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Smoke management with Banana Jet® Systems

Summary

- Many misconception about how Jet fans are used for smoke ventilation
- The first 90 seconds Banana Jet ensures much better stratification of the smoke compared to Traditional Jet fans.
- Traditional Jet fans initially fill a significantly larger section of the tunnel down stream of the fire compared to Banana Jet.
- Banana Jet fans can be switched on immediately and do not need a time lag.
- Banana Jet fans can get the air moving more quickly than Traditional Jet fans, helping to reduce the fire size by significantly cooling the fire early on, without additional reduction in visibility.

In general Banana Jet fans are better in smoke ventilation of tunnels

Common misconception about smoke ventilation

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- Jet fans do not, contrary to common believe, transport the smoke. Only 10% of the air volume actually pass through the fan. Jet fans give an impulse to the air column in the tunnel, to get the air moving as a whole.

- The fans closest to the fire (upstream) are in generally not turned on in tunnels or parking garages to avoid turbulent flow of the smoke.

- To get the best smoke profile the fan down stream of the fire should be started first.

- Although a large fire can produce in excess of 100.000 m³/h of smoke, this takes time. For a burning car it typically takes 15 – 20 minutes to reach full fire size.

- In general smoke production is assumed to be a fairly linear function. If for a fire a maximum smoke production of 120.000 m³/h is assumed (2.000 m³/min), then the first minutes will only produce a few hundred m³ of smoke (see next slide).

- In a tunnel section of 100 m length and 8 m width (2 lanes), a fire will typically in 90 seconds produce less than 100 – 300 m³ of smoke. This equates to filling about 25 – 40 cm (!) of the top of the tunnel depending on the cross section type.

Common misconception about smoke ventilation

- The smoke will typically be above the Banana Jet fan outlet but fully within the max. speed profile of a Traditional Jet fan, especially due to the Coanda effect. The speed under the ceiling with TJ is typically 50% above the average air speed.

- All being equal, a Banana Jet system will in general give a more uniform flow since there is no Coanda effect

The first 90 seconds smoke production is fairly small

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Traditional Jet fans create a very different flow profile In a tunnel compared to Banana Jet ®

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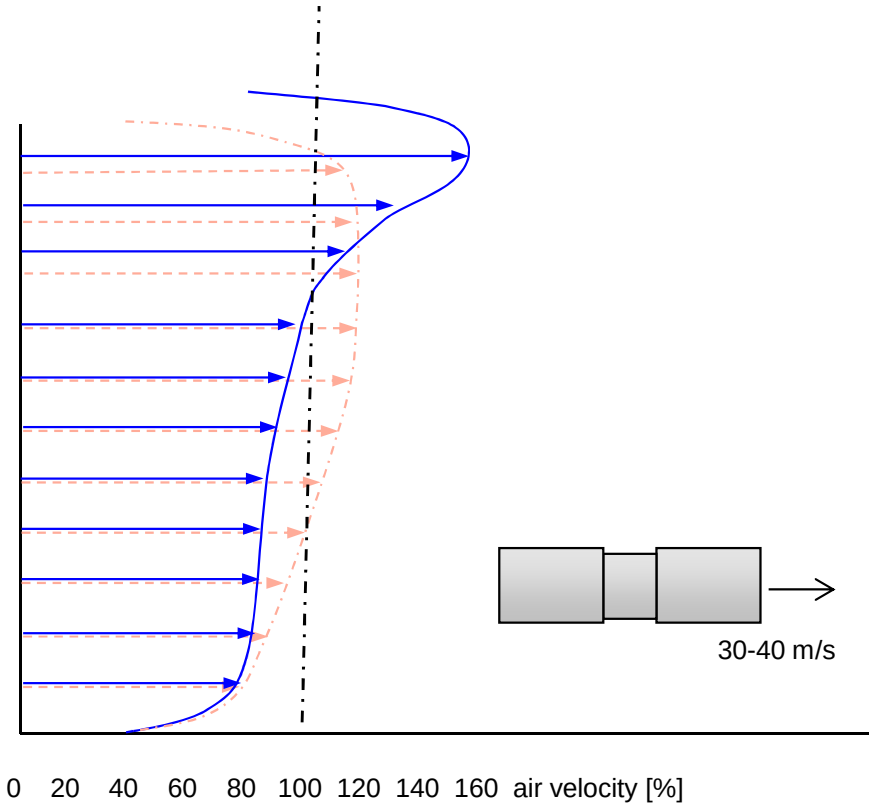
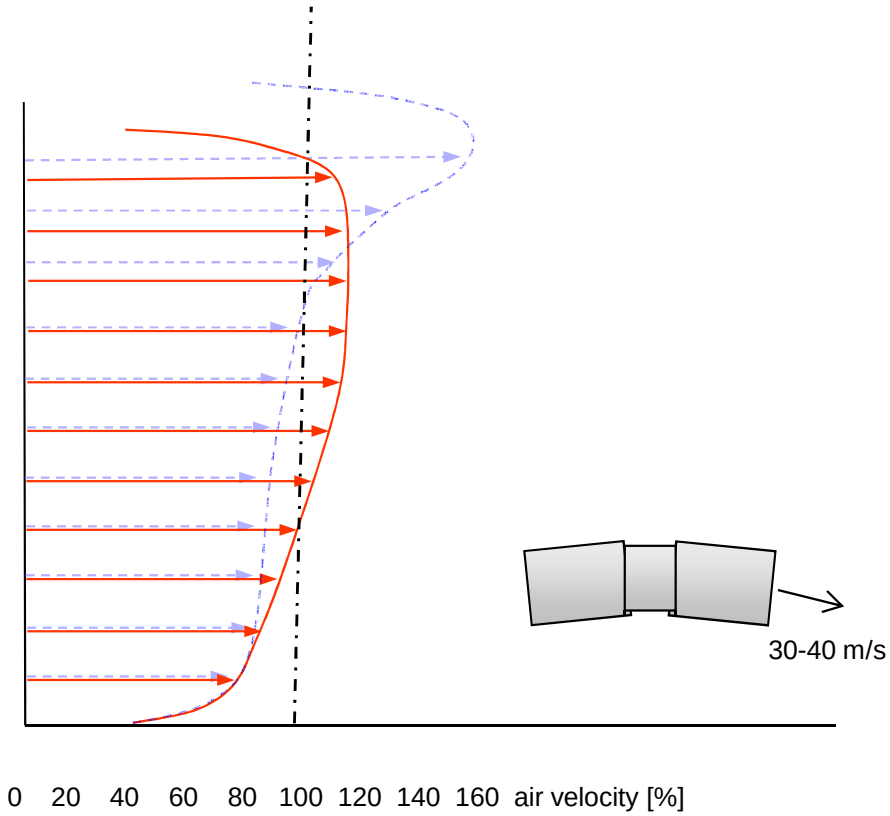
Average flow profiles



Traditional Jet Fan (TJ)



Banana Jet ® (BJ)

Note: Under the ceiling a TJ typically has a 50% high air speed compared to the average and BJ 50% lower.

Traffic Jam Situation

- Cars (traffic jam) in the tunnel with TJ will in general be worse compared to a tunnel with BJ. With BJ the smoke is carried away at high speed over the cars, while the Coanda effect with TJ will force the smoke down along the walls to the cars, were it then remains quite static due to the almost nonexistent air speed there.

The Coanda effect leads the smoke down to the cars

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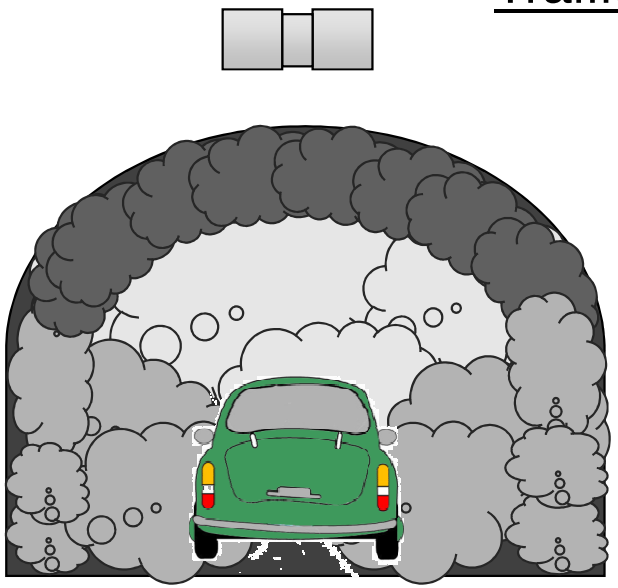
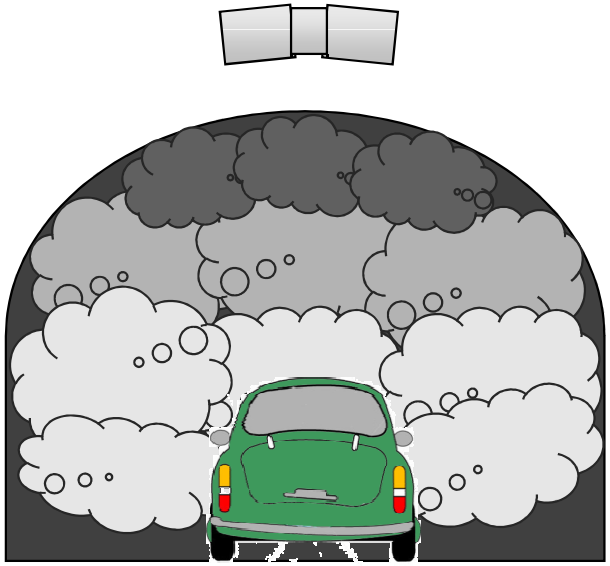
Comparison of smoke development traditional & Banana Jet longitudial ventilation

Illustrative

Traffic jam situation



Traditional Jet Fan (TJ)



Banana Jet ® (BJ)

Assumptions:

- 25 MW fire
- 100.000m^3/h smoke ~ 200m^3/min*
- Smoke propagation: 1 m/s
- Average design speed: 4 m/s

**Value for the first 3 minutes, assuming fire developing at an increasing rate*

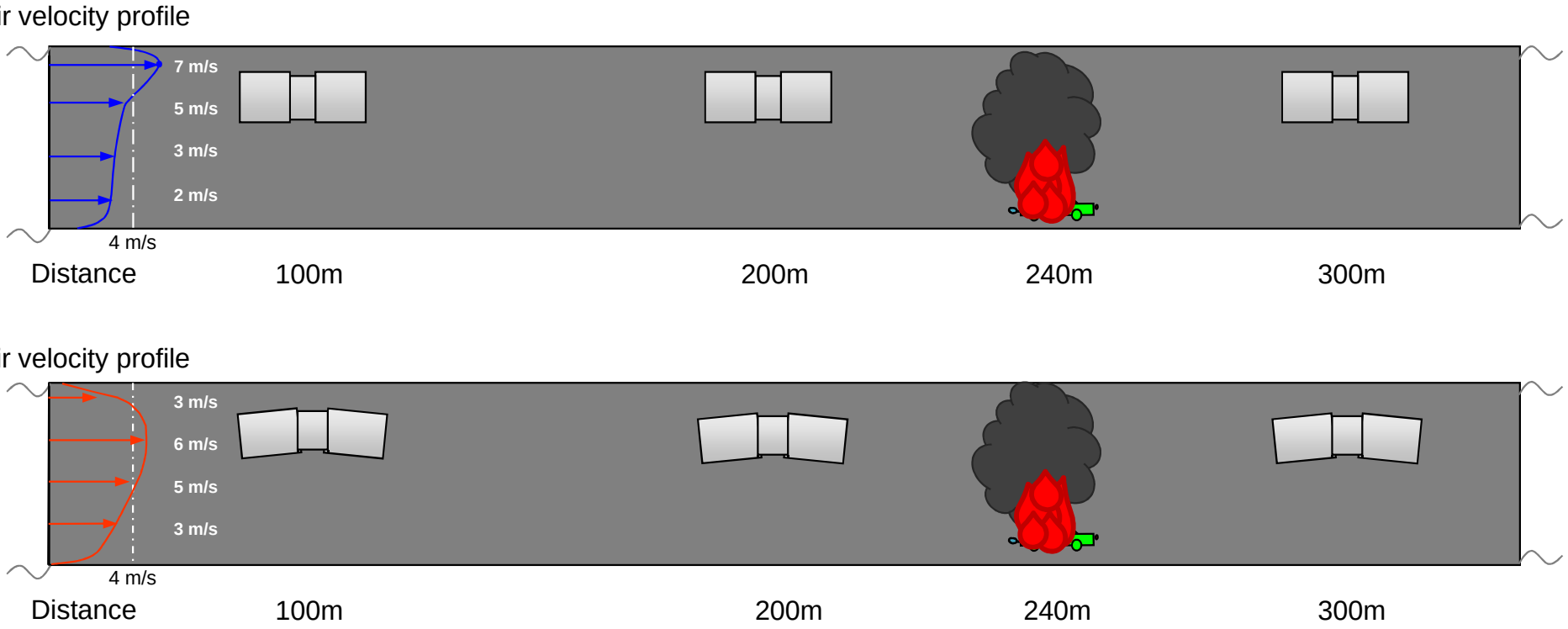
Starting conditions

- The fan(s) nearest to the fire (upstream) are not switched on to avoid turbulence.
- The air speed near the ceiling from TJ is typically 6-8 m/s vs 2-3 m/s for BJ (plus and minus 50% of the target total airflow speed).
- The steady state size of a fire determines the smoke production. It can be safely assumed that the first 1-2 minutes only 100 – 300 m^3 smoke is produced (A vehicle fire normally takes at least 10-20 min. to develop to full size) see previous slide.

Comparison of smoke development traditional & Banana Jet longitudial ventilation

Time = 0 seconds

Illustrative



Assumptions:

- 25 MW fire
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- Smoke propagation: 1 m/s
- Average design speed: 4 m/s

** Value for the first 3 minutes, assuming fire developing at an increasing rate*

Comparison of smoke development traditional & Banana Jet longitudial ventilation

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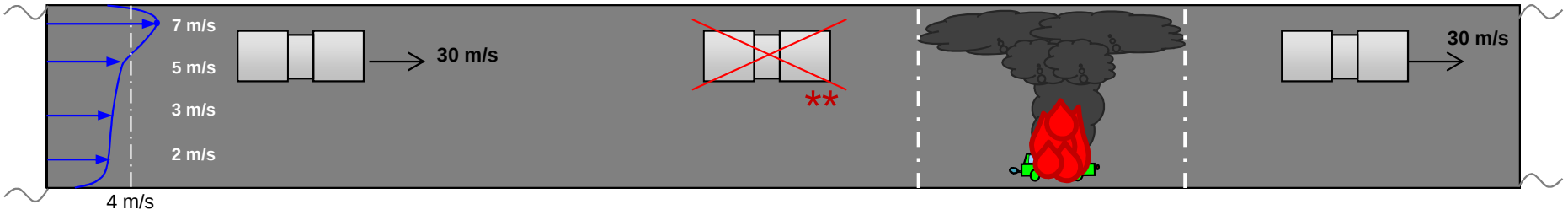
Time = 10 seconds

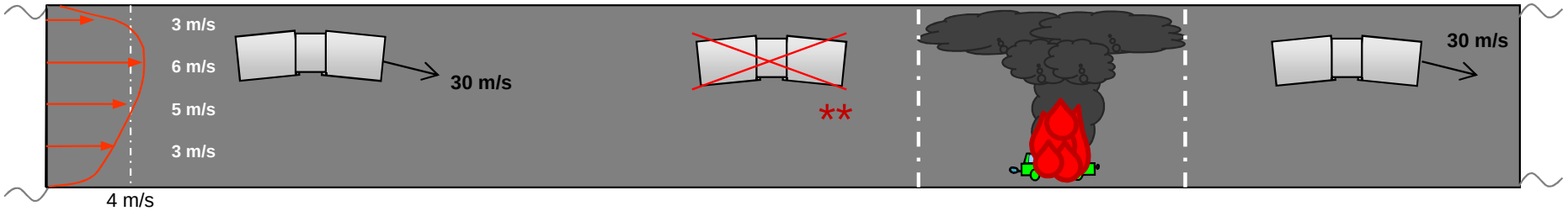
Illustrative

Air velocity profile



Distance 100m 200m 230m 240m 250m 300m

Air velocity profile



Distance 100m 200m 230m 240m 250m 300m

Assumptions:

- 25 MW fire
- 100.000m^3/h smoke ~ 200m^3/min*
- Smoke propagation: 1 m/s
- Average design speed: 4 m/s

**Value for the first 3 minutes, assuming fire developing at an increasing rate*

*** Not turned on*

After 20 seconds

- With a typical average distance of 100 m between fans, the high speed air from TJ will start reaching the smoke below the ceiling over the fire in around 20 seconds. In contrast it takes 50-100 seconds before the low speed air stream from the BJ arrives there.

Comparison of smoke development traditional & Banana Jet longitudial ventilation

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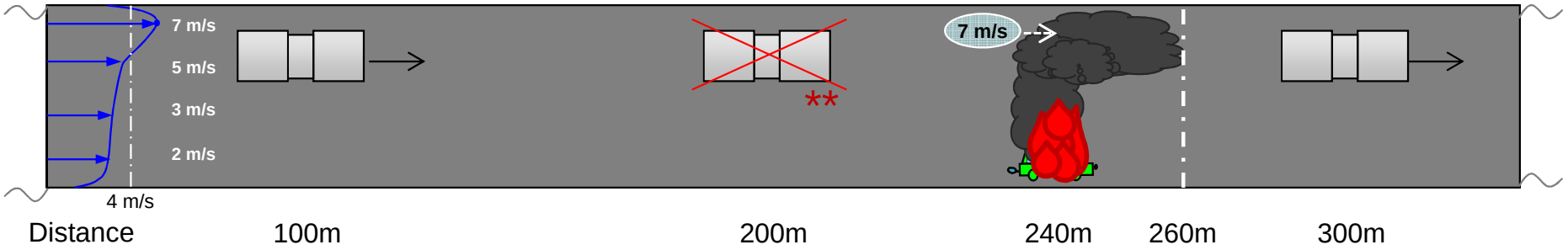
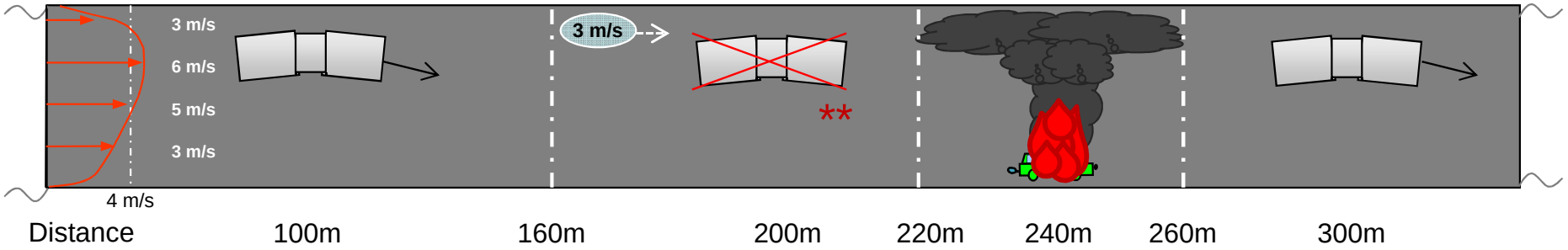
Time = 20 seconds

Illustrative

Air velocity profile



Air velocity profile



Assumptions:

- 25 MW fire
- 100.000m^3/h smoke ~ 200m^3/min*
- Smoke propagation: 1 m/s
- Average design speed: 4 m/s

**Value for the first 3 minutes, assuming fire developing at an increasing rate*

*** Not turned on*

Comparison of smoke development traditional & Banana Jet longitudial ventilation

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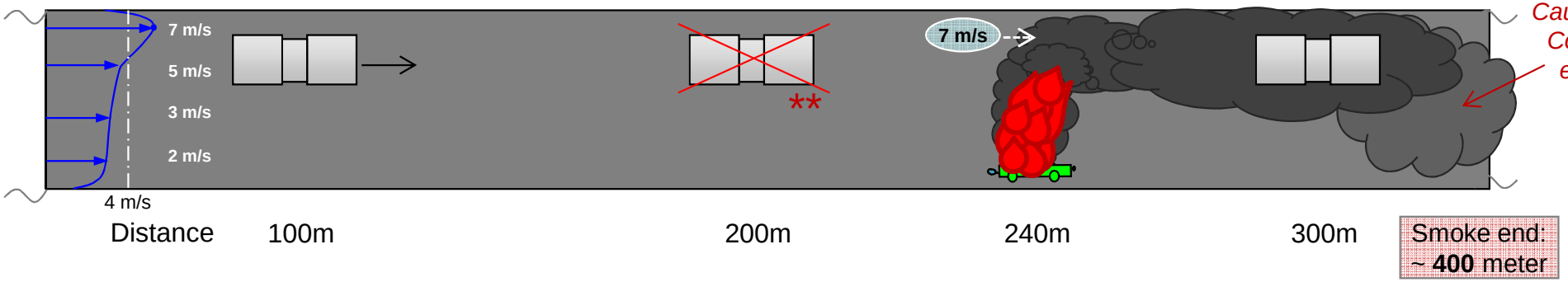
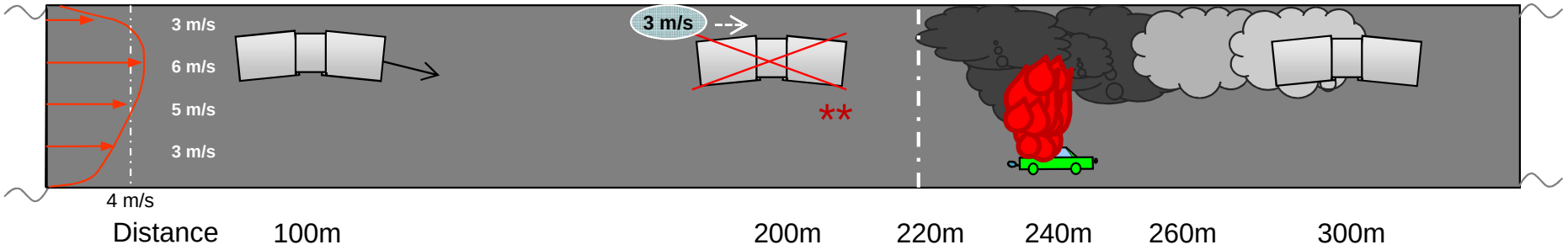
Time = 40 seconds

Illustrative

Air velocity profile



Air velocity profile



Assumptions:

- 25 MW fire
- 100.000m^3/h smoke ~ 200m^3/min*
- Smoke propagation: 1 m/s
- Average design speed: 4 m/s

**Value for the first 3 minutes, assuming fire developing at an increasing rate*

*** Not turned on*

After 60 seconds

- The Coanda effect will force smoke down the walls behind TJ. The smoke down stream is diluted but has reached 300 - 500 m down the tunnel. For BJ the smoke filled area is limited to maybe 60m to each side of the fire.
- The smoke filled air volume will normally not exceed 100 - 300 m^3 i.e. about the top 0,2 - 0,5m of the tunnel with good visibility being maintained.
- The smoke filled tunnel section with TJ fans will at least be 5-10 times larger because the smoke has been pushed further down stream and because of the Coanda effect forcing smoke down along the walls.

Comparison of smoke development traditional & Banana Jet longitudial ventilation

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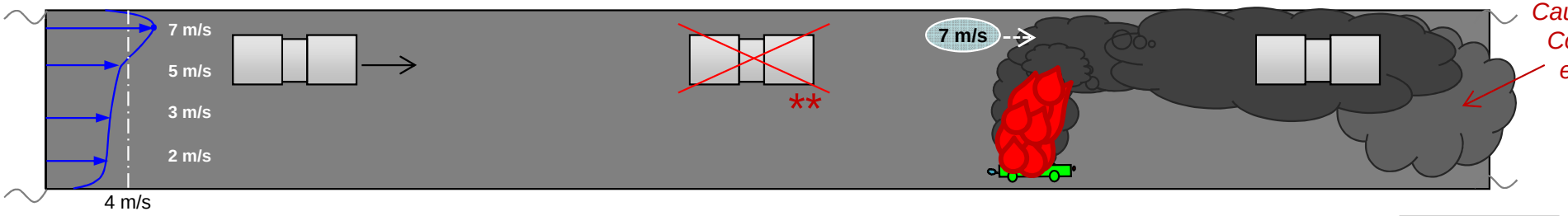
Time = 60 seconds

Illustrative

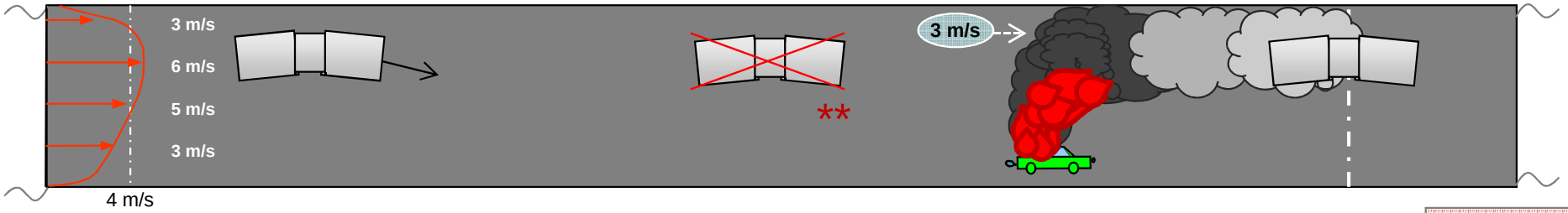
Air velocity profile



Distance 100m 200m 240m 300m

Smoke end: ~ **700** meter

Air velocity profile



Distance 100m 200m 240m 260m 300m

Smoke end: ~ **300** meter

Assumptions:

- 25 MW fire
- 100.000m^3/h smoke ~ 200m^3/min*
- Smoke propagation: 1 m/s
- Average design speed: 4 m/s

**Value for the first 3 minutes, assuming fire developing at an increasing rate*

*** Not turned on*

After 90 seconds

- The whole tunnel with the TJ will be filled at least 700-1000m down stream of the fire.
- With BJ down stream of the fire, the majority of the smoke is under the ceiling. It is being moved along in a laminar flow at 1-2 m/s. The smoke that has cooled and is falling down will be strongly diluted by the faster air speed 2/3 height of the tunnel. Only maybe 500-600m of the tunnel will be seriously smoke filled down stream of the fire.

Steady State

- Since no time lag is required to avoid de-stratification of the smoke BJ can be switched on immediately after detecting the fire.
- The higher air speed above the cars, closer to the fire source, will significantly cool the fire, reducing the amount of smoke produced.

Comparison of smoke development traditional & Banana Jet longitudial ventilation

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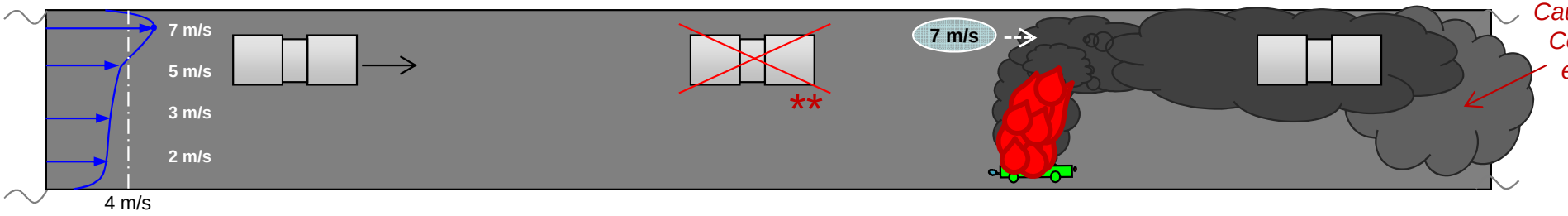
Time = 90 seconds

Illustrative

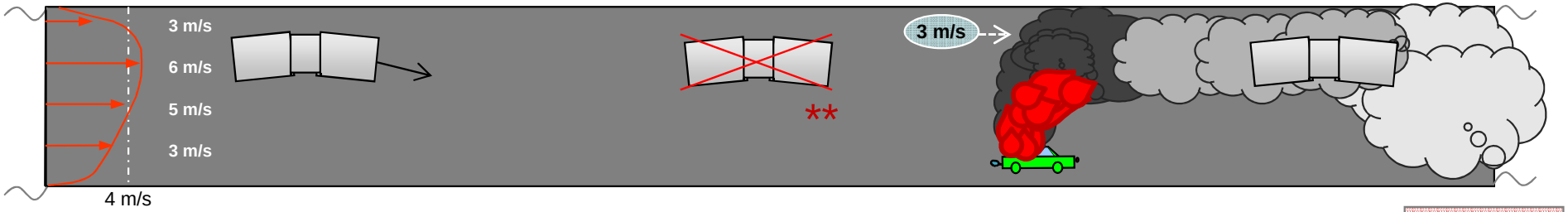
Air velocity profile



Distance 100m 200m 240m 300m

Smoke end: ~ **1000** meter

Air velocity profile



Distance 100m 200m 240m 300m

Smoke end: ~ **400** meter

Assumptions:

- 25 MW fire
- 100.000m^3/h smoke ~ 200m^3/min*
- Smoke propagation: 1 m/s
- Average design speed: 4 m/s

**Value for the first 3 minutes, assuming fire developing at an increasing rate*

*** Not turned on*

Conclusion

- The best strategy of turning on Jet fans seems to be:

  → First turn on the fans down stream of the fire
  → Then turn on the fans up stream furthest away from the fire up stream
  → Avoid to turn on the fans closest to the fire, at least until all other fans are running

- BJ creates a better flow profile and will be better and longer able to keep the smoke stratified if the fire creates stratified smoke layers.

- TJ fans will in general be quicker in filling the tunnel with smoke and due to Coanda effect let it remain amongst the stopped cars.

In general Banana Jet fans are better in smoke ventilation of tunnels