

# Thrust Comparison Of Conventional Jet Fans And Fans With Shaped Silencers in an Italian Road Tunnel Based on In-Situ Measurements

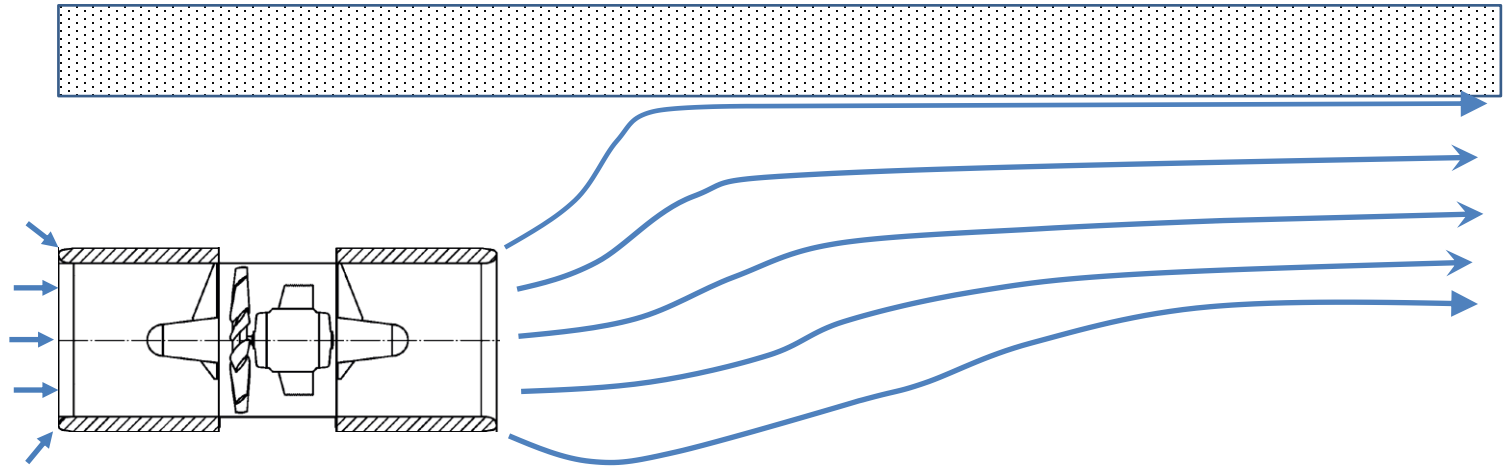


Luca Stantero, Fathi Tarada, Pier Bertacche, Natalino Daniele Boffa,  
Francesco Bezzi, Natalino Lucatelli

# Background

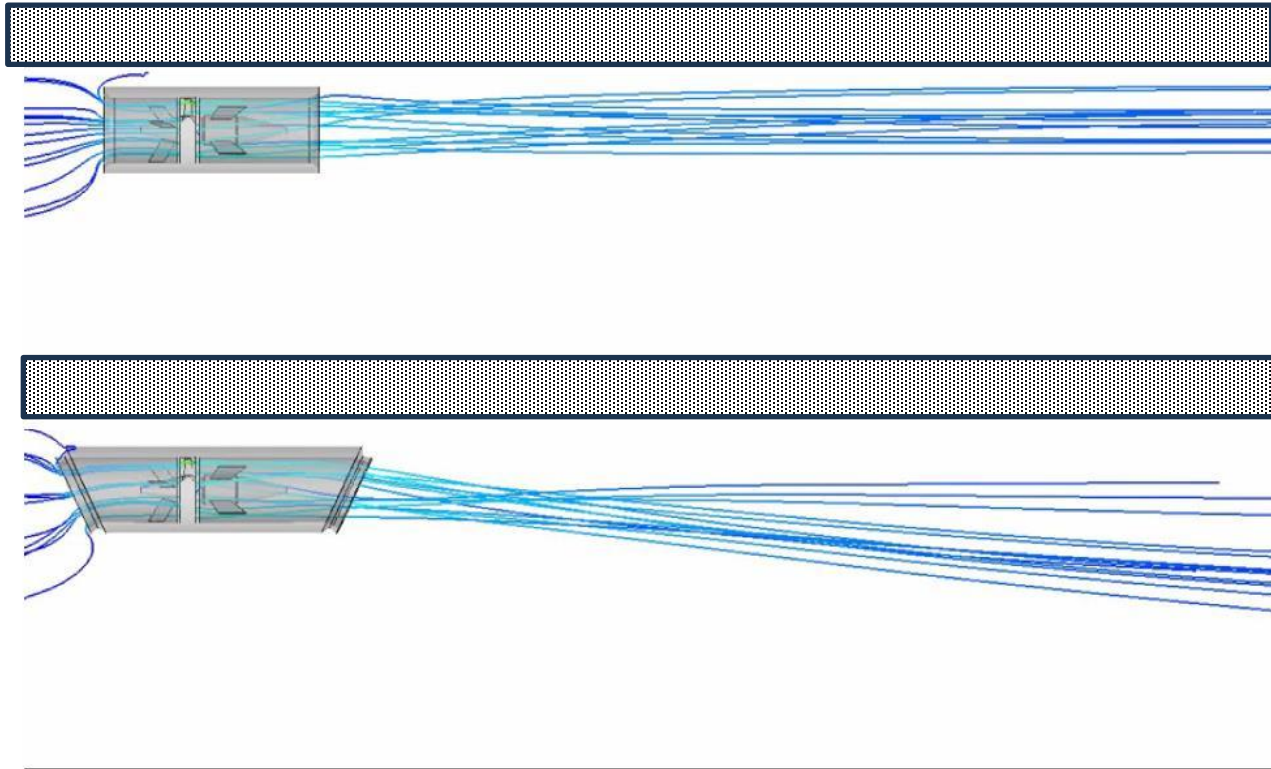
- Longitudinal ventilation is widely used in European and international tunnels
- Jet fans suffer from aerodynamic losses
- Up to 50% of thrust lost due to Coanda effect
- Efficiency improvement is key objective

# The Coanda Effect



Discharged jet is deflected towards the tunnel soffit

# Effect of Shaped Silencers

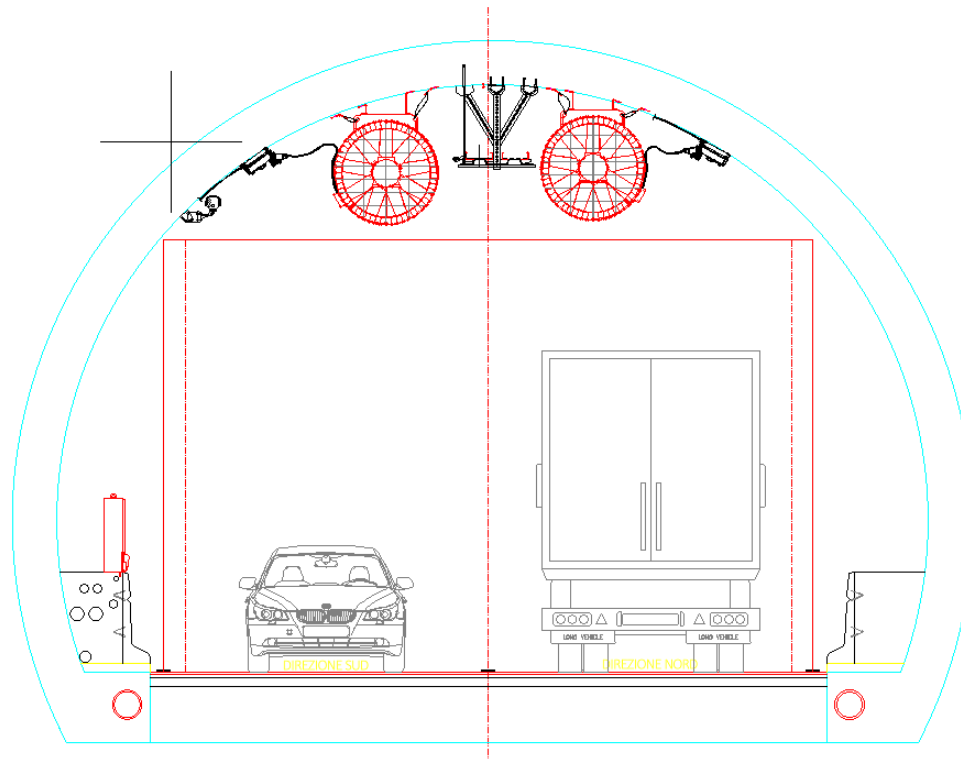


# Objective

- Quantify in-tunnel thrust performance
- Compare conventional vs shaped silencers
- Full-scale in-situ measurements

# Test Site – Verta Tunnel

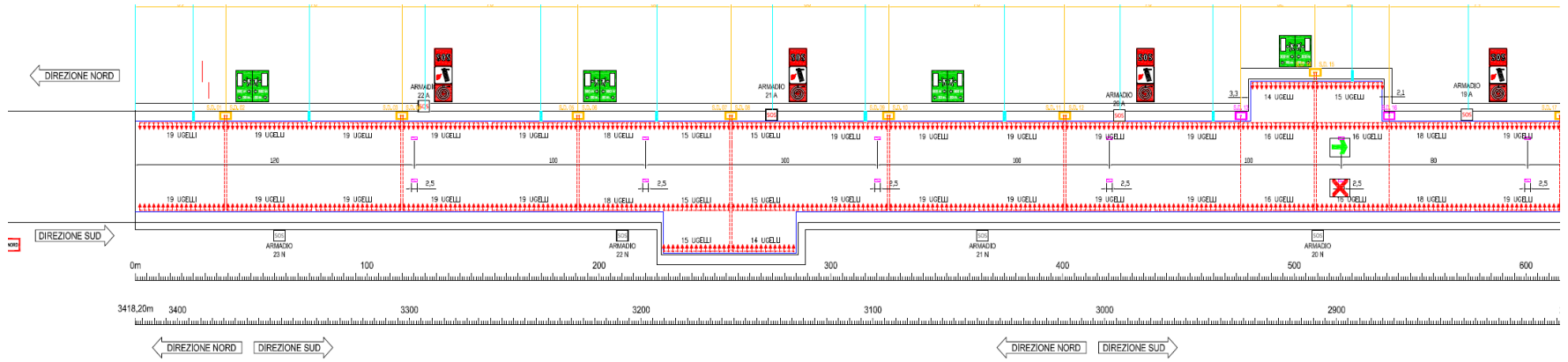
- 3.5 km two-lane road tunnel in Omegna, Italy
- Arched tunnel cross-section
- Operated by the Italian highway owner/operator, ANAS



# Fan Configuration

- 10 pairs of jet fans
- 5 pairs at north portal, 5 pairs at south portal
- Banks spaced at 100 m
- Tests focused on first 4 banks

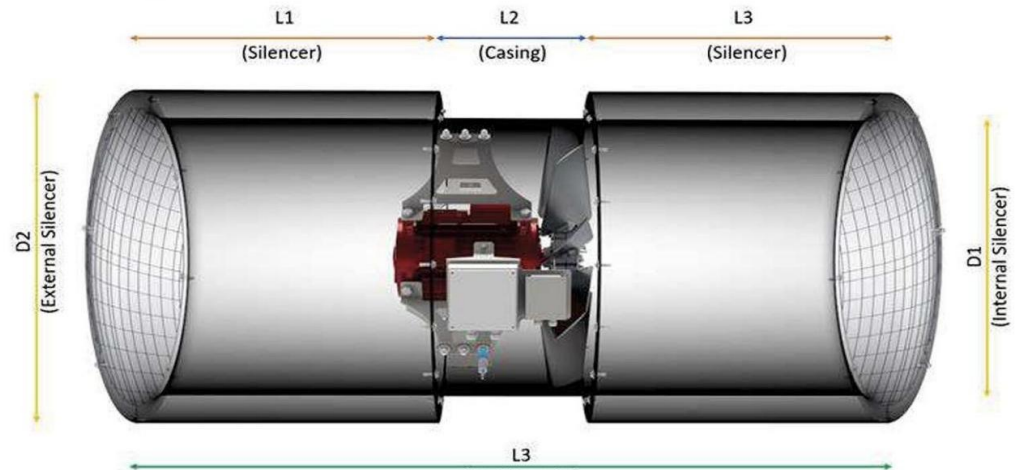
# Jet fan banks at north portal



# Jet Fan Specifications

- Flow rate: 24.3 m<sup>3</sup>/s
- Jet velocity: 30.9 m/s
- Bench thrust: 900 N
- Absorbed power: 26 kW
- Sound pressure: 71±3 dB(A) (measured 10 m away, at a 45° angle from the fan axis)

Shaped silencers do not change these parameters.



# Jet Fans with Shaped Silencers

- Deflect jet away from soffit
- Reduce wall friction losses
- No increase in power or noise



# Measurements Undertaken

To estimate jet fan installation factor:

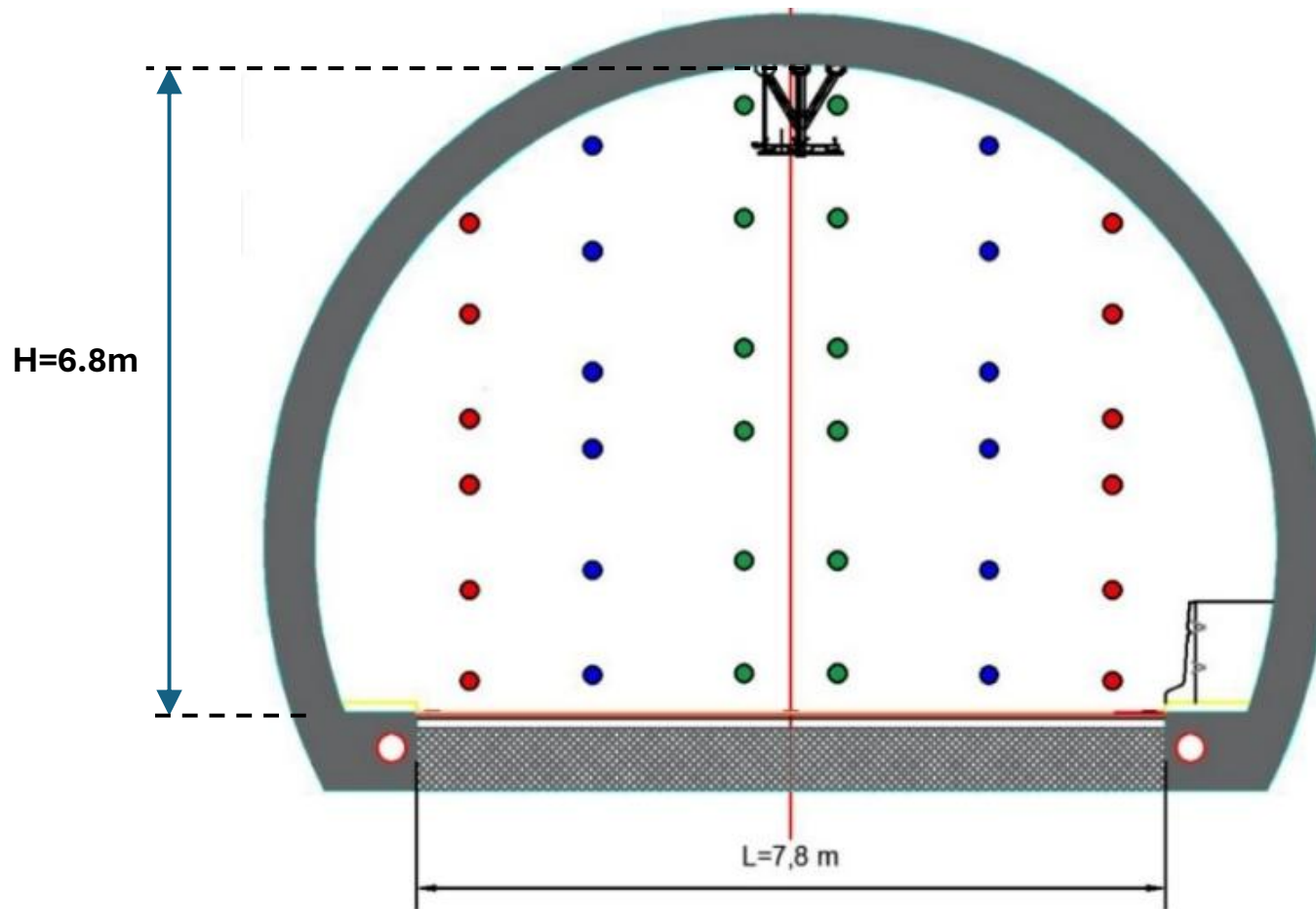
- Velocity measurements: hot wire grid (36 points)
- Static pressure rise across jet fans (+/- 50 m from jet fans)

To estimate tunnel friction factor:

- Fan run-down tests

All measurements were undertaken by Risk Design Engineering SRL

# Velocity Measurements Across Tunnel Cross-Section



# Velocity Measurements

- ISO 5802 methodology
- Log-Tchebycheff distribution
- Area-weighted averaging

# Instrumentation

- Hot-wire anemometers
- Tripod-mounted grid
- Static pressure probes
- Tablet-based data logging

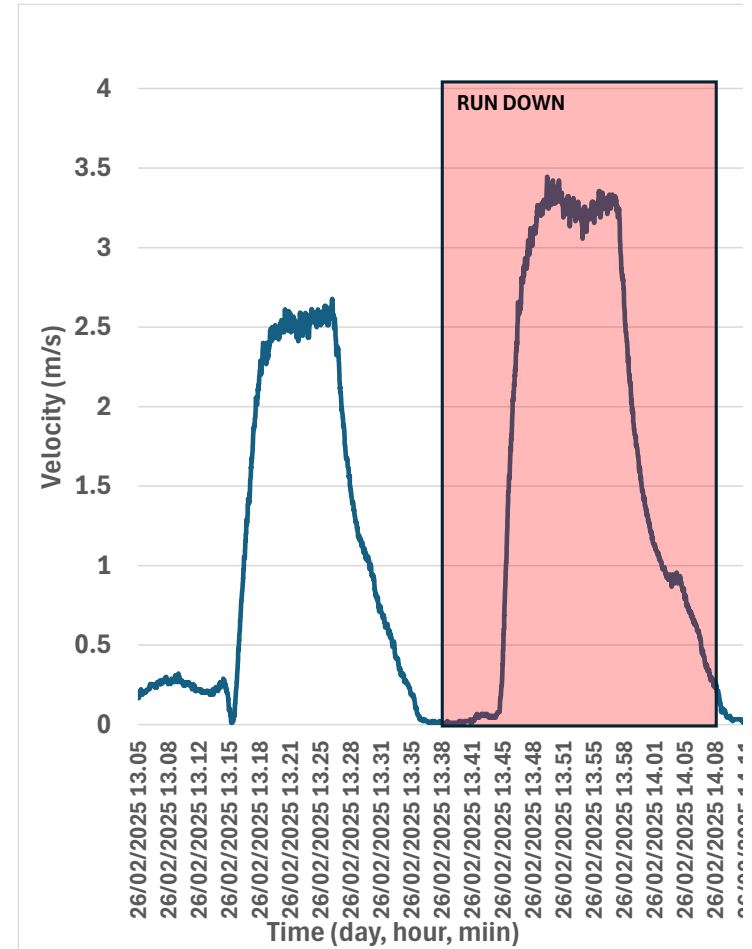


# Test Conditions

- Moderate external wind
- Controlled fan operation
- Repeat measurements using linear arrangement of jet fans (over four banks)

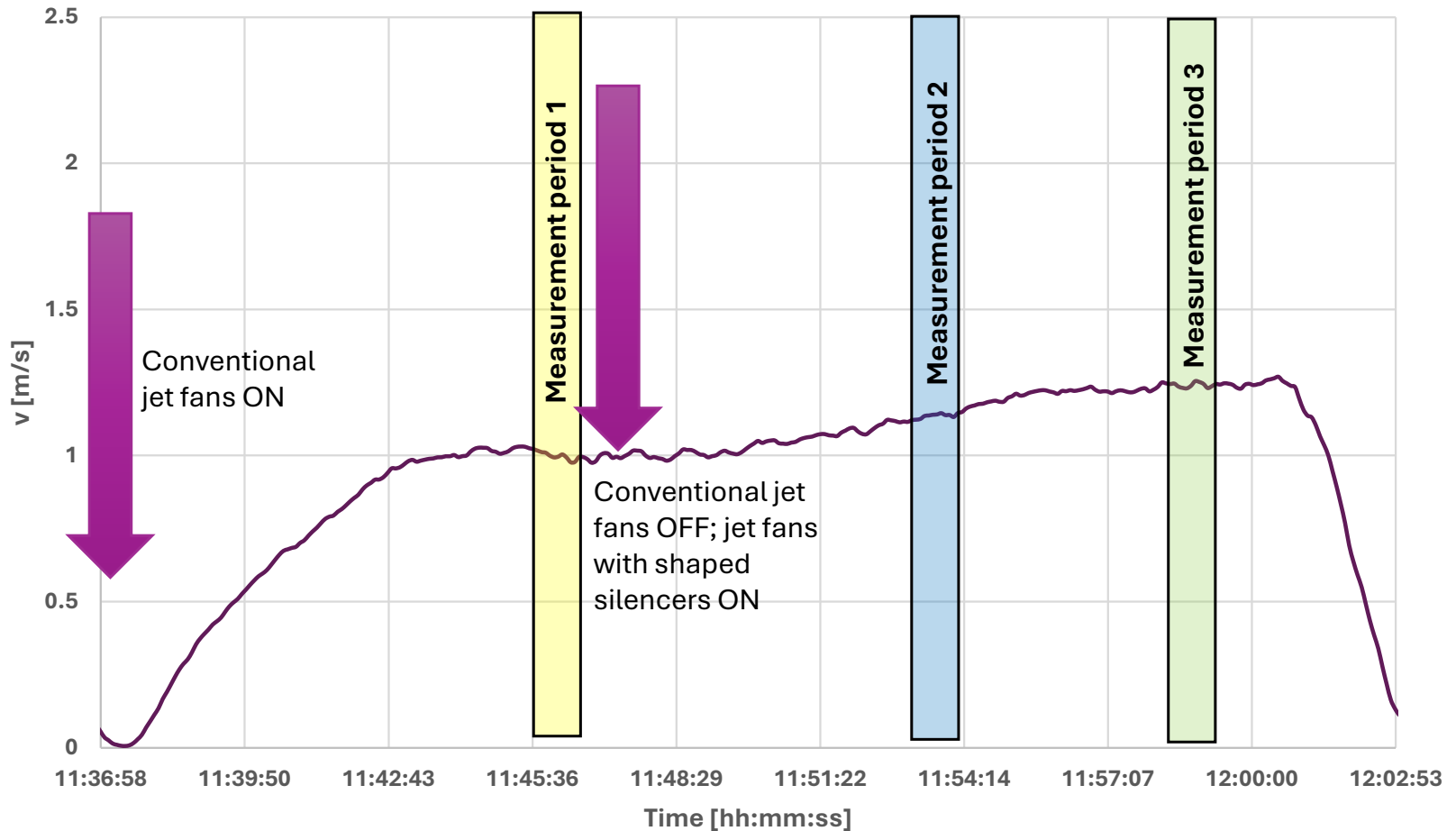
# Fan Run-Down Test

- Friction factor  $\approx 0.025$
- $\pm 10\%$  uncertainty



# Tunnel Velocities

ISO-Average Air Velocities (m/s)



# Average Tunnel Velocity Results

- Conventional jet fan:  $\sim 1.0$  m/s
- Shaped silencers:  $\sim 1.2$  m/s
- Indicates higher in-tunnel thrust for shaped silencers

# Pressure Results

- $\Delta p$  conventional: 20.6 Pa
- $\Delta p$  shaped silencer: 29.6 Pa
- Higher pressure rise for shaped silencer, indicating an improved in-tunnel thrust

# Installation Factor

Installation factor =  $\frac{\text{In-Tunnel Thrust}}{\text{Theoretical thrust}}$

- Conventional: 0.703
- Shaped: 0.948
- Significant improvement with shaped silencers

# Interpretation

With shaped silencers:

- Improved jet alignment
- Reduced soffit interaction
- Better momentum transfer

# Uncertainty

- $\pm 10\%$  overall uncertainty
- Wind variability
- Measurement limitations

# Comparison with Literature

- Consistent with prior measurements on shaped silencers in arched tunnels, which indicate  $\sim 30\%$  thrust improvement
- Validated by detailed CFD studies

# Implications

- Energy efficiency gains
- Reduced number of fans
- Lower operational cost

# Conclusions

- Shaped silencers improve in-tunnel thrust
- No penalty in power/noise
- Recommended for future designs and installations