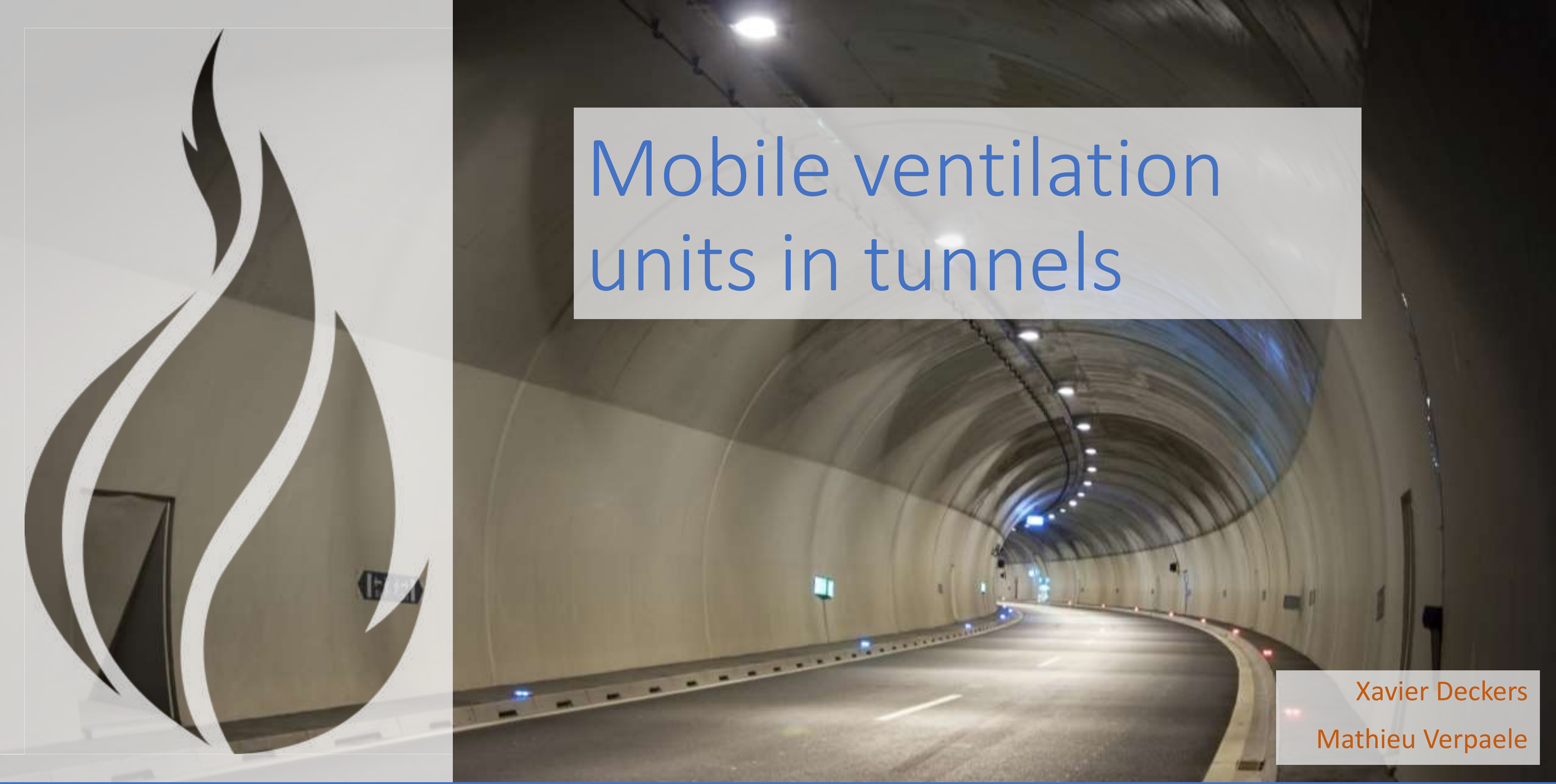

Mobile ventilation units in tunnels

Xavier Deckers

Mathieu Verpaele

Fire Engineered Solutions Ghent

- Fire science and engineering company with offices in Belgium and Sweden
- Started as spin-off company of Ghent University (2009)

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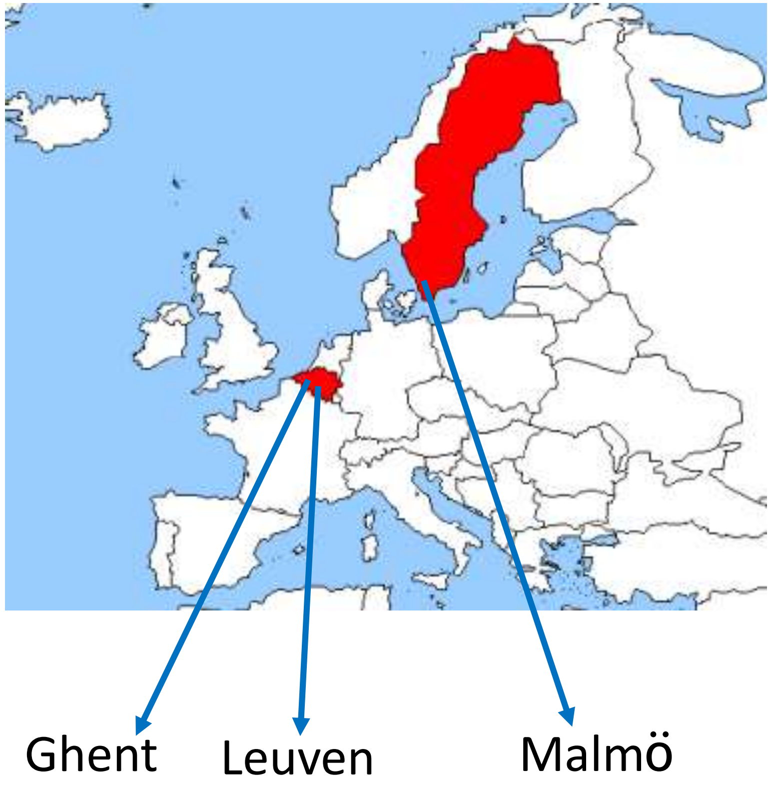
- Independent fire safety consultancy
- Specialised in Performance Based Solutions (PBD)



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Use of Mobile fans: Why relevant in Norway?

- 1140 + tunnels with traffic
- Many tunnels without tunnel ventilation
- No fatalities in recent fires: fire brigade intervention!

Oslofjord tunnel
June 2011

Gudvanga tunnel
August 2013

Skatestraum tunnel
July 2015

Gudvanga tunnel
August 2015

Oslofjord tunnel
May 2017

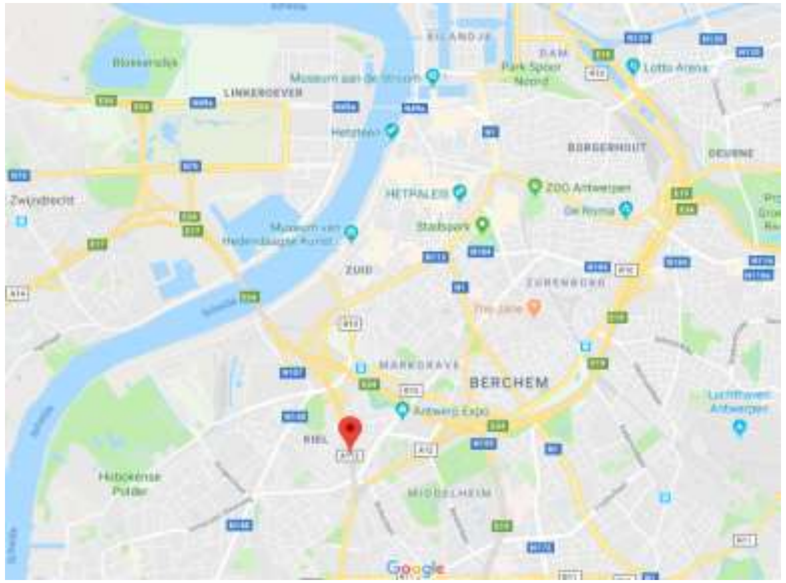
Questions to answer

Q1. How performant are mobile fans in road tunnels?	Experiments in cold conditions
Q2. How do they perform in case of fire?	CFD
Q3. Till which fire size can they successfully be utilized?	QRA

Q1. EXPERIMENTS

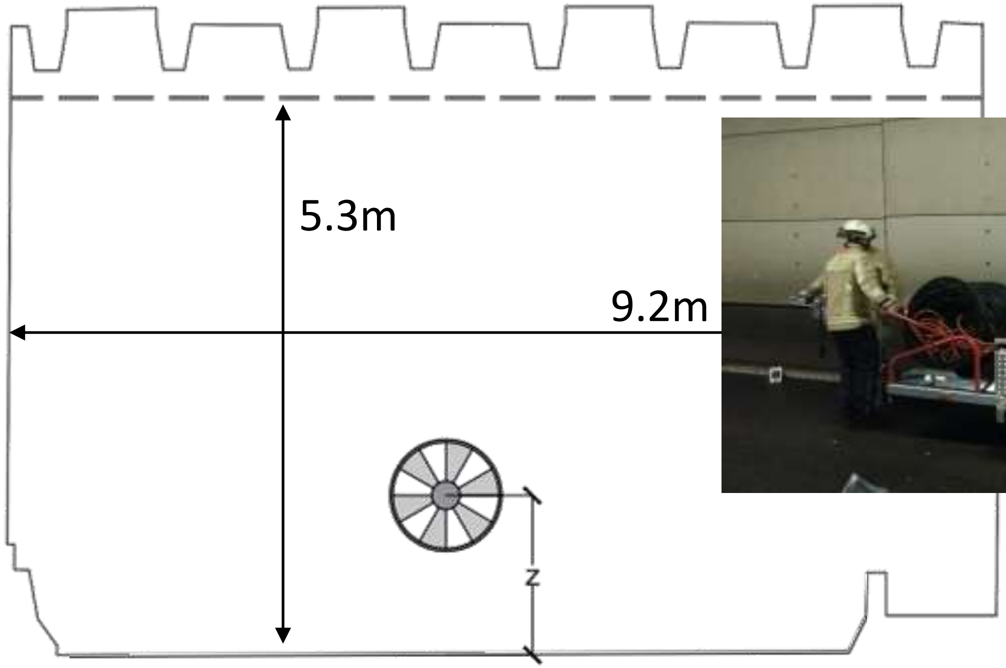
General

- Jan De Vostunnel (Antwerp,Belgium)



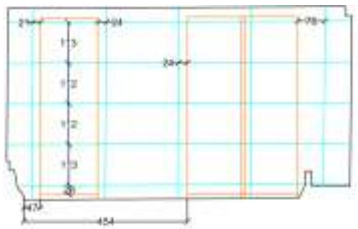
- Length = 740m
- 2 tubes
- 2 lanes/tube
- Max. slope = 1.8%

- Difficult geometry (Beams every 11.5m)
- Mobile fan:
  - positioned in the middle
  - 145.000 m³/h (1600N)



Procedure

- Velocity measurements: 5x5 grid (Hot bulb probes)

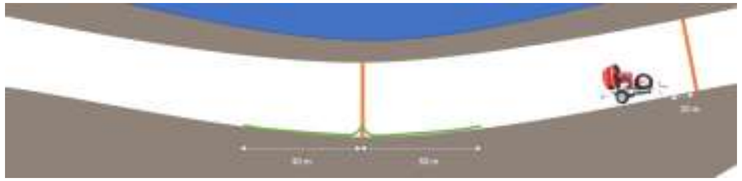


5x5

50 Measurements

Expected real-life set-up.

Fan 30m in the tunnel.



Pressure drop measurements over L = 60 m

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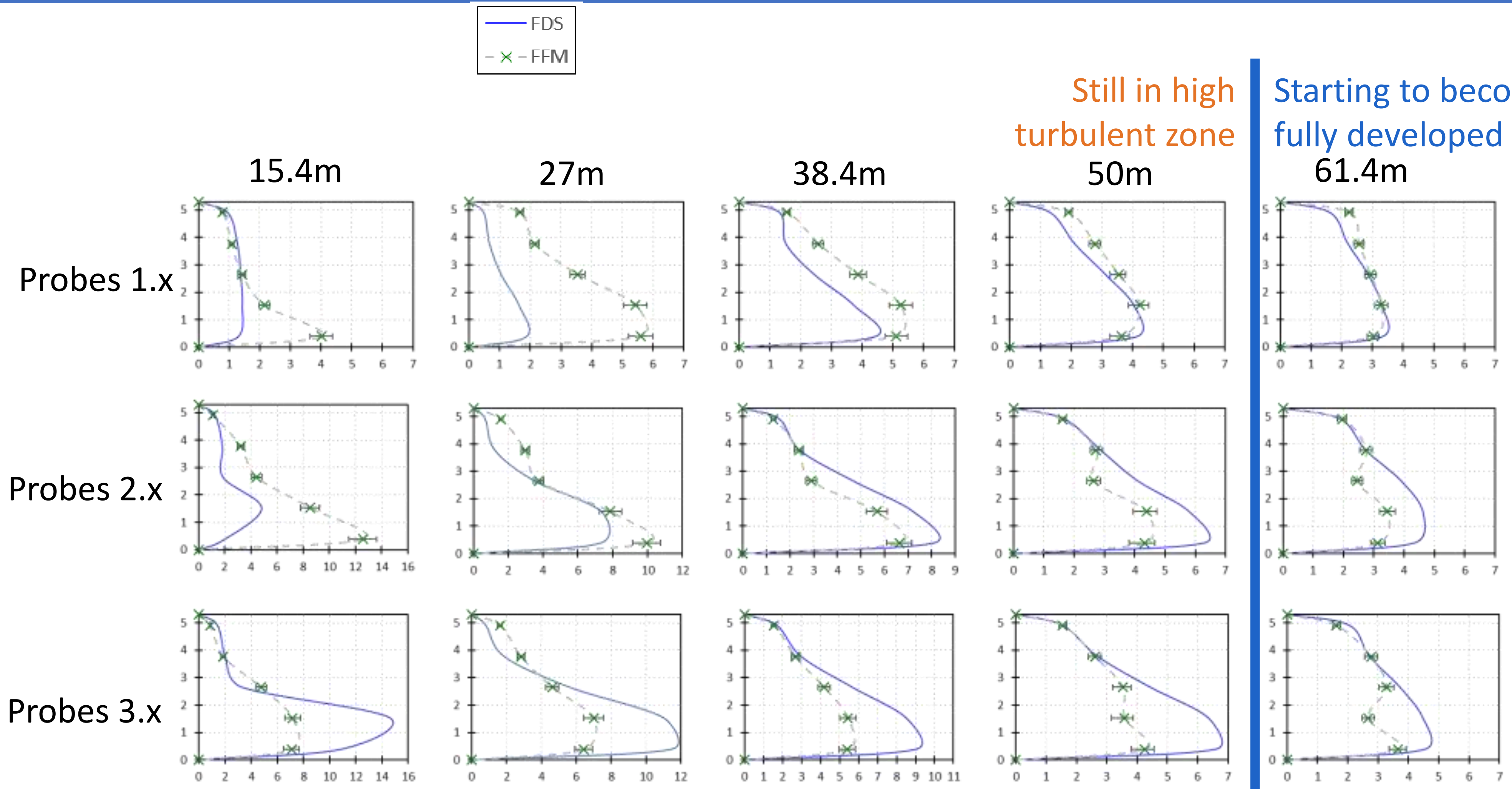
Raw Data

Still in high turbulent zone

Starting to become fully developed



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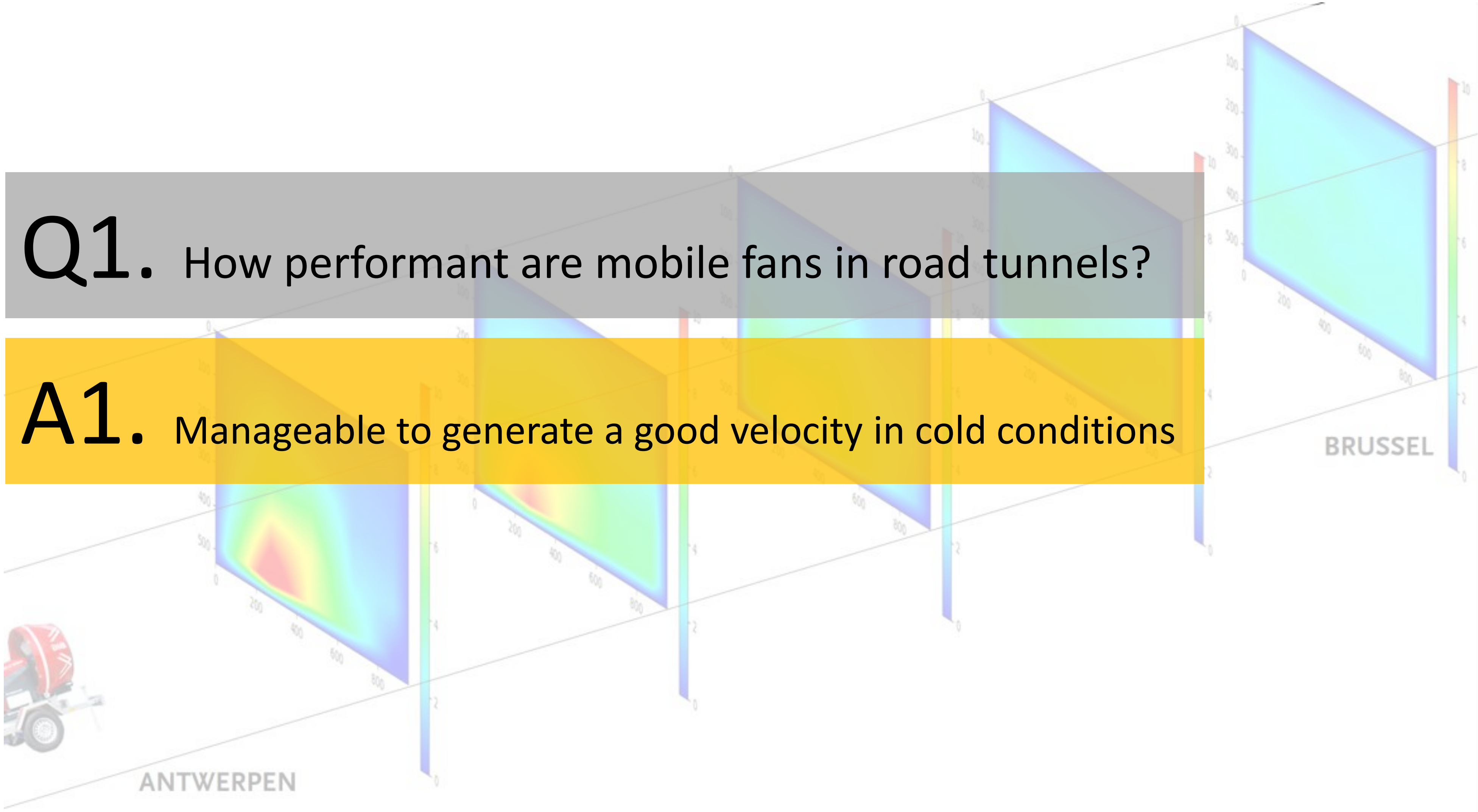
Results

Q1. How performant are mobile fans in road tunnels?

A1. Manageable to generate a good velocity in cold conditions



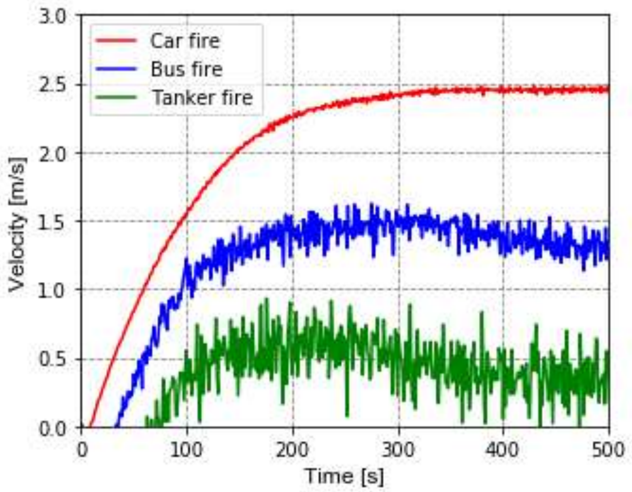
Q2. How do they perform in case of fire? -> CFD

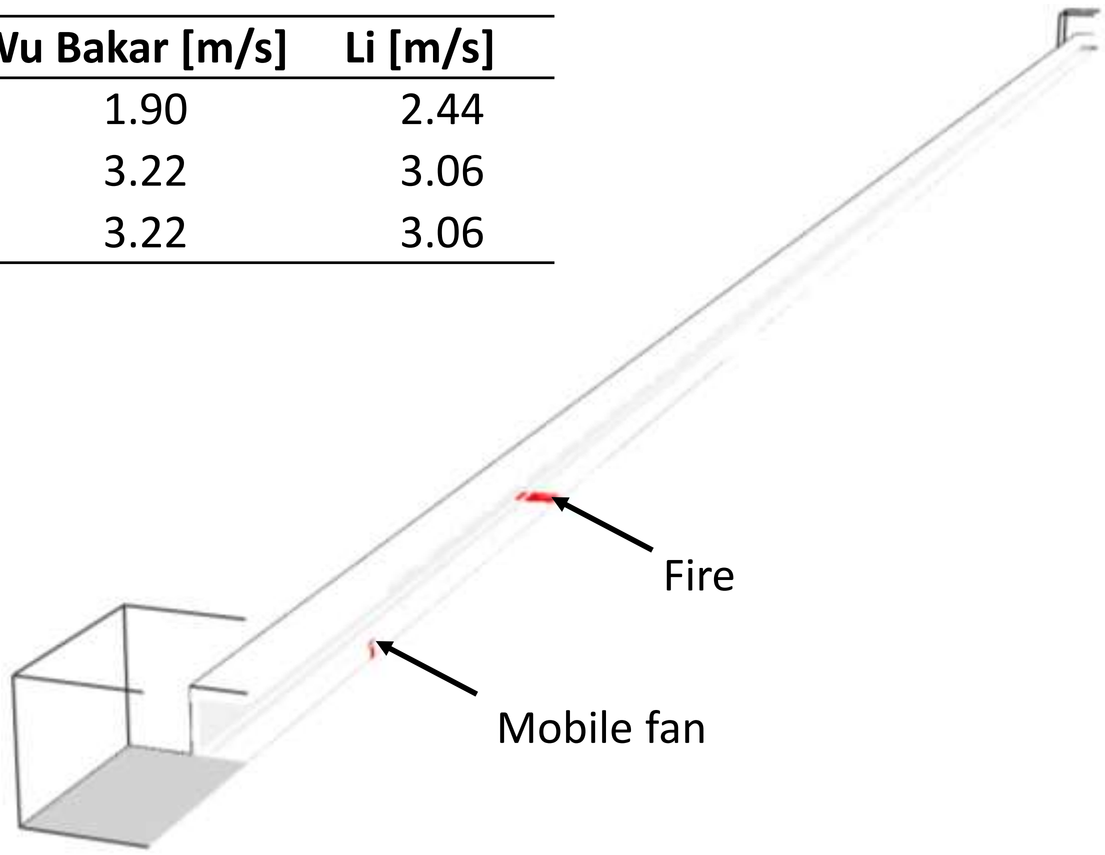
Simulations

Fire at 90 m from the inlet portal and 60 m from the mobile fan.

Case	HRR [MW]	Velocity [m/s]	Wu Bakar [m/s]	Li [m/s]
Car fire	5.0	2.45	1.90	2.44
Bus fire	30.0	1.91	3.22	3.06
HGV fire	100.0	0.36	3.22	3.06

Longitudinal velocity monitored during the fire.

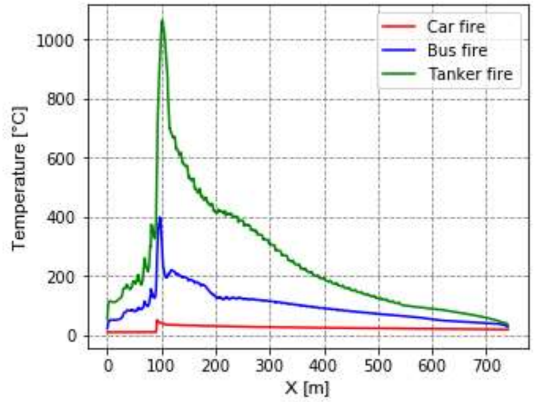


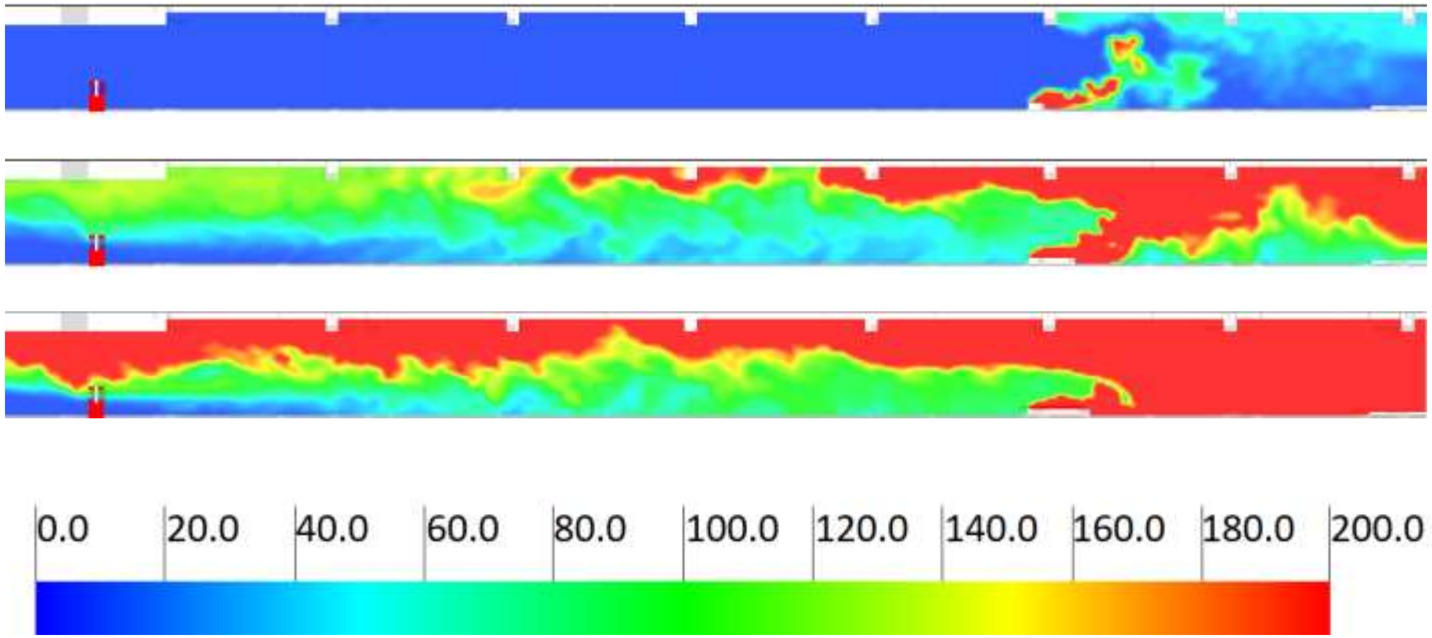


Simulations

When **HRR ↗, longitudinal velocity ↘.**

Smoke flows upstream.





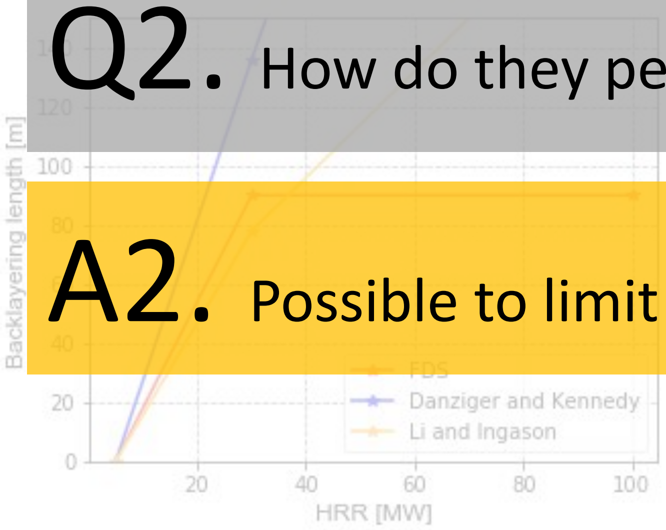
Simulations

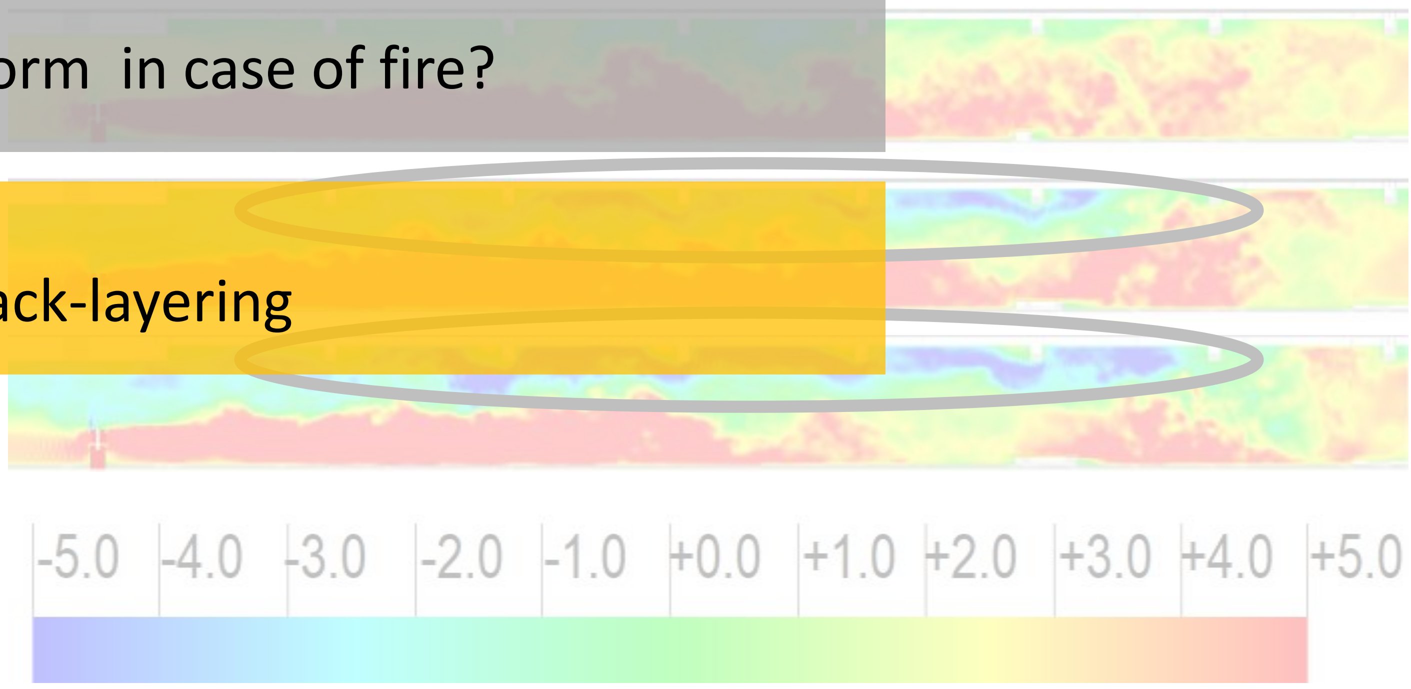
When **HRR ↗**, **backlayering length ↗.**

Big recirculation zone for high HRR.

Q2. How do they perform in case of fire?

A2. Possible to limit back-layering





Q3. Till which fire size can they successfully be utilized? -> QRA

Main influencing parameters

VENTILATION DESIGN DEPENDS ON

- Fire load
- Fire location
- Ambient conditions
- Traffic
- Type and # of mobile fans
- and more…

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1D

1D calculations to check the added value of mobile fans in tunnel fires.

Performance criteria :

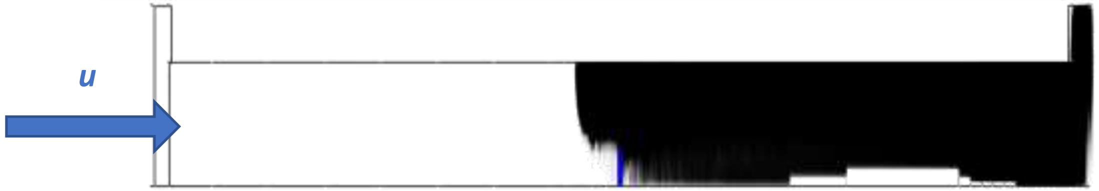
- BL = 50m

Critical velocity*

$$V_c^* = \frac{V_c}{\sqrt{gH}} \qquad V_c^* = \begin{cases} 0.81Q^*, & Q^* \leq 0.15 \\ 0.43 & Q^* > 0.15 \end{cases}$$

Backlayering length*

$$l^* = \frac{L_{bl}}{H} \qquad l^* = \begin{cases} 18.5ln(0.81(Q^*)^{1/3}/V^*), & Q^* \leq 0.15 \\ 18.5ln(0.43/V^*) & Q^* > 0.15 \end{cases}$$



Momentum equation

$$\frac{1}{2}\int_0^{L_t}\left(f\frac{1}{D_h}dx + \sum\beta\right)\rho_0 v_t^2 + \Delta P_{fan} + \Delta P_{fire} + \Delta P_{wind} + \Delta P_g = 0$$

* Ignason & Li

QRA – example of tunnel ventilation

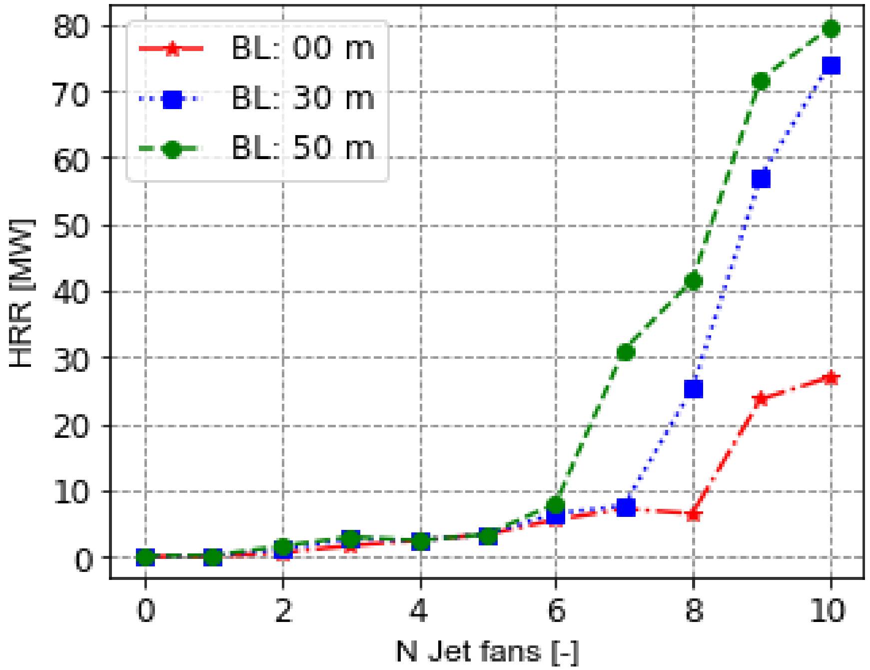
Fire size = f()

- *Fire Position*
- *Wind*
- *Tunnel's geometry & slope*
- ~~*Number jet fans*~~ *-> mobile fan*

Performance criteria

↓

limited backlayering?



Default wall roughness

- Lambda = 0.024

	1 Fan (1xL105)	2 Fans (2xL105)	2 Fans (L105 + L125)
5MW - auto	-	-	-
30MW - bus	115	38	-
100MW - Truck	291	106	74

Calculated wall roughness:

- Lambda = 0.051

	1 Fan (1xL105)	2 Fans (2xL105)	2 Fans (L105 + L125)
5MW - auto	7	-	-
30MW - bus	133	71	50
100MW - Truck	306	133	107

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CONCLUSION

Conclusion

- Potentially suited for an intervention with one car burning with an estimated HRR of 5MW.
- The use of multiple fans is preferable and is an option to be pursued in any case of fire in a tunnel. The deployment of the fans, whether parallel or in series, will depend on the conditions in the tunnel
- Suitable for:
    - Short tunnels such as the Jan De Vostunnel: the advised deployment is to place the fans in parallel since the tunnel is short in length (pressure losses are less important, main task is to maintain high velocity)
    - Long tunnels: it is advised to place the fans in series to handle the larger pressure losses due to the length of the tunnel.
    - Tunnels with an existing and working ventilation system dimensioned for a limited HRR: it can be interesting to deploy the mobile fans to improve the conditions after the fire brigade arrives on-site.

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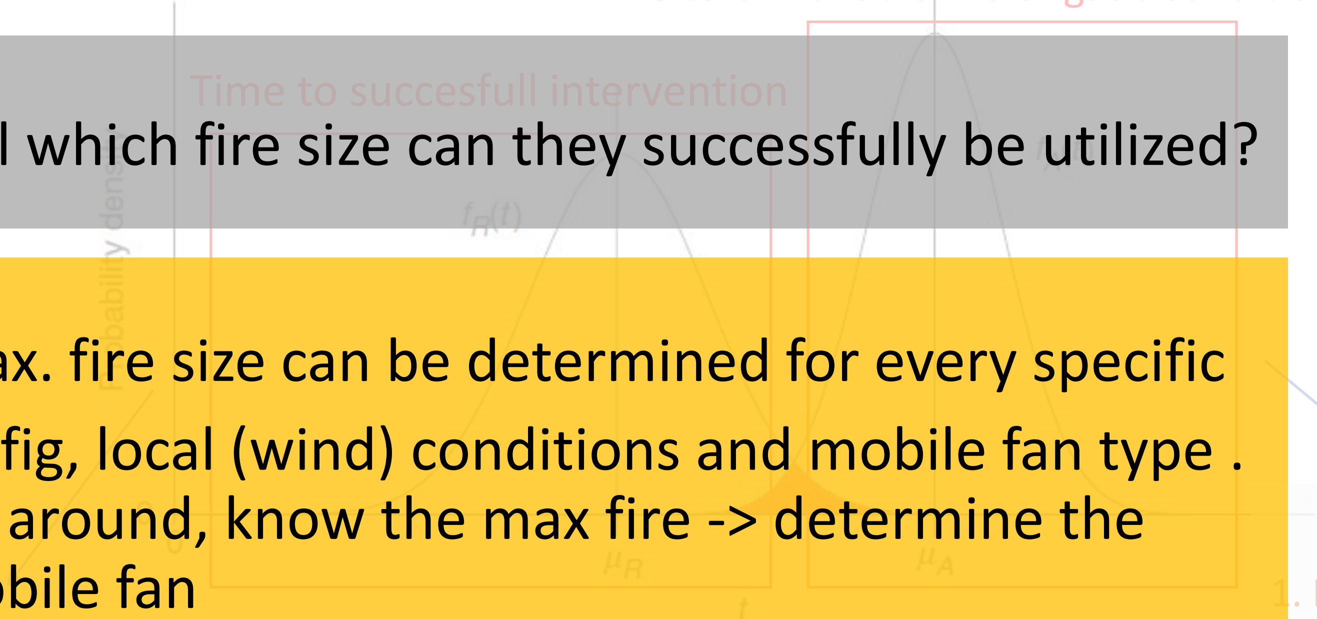
How to choose which tunnels to tackle first?

- Use of Fire Brigade Intervention Model!!



Q3. Till which fire size can they successfully be utilized?

A3. Max. fire size can be determined for every specific tunnel config, local (wind) conditions and mobile fan type . Other way around, know the max fire -> determine the type of mobile fan

1. Detection and notification
2. Responsetime
3. Taveltime
4. Recon and set-up
5. Going to the fire source

QRA

1. HHR curve 1 car
2. Firespread model multiple cars
3. Predictions:
   - smokespread/visibility
   - Temperature/radiation

Questions?

Your Fire Engineered Solutions

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