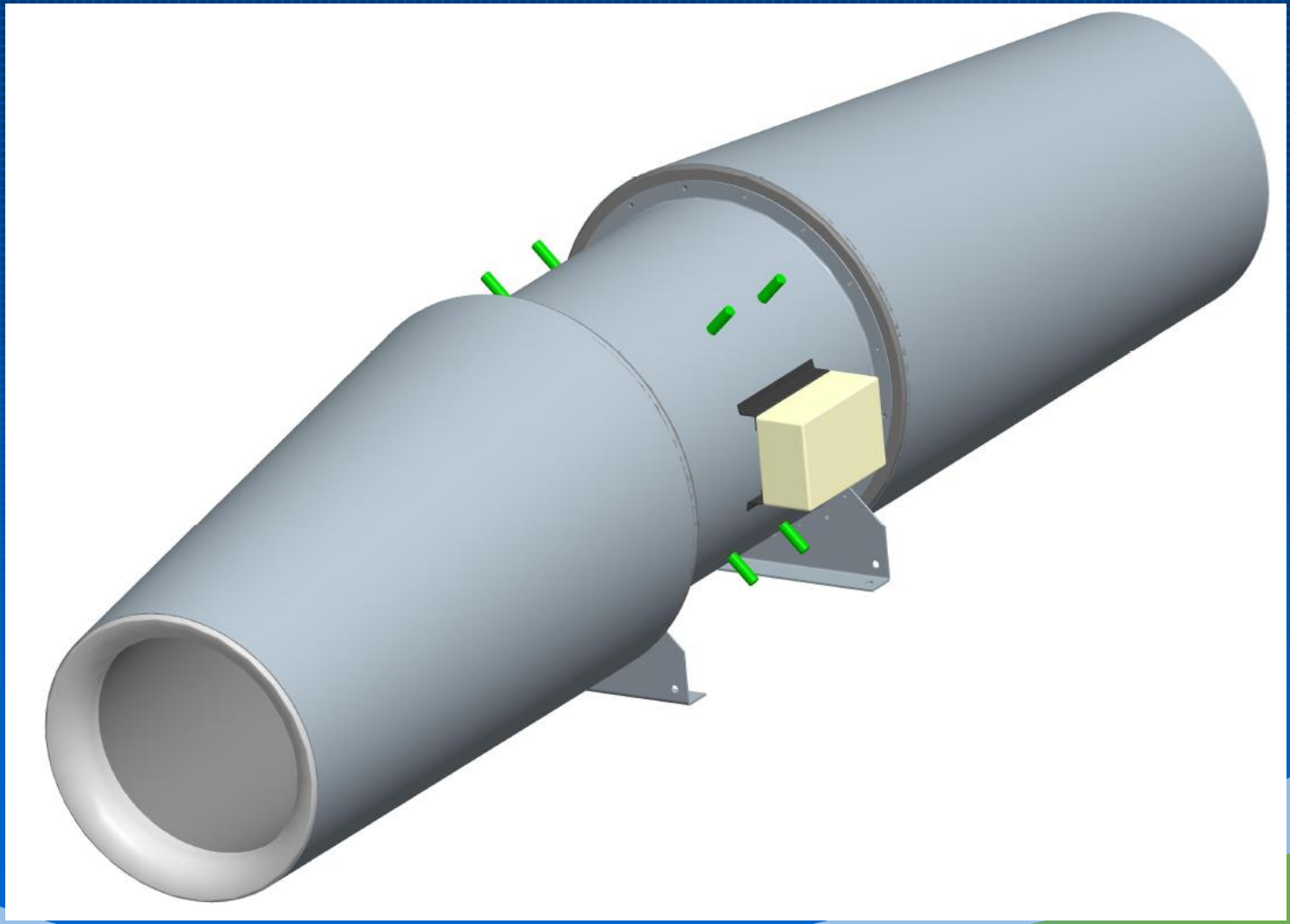
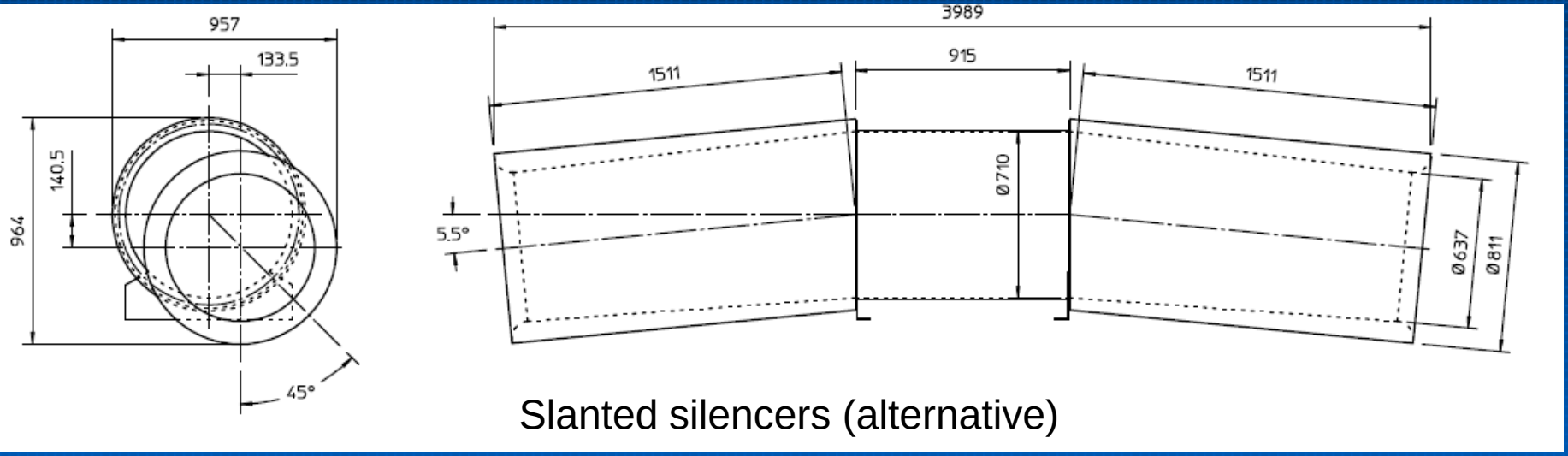
Road Tunnel, Middle East



Road Tunnel, Middle East



Slanted silencers (alternative)

- Slanted silencers required 30% more power consumption than MoJet®, since its fan diameter was smaller (for the same installation space).

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Summary

1. Principles of the MoJet®
2. Advantages of the MoJet®
3. Selecting the right MoJet®
4. Projects / Prospects

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