LIFE SAFETY

EUROPEAN REGION

(F.CORSANEGO)

CFS Technical Review - March 2012

OBJECTIVES FOR THIS PRESENTATION:

To highlight a few aspects of the EU regulatory framework;

To understand the lessons learned during major tunnel fire accidents of the last decade, and how this influenced the EU regulation;

to understand how ILC project could benefit from detailed fire scenario assessment, in order to obtain Host States approval for construction.

EUROPEAN REGION, WHAT DOES THIS MEAN?

- EU does not have a uniform building code, (or a code for building underground research facilities…); this falls primarily in the competence of Member States. EU has only a complementary role. *(Ref.: question n.854/98 to the Commission, J.Off. C013 18.01.1999)*
- EU safety regulation is aimed to create a barrier-free space for circulation of people and development of economy with low level of risk;

- EU regulation is complementary to the national regulation, and typically associated to a notion of circulation:
  - for products (i.e. construction materials);
  - for services (i.e. electric networks);
  - for workers and multinational enterprises (i.e. workplace directives);
  - for citizens (i.e. road and railways tunnels).
- A detailed presentation on main safety aspects in the EU zone was given in EDR kick off meeting 3 of 5/09/2007.
- Here a few points of that talk are developed further

What are the main design tools?

Directive 89/391 - OSH "Framework Directive" of 12 June 1989

on measures to encourage improvements in the safety and health of workers at work

It states the general workers safety principles (next slide), and responsibilities for all the actors

Several other directives have been written under this framework:

- Directive 89/654/EEC - workplace requirements
- Dozens of other directives on various occupational safety aspects: http://osha.europa.eu/en/legislation/directives

The general principles of prevention listed in the directive **89/391** are:

- **avoiding risks**
- **evaluating the risks**
- **combating the risks at source**
- **adapting the work to the individual**
- **adapting to technical progress**
- **replacing the dangerous by the non- or the less dangerous**
- **developing a coherent overall prevention policy**
- **prioritizing collective protective measures (over individual protective measures)**
- **giving appropriate instructions to the workers**

Relevant Safety Regulation

Directive 2004/54 EC on minimum Safety Requirements for tunnels in the Trans-Europe network:

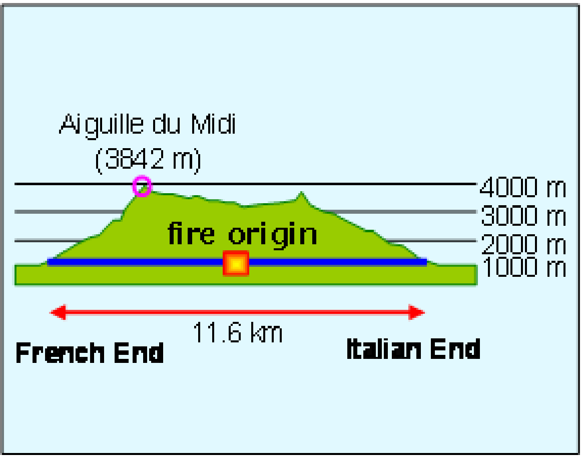
- Issued by EU Commission as consequence of many severe tunnels fires, like the Mont Blanc and Tauern ones;
- applies to tunnels longer than 5 km (3 mi).

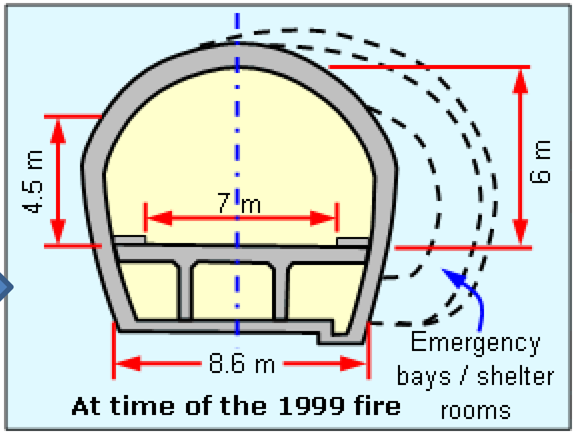
- This directive applies to road tunnels (high fire loads), but the accident dynamic contain important lesson learned for all kind of long tunnels.

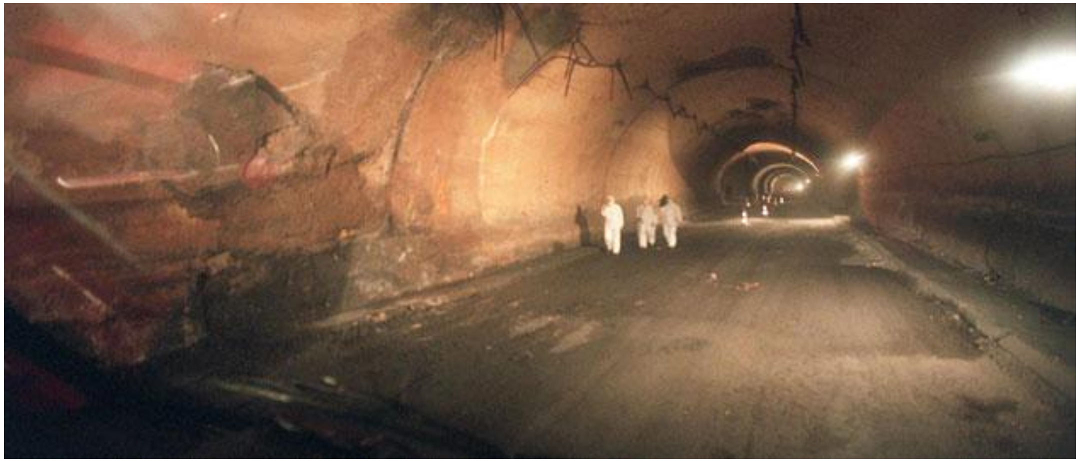
- We will look at three cases:
  - Mont Blanc;
  - Tauern;
  - Gotthard.

Mont Blanc tunnel - 24 March 1999 - 39 fatalities

- Two ways tunnel –Heavy Goods Vehicle took fire (300MW)
- Fire lasted 53 hours







- The tunnel has a semi-transversal ventilation scheme:
  - Fresh air longitudinal flow in the road way (reversible), and
  - vault smoke extractors with ducts under the road floor

Mont Blanc Accident facts

- Smoke could not be extracted via the vault extractors, and was directed in the road tunnel, towards the French side;

- all the victims were found in the 5 km downwind of the smoke;

- Some of the victims were found in the fire cubicles;
- The fire crews attacking from France could not advance; they took refuge in two of the emergency fire cubicles (fire-door sealed small rooms set into the walls every 600 metres)..
- ..they were rescued five hours later by a third fire crew that reached them via a ventilation duct; of the 15 firefighters that had been trapped, 14 were in serious condition and one (their commanding officer) died in the hospital.

Mont Blanc - lessons learned

- Fire was much larger than predicted;
- Ventilation was mismanaged;
- Ventilation system was complex, with no monitoring of the fire evolution and no real feedback on the effects of each maneuver,
- Scarce capacity to concentrate smoke extraction power right over the fire;

Mont Blanc - lessons learned 2

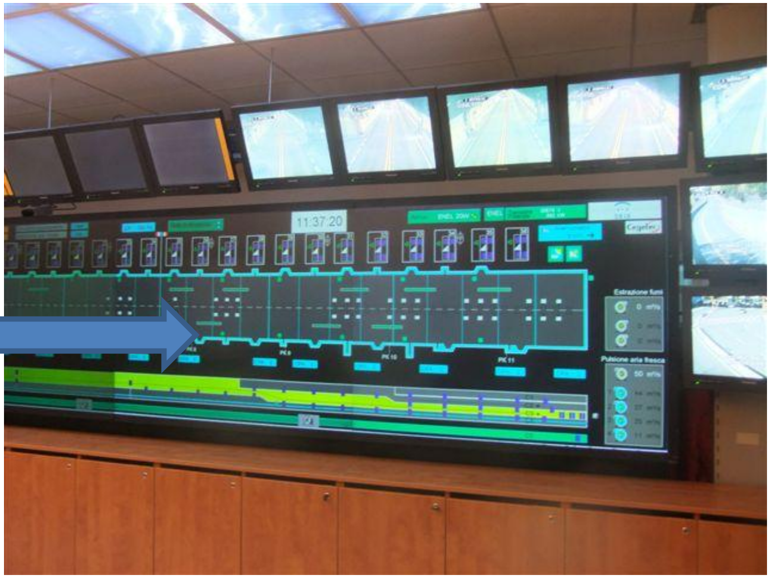
- There was not a realistic « plan b » to rescue people in case of loss of control of the smoke flow

Mont Blanc - modifications

The tunnel underwent major changes in the three years it remained closed after the fire.

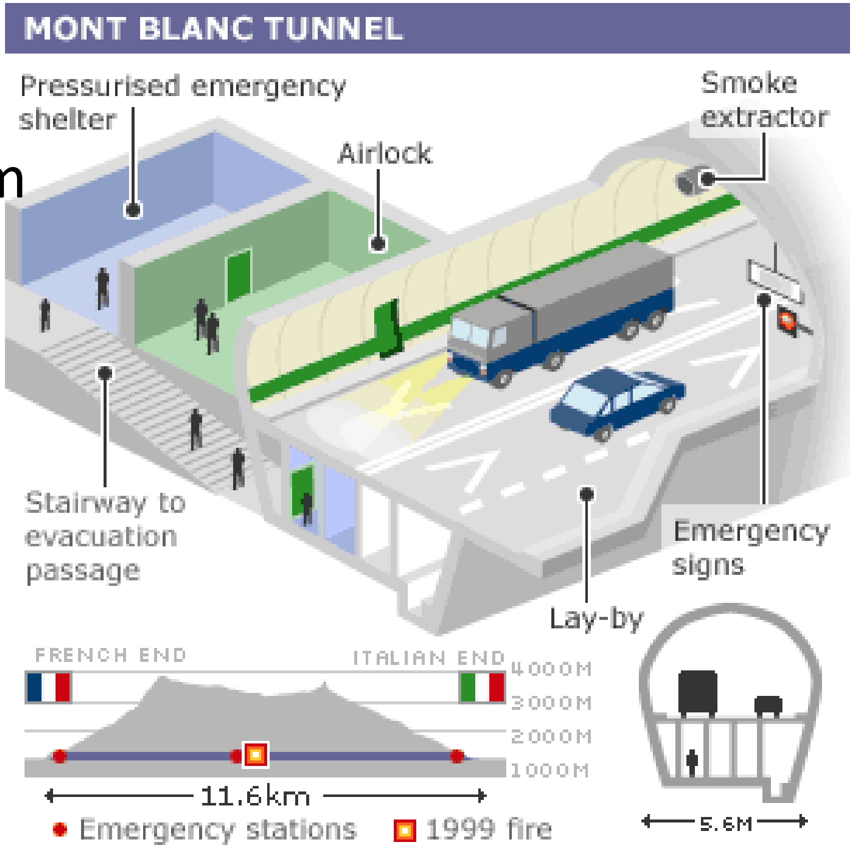
Renovations include computerized detection equipment, extra security bays, and a fire station in the middle of the tunnel complete with double cabbed fire trucks.

In case of fire, « one button reconfiguration » of dozens of boosters and ventilation dampers!



The safety shafts now also have clean oxygen flowing through them via air vents, and a parallel escape tunnel.

Any people in the security bays now have video contact with the control centre, so they can communicate and inform them about what is happening in the tunnel more clearly.



Tauern tunnel 29 May 1999-

- Austria, A10 Salzburg-Villach -6.4 km long
- 12 fatalities
- Collision between vehicles followed by fire, in a work-in-progress area
- 300-400MW fire
- Fire lasted for 14 hours, impossible to access

Tauern tunnel description

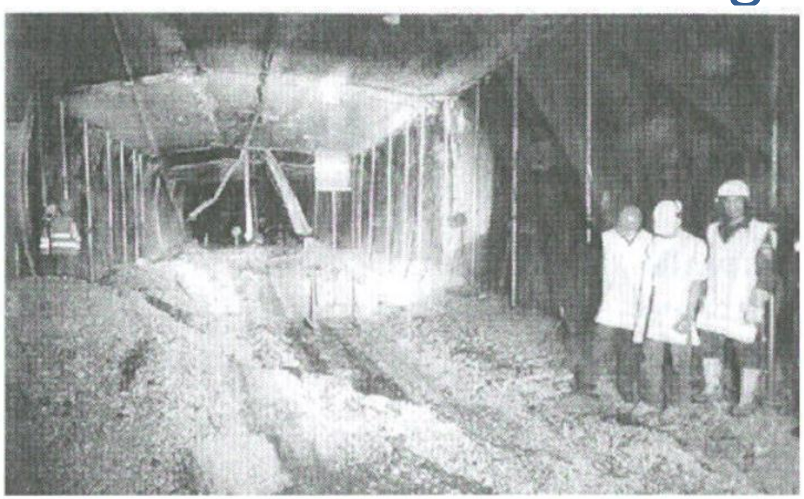
- Ventilation transversal subdivided in 4 sections, two controlled by stations at each exit, and two by a median vertical shaft;
- A new parallel tunnel was in construction at the time of the accident;
- Shelters are connected via an emergency gallery.

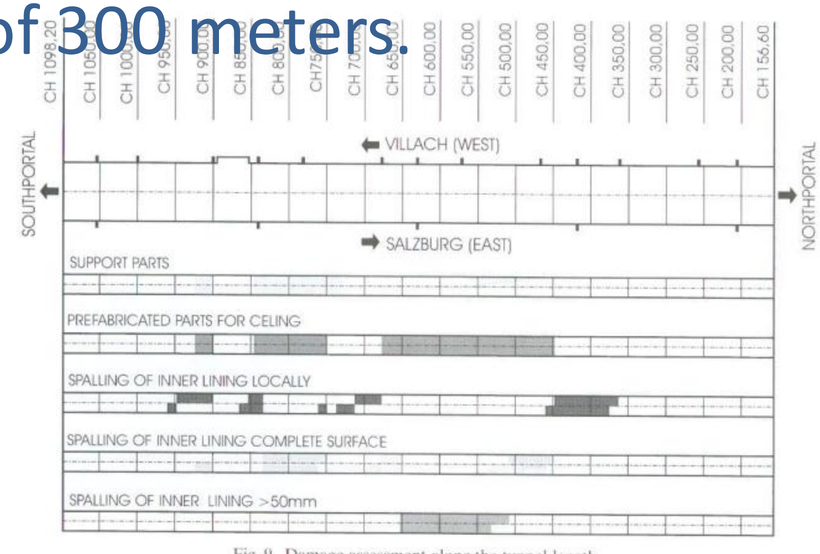
Tauern accident facts

- Ventilation failed to control the fire, there was an unwanted longitudinal flow along 2 km;
- Due to heat, fire brigade could not access the burning site;
- 30 minutes after fire, the flashover obliged fire brigade to leave the tunnel;
- they could re-enter only 5 hours later;
- 2 people were saved by fire brigade in one of the niches.

Tauern - structure damage

- Ceiling of the ventilation duct collapsed on a length of 6 meters;
- 500 cubic meters of spalled concrete had to be removed
- Tunnel walls and ceiling to be completely demolished and rebuilt over a lenght of 300 meters.





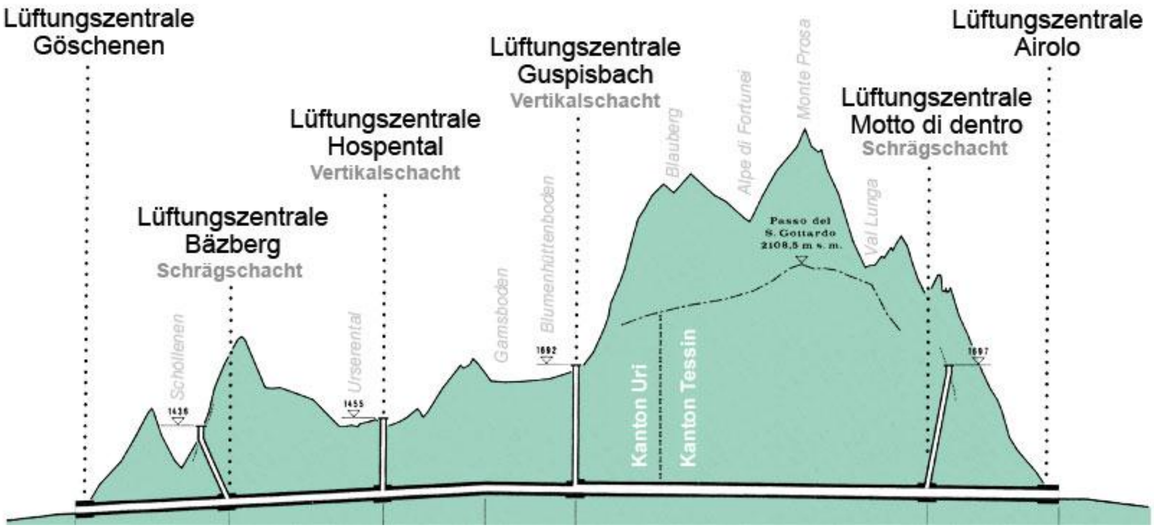
Tauern Tunnel, modifications after the fire

- After the fire, a compressed air system to create positive pressure in the shelters was added;
- 136 exhaust air blinds were added to concentrate full extraction power right over the fire.

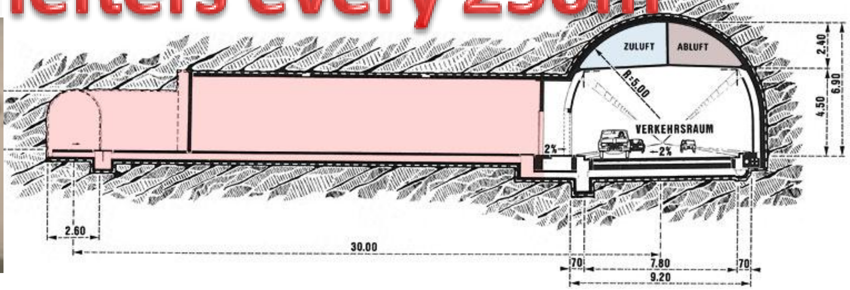
Gotthard 24 October 2001-

- 17 km long- 2 vehicles collided - HGV fire
- 11 fatalities, 200MW fire, lasted for 24 hours
- Flames spread over 300m

Gotthard tunnel, profile and shelters



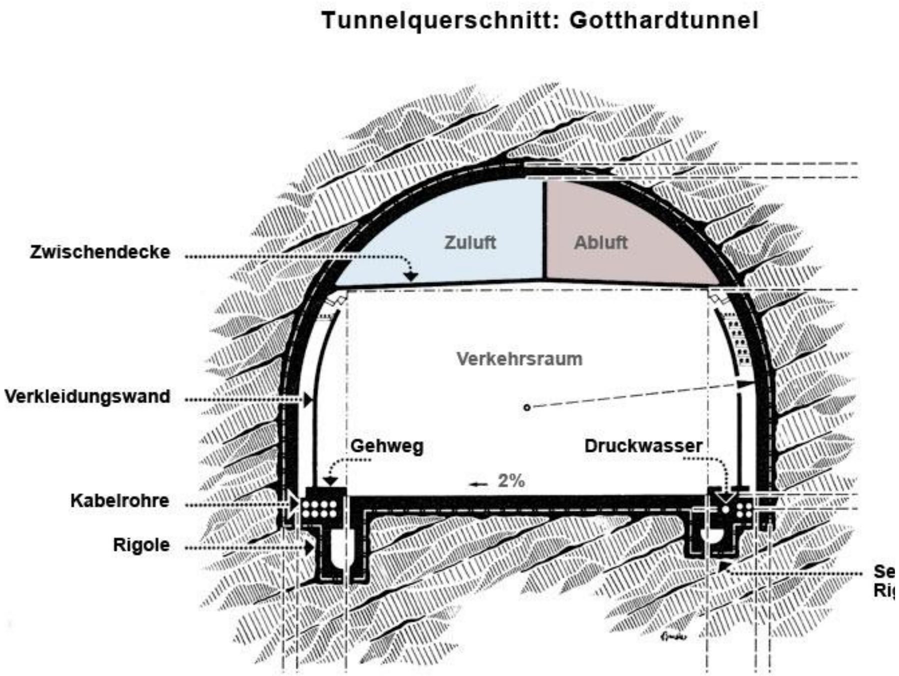
shelters every 250m



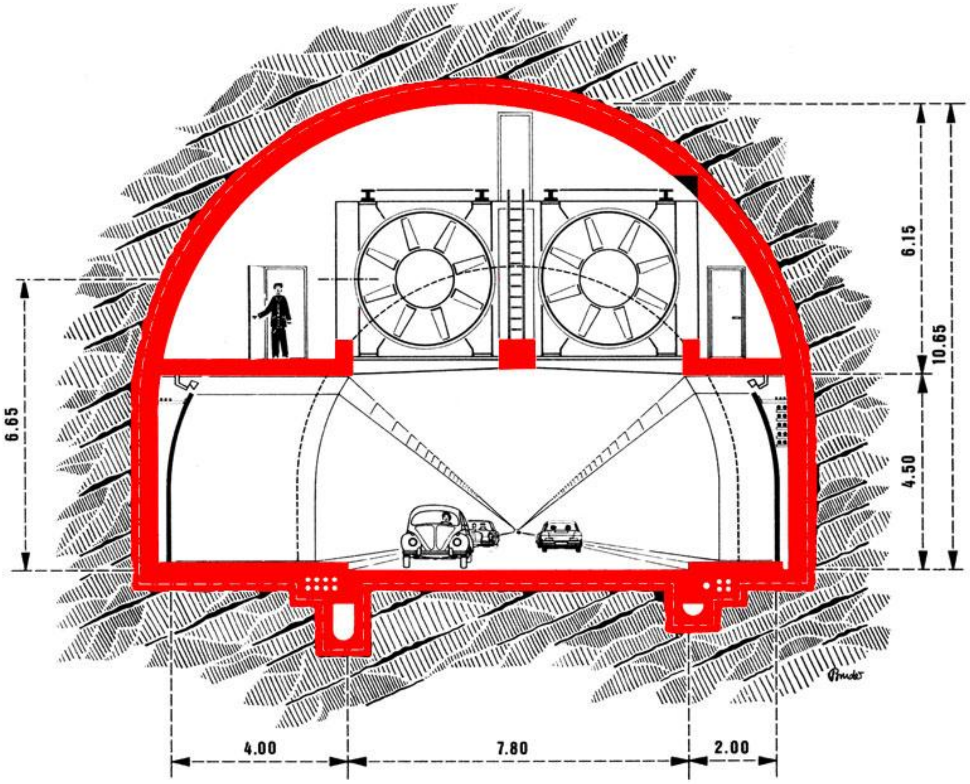
Evacuation gallery

Gotthard tunnel sections

Standard section



Ventilation station section

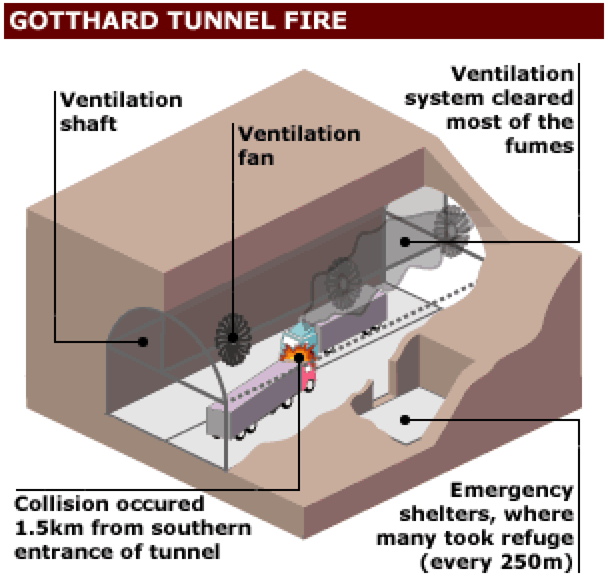


Gotthard tunnel fire

Thick black smoke flowing from an intermediate shaft

upwind of the fire

- Shelters every 250m, linked to an emergency tunnel, could evacuate most of the users



Gotthard fire, facts

- Ventilation failed to contrast longitudinal flow;
- Fresh air supply from the ground was not reduced in the area of the fire;
- the availability of an emergency gallery played a significant role in the self-evacuation of the users;
- 3 Victims walked 200 m, failing to find or open emergency doors.

Gotthard: Ceiling collapsed on a length of 250m

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Gotthard: Smoke damage extended downwind for over 2 km

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Table of main tunnels fires from 1999 to 2005

Accident, year	Vehicle type	Tunnel cross -section (m2)	Estimated Etot (GJ)	Estimated peak HRR (MW)	Estimated time to peak HRR	Estimated fire duration	Number of fatalities
Road tunnels							
Channel tunnel, 1996	10 HGV	**45**	**2200**	**370**	**1 h**	**2.5 (3.4) h**	**0**
Mont Blanc, 1999	15 HGV, 9 cars *	**50**	**5000-7000**	**300-380**	**2-3 h**	**9-13 h**	**39**
Tauern, 1999	16 HGV, 24 cars	**45**	**4000-4500**	**300-400**	**2-3 h**	**7-10 h**	**12**
St Gotthard, 2001	13 HGV, 10 cars	**41**	**-**	**>200**	**-**	**3-4**	**11**
Frejus tunnel, 2005	4 HGV, 3 fire fighting vehicles	**50**	**-**	**>200**	**-**	**<6**	**2**

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EU Directive 2004/54 conclusion

1

- Need to establish a tunnel manager for each tunnel infrastructure

2

- Tunnel manager has to request and obtain authorization from the national AHJ
- Procedures have to supported by risk analysis made with standard methodology

3

- Standard methodology can recur to Computer Fluid Dynamic studies to assess the different fire scenario and response
- This approach is perfectly coherent also with the directive 89/361 on workplace safety

LESSON LEARNED for us

- It is very difficult to asses the scenario in a tunnel. It is difficult to predict if and where a fire will stop, and how much heat it will release. This holds true for any tunnel, not only road.
- Many road tunnel designers failed to consider occasionally large fire loads, and longitudinal item-to item fire propagation.
- Design has to be very conservative.

- The two key points are
  - powerful smoke control;
  - separate evacuation of the occupants not depending from the success of smoke control or of fire brigade rescue.

- Smoke extraction has a very small “payload” (extraction rate vs. amount of excavated rock to house the ducts);
- Smoke extraction power is “precious” and should be concentrated only in the critical 20-30 meters right above the fire;
- Smoke extraction control should be configured to seek and extract right over the fire by clicking just “one button” to find the fire;
- Systems have to be dimensioned with safety margins over the real fire power, otherwise the extra heat and smoke will superimpose a longitudinal flow with catastrophic consequences

Annex II of the directive

- Contains requirements for road tunnels, like:
- Shelters or bypass every 500m, connected with gallery allowing to reach the outside
- Communication systems,
- Handling of ventilation,
- Etc.

Evaluation of scenarii

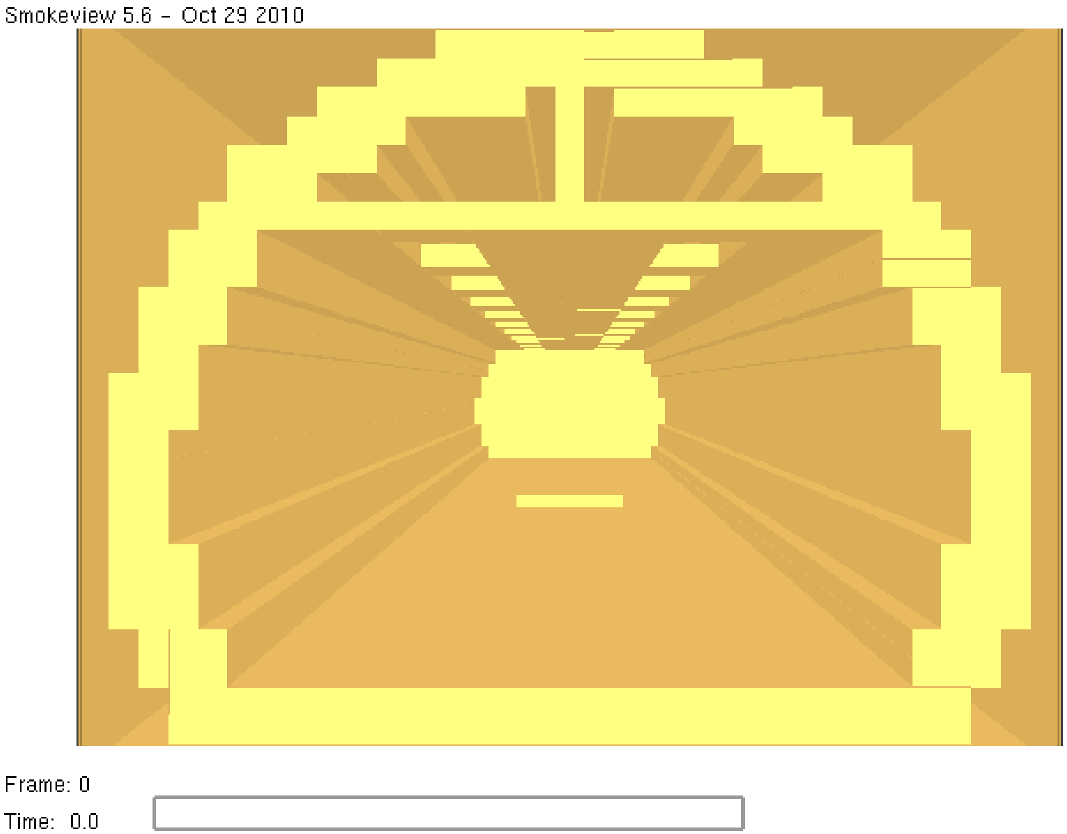
- Computer aided fire simulation
- Allows to estimate the impact of fire on the structures ,and on the ventilation system

Objectives of fire protection during an accident

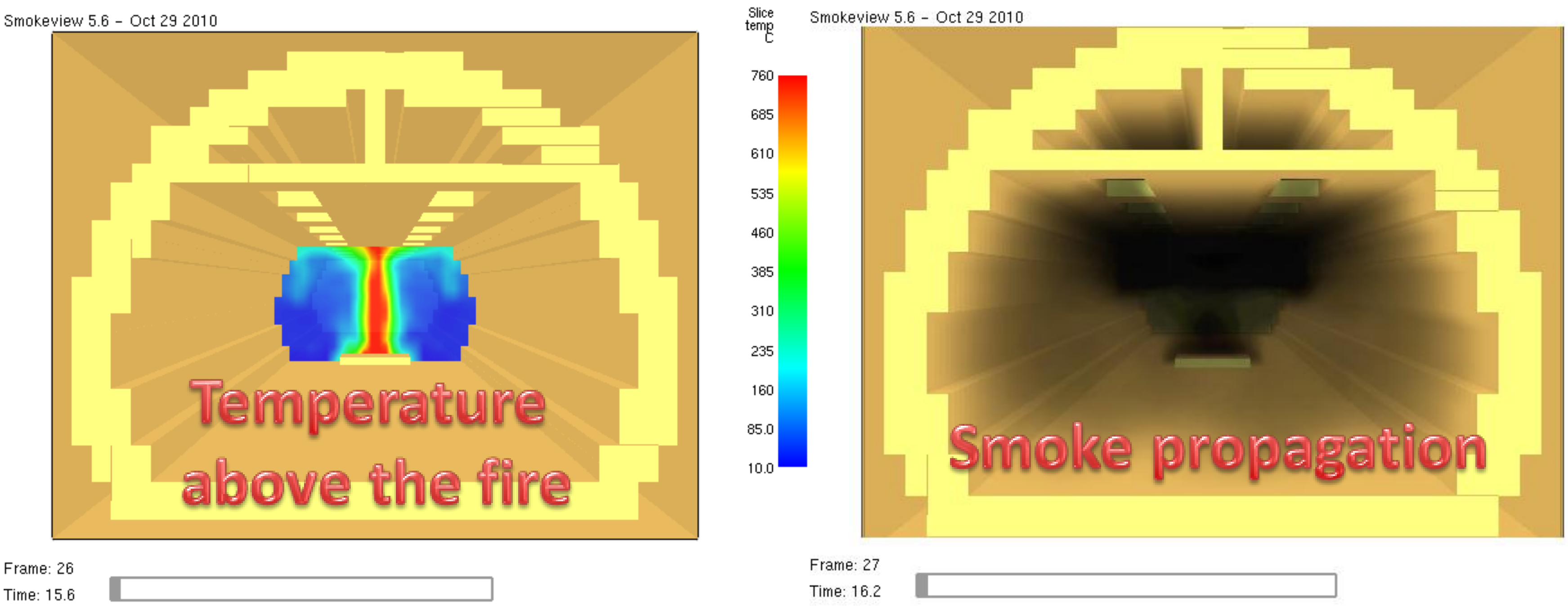
- smoke to be managed by ventilation;
- People to have time to reach a safe area in tenable conditions;
- Thermal conditions low enough to allow fire brigade to be able to reach the spot;
- Soot Damage to be limited;
- Structural damage (collapses) to be limited;
- Environmental pollution to be limited;

Fire Scenario modelization

- First trials on a 1MW fire in a typical ILC 5.2m section
- (exploration of the concept)

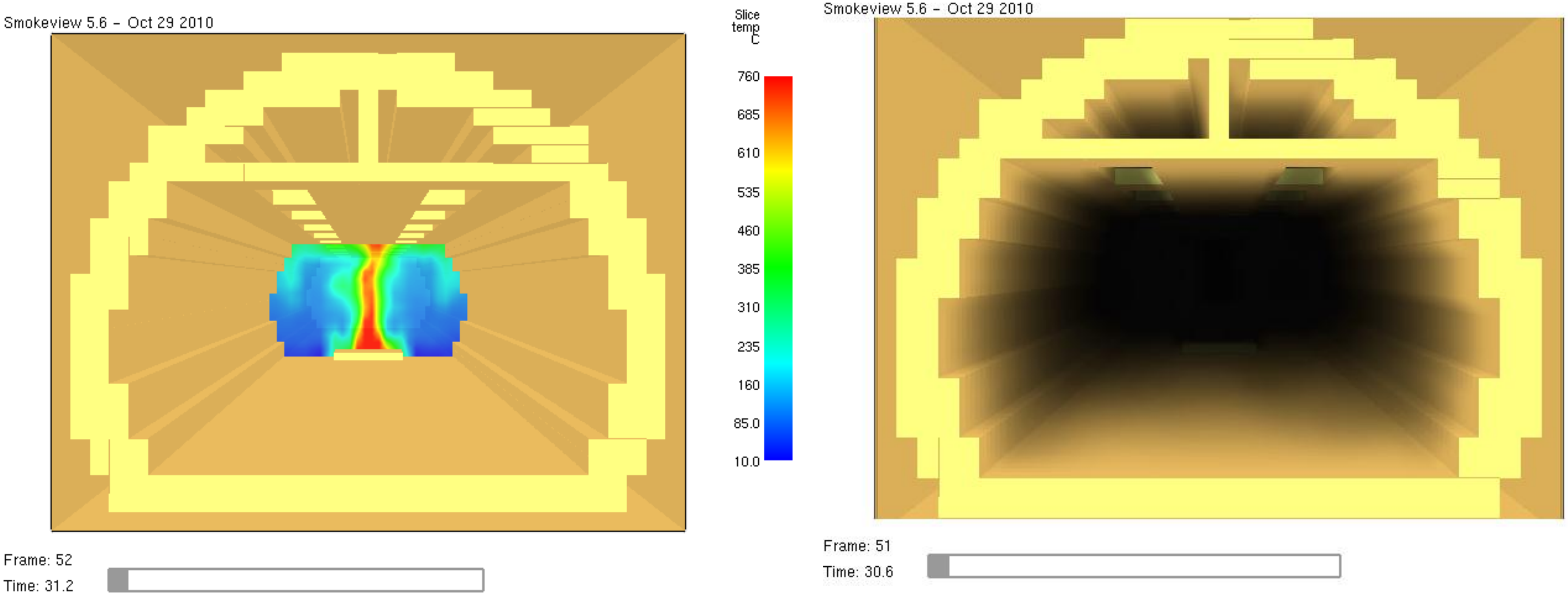


15’’



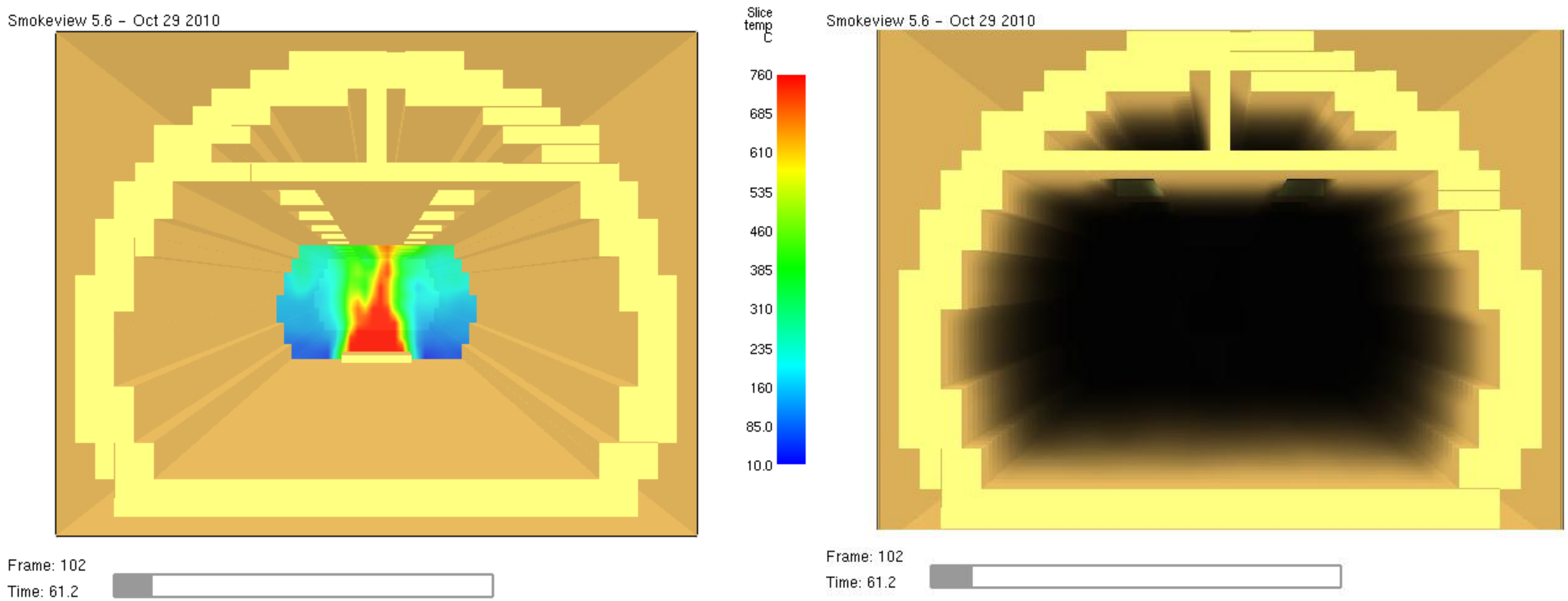
- This is a first test made just to demonstrate the applicability of CFD to fire scenarios validation

30”



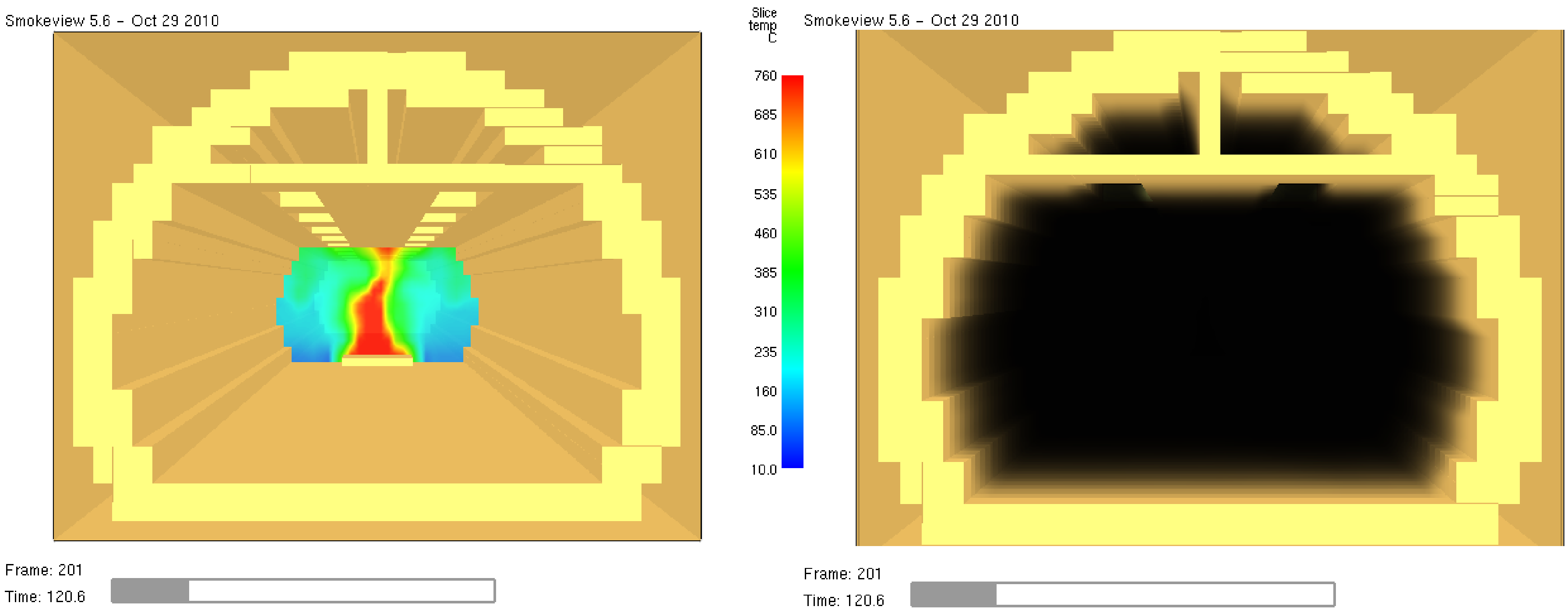
- Heat release has to be introduced as hypothesis based on experimental data on cables and component combustion

60”



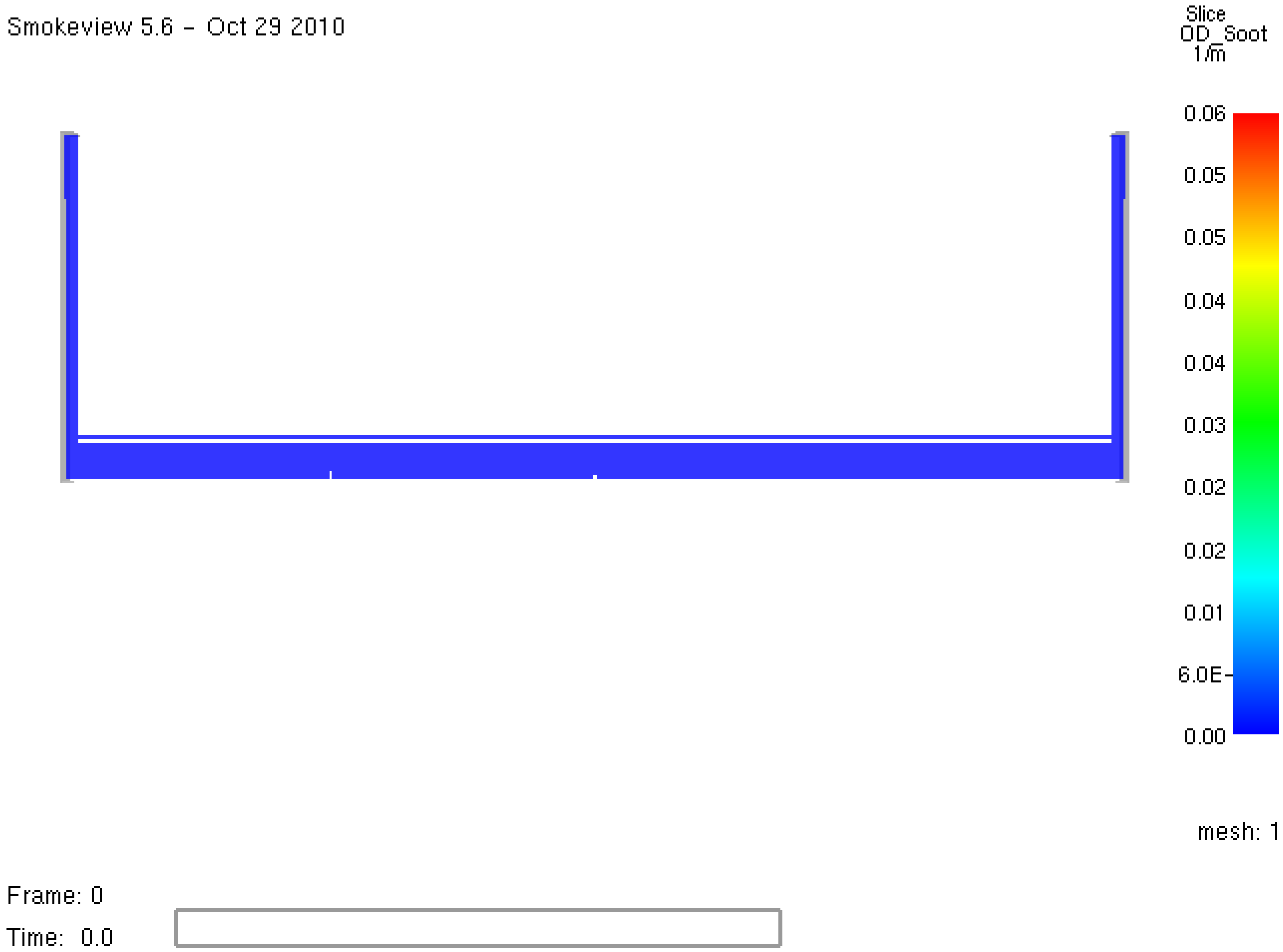
- As output we obtain: volume of smoke produced, temperatures of the smoke, pressure, temperature of the wall, and all that we might want to define smoke extraction volumetric and thermic needs.

120''

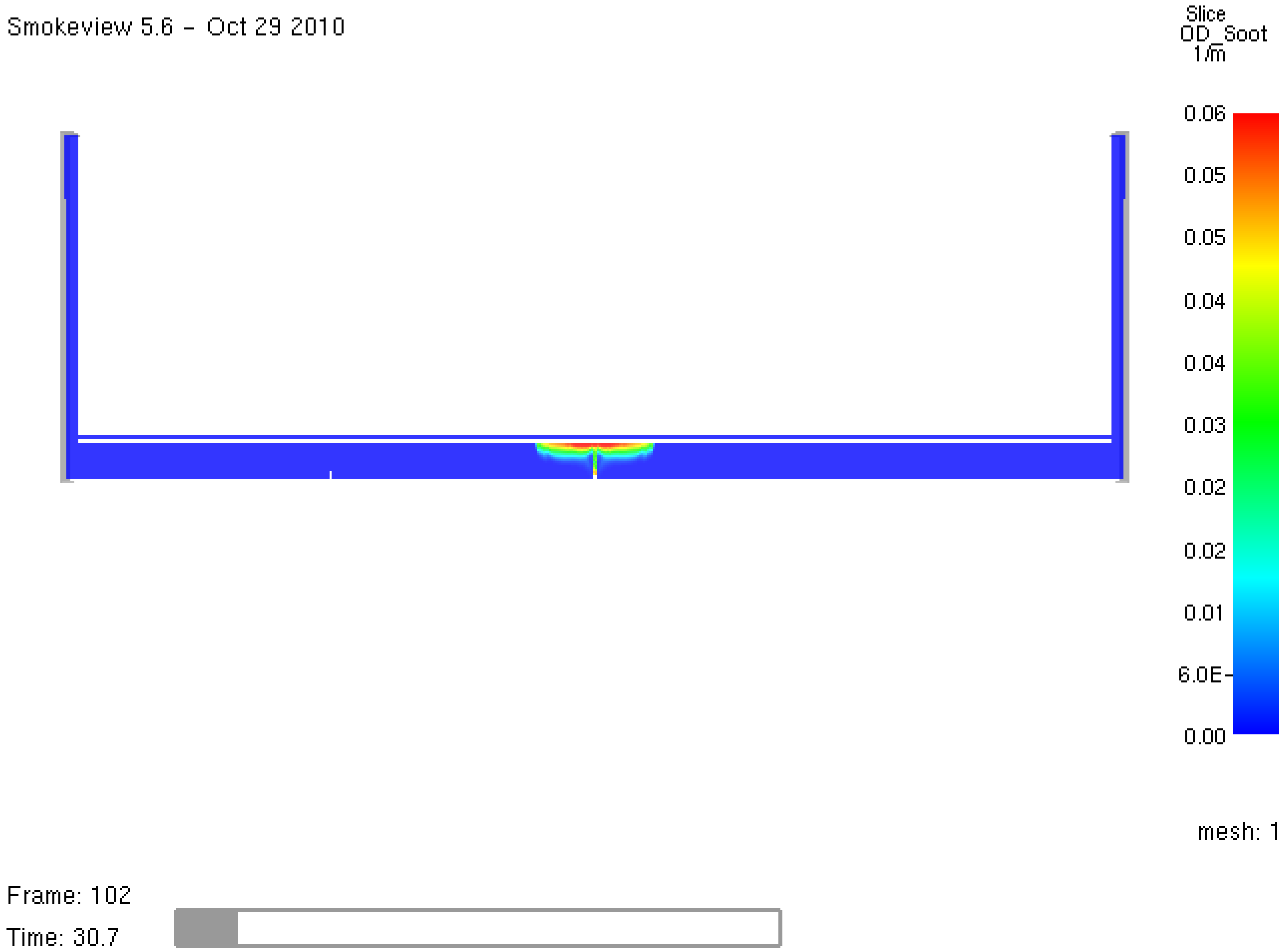


There are many scenarios simulations to do in the near future to cover different fire sizes, location, and ventilation hypotheses.

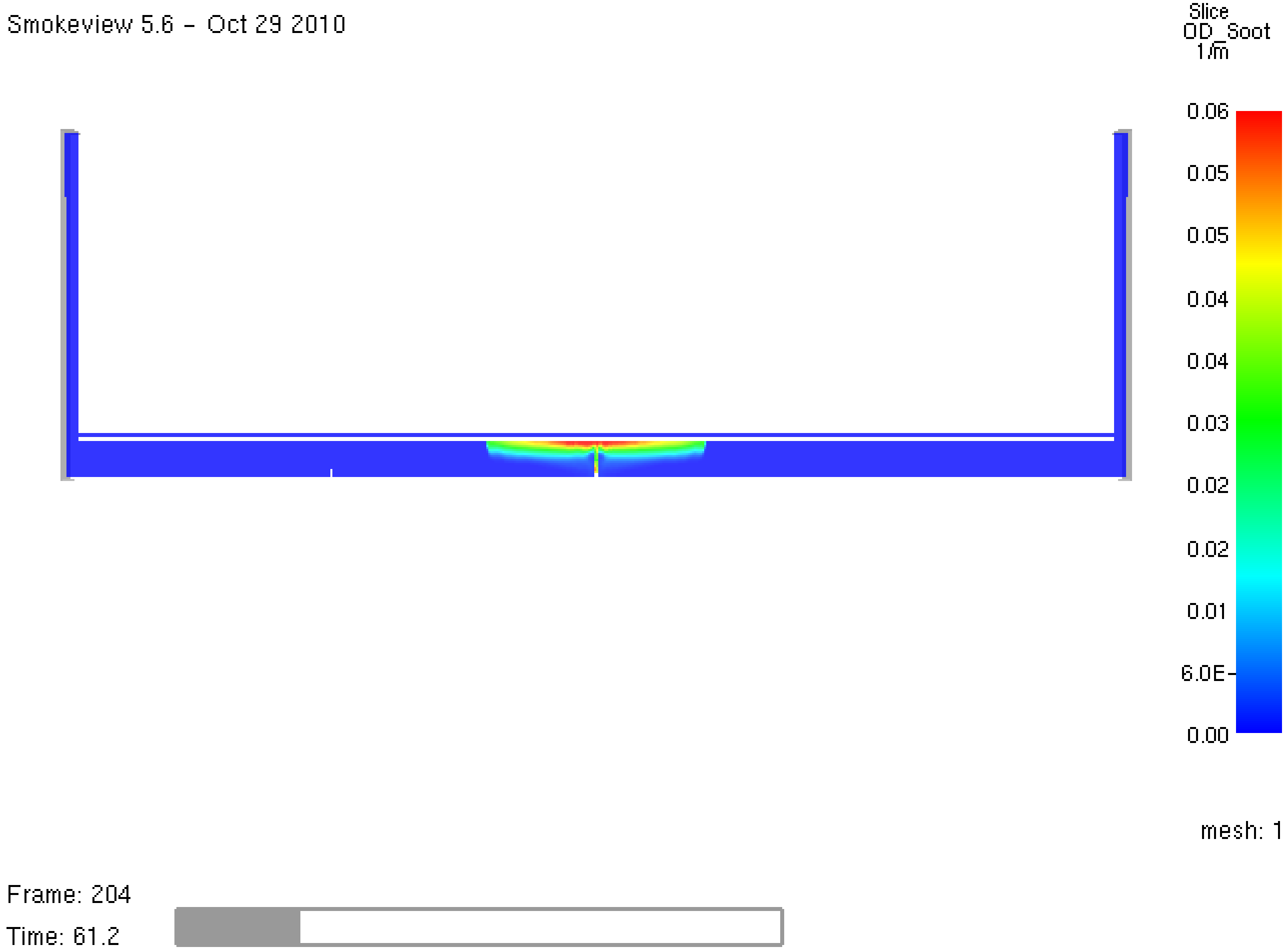
Propagation of smoke along a Ø6m horizontal tunnel section (HRR 1MW= 4 racks, scale length =800m)



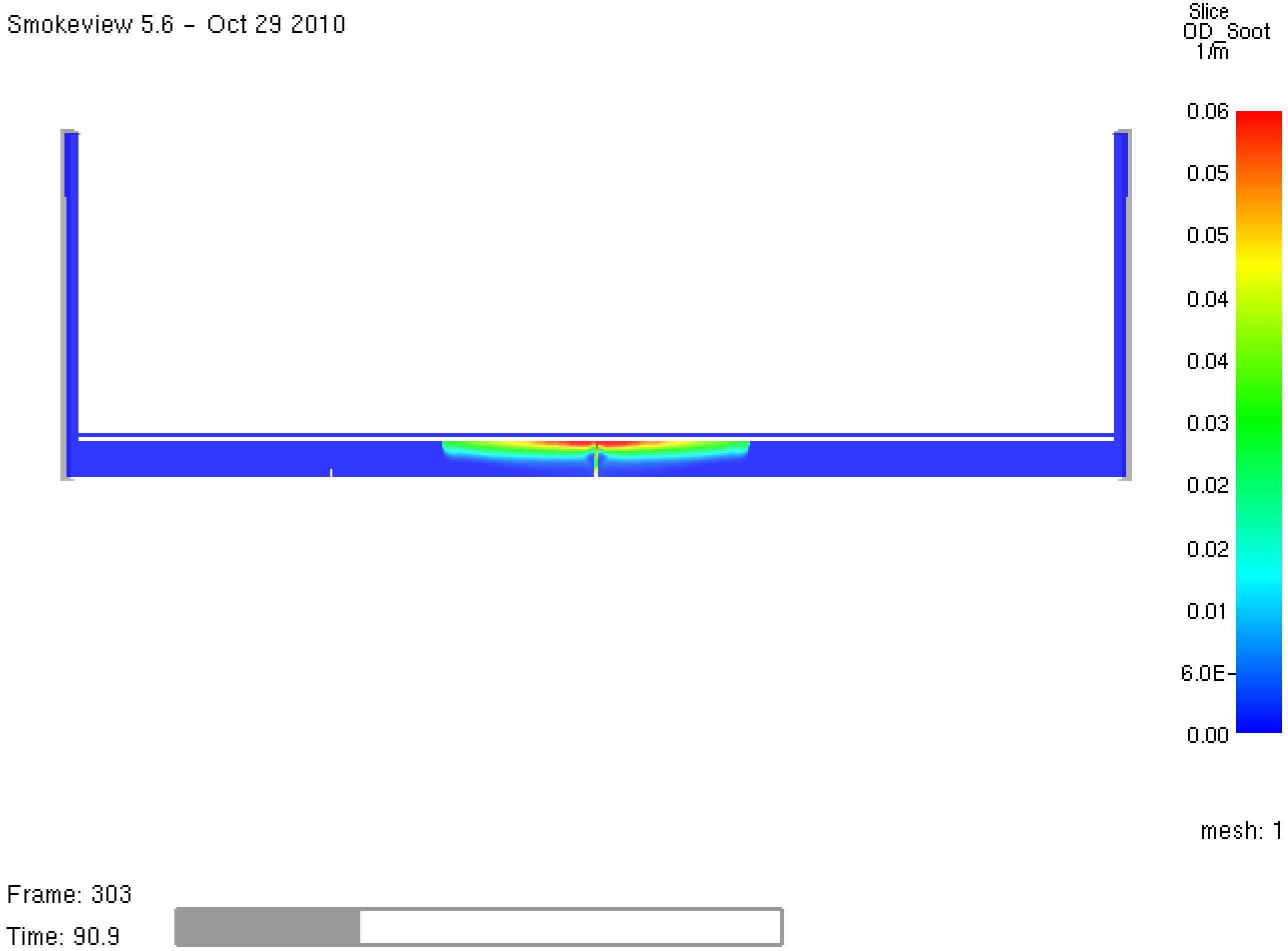
Smoke plume rises to the ceiling

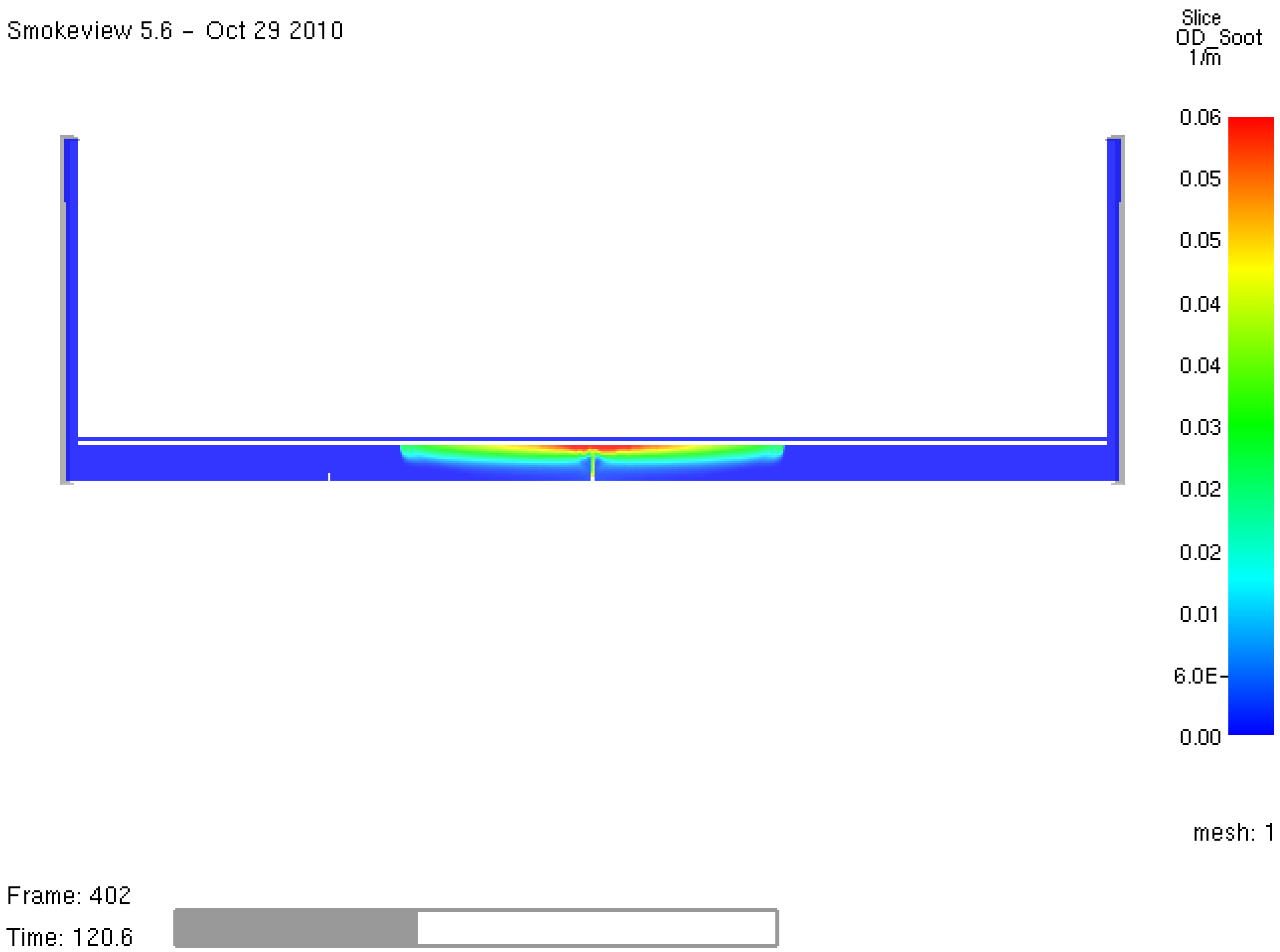


…then it bents and deviates on both sides



..and travels with a velocity proportional to the HRR, and to the vicinity to fire




Smokeview 5.6 - Oct 29 2010
Slice
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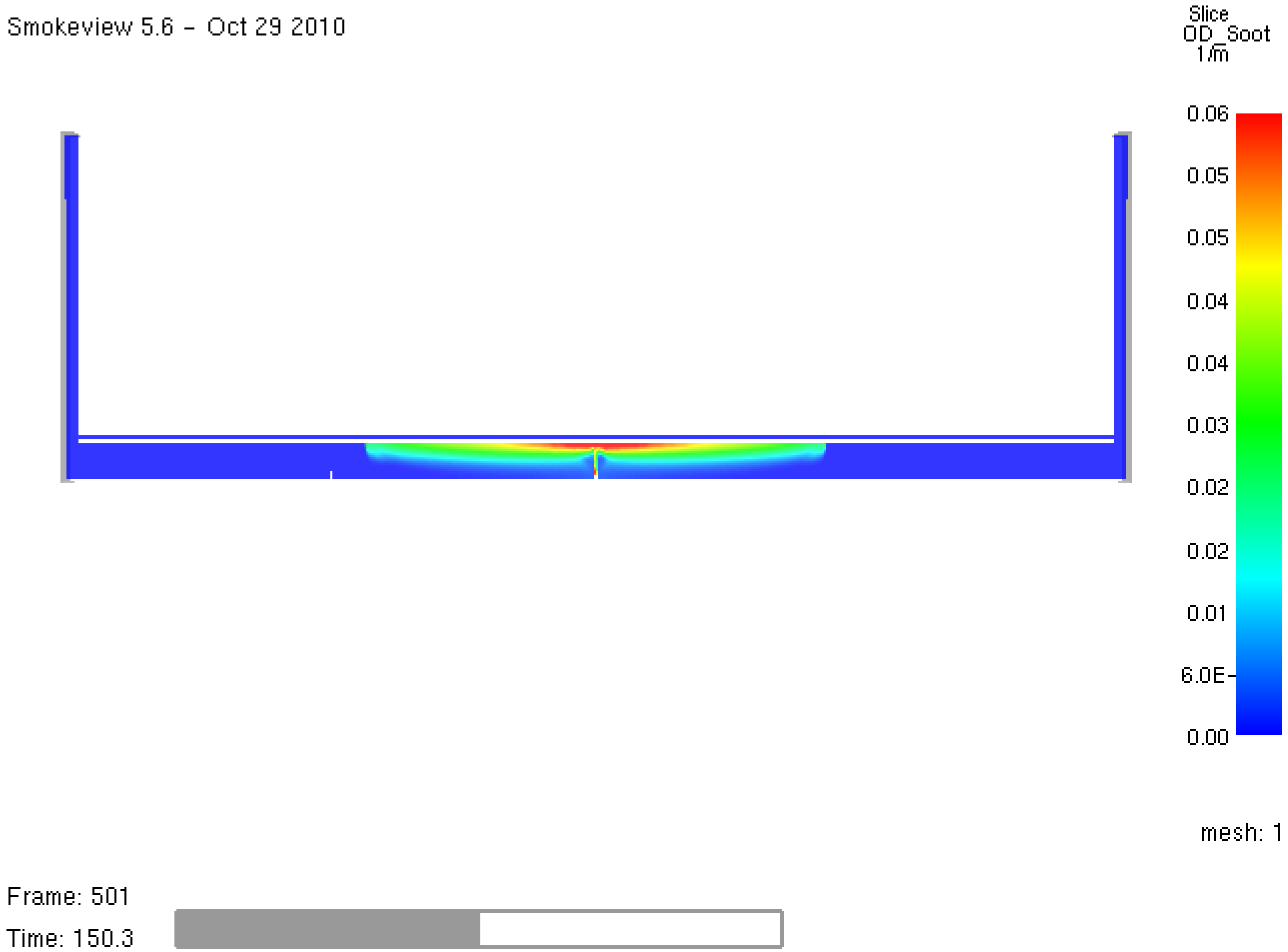
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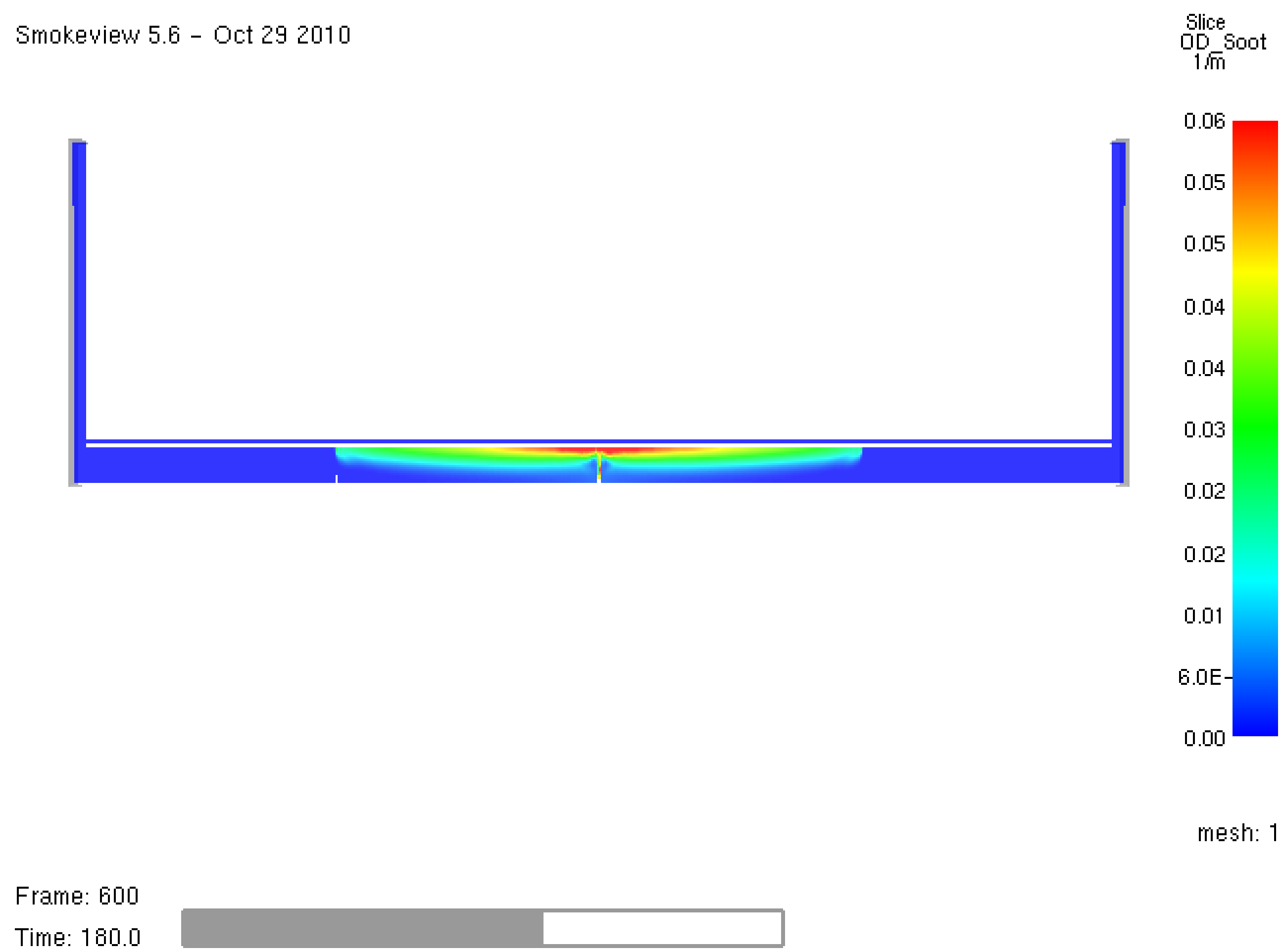
Smokeview 5.6 - Oct 29 2010
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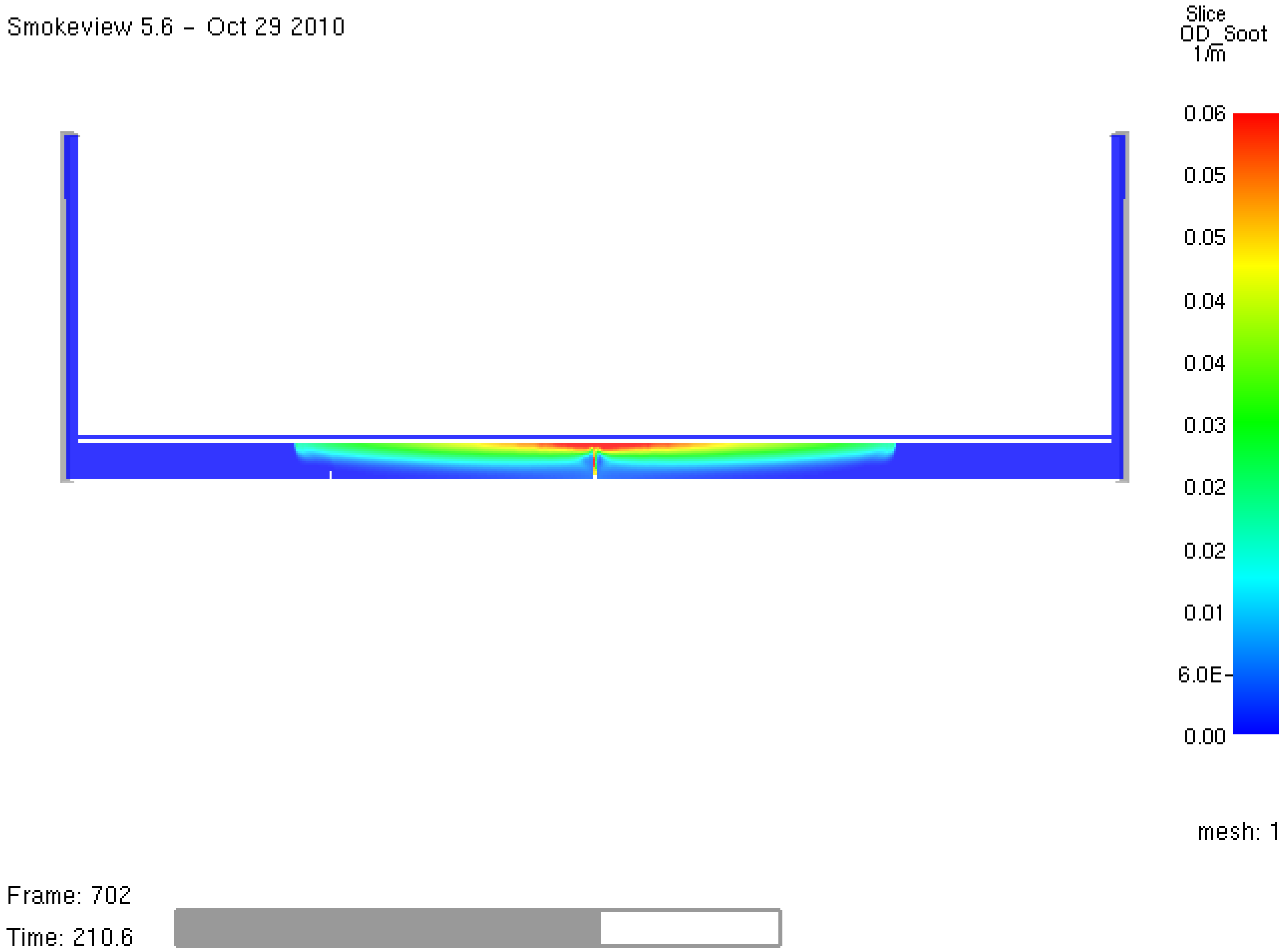
Time: 180.0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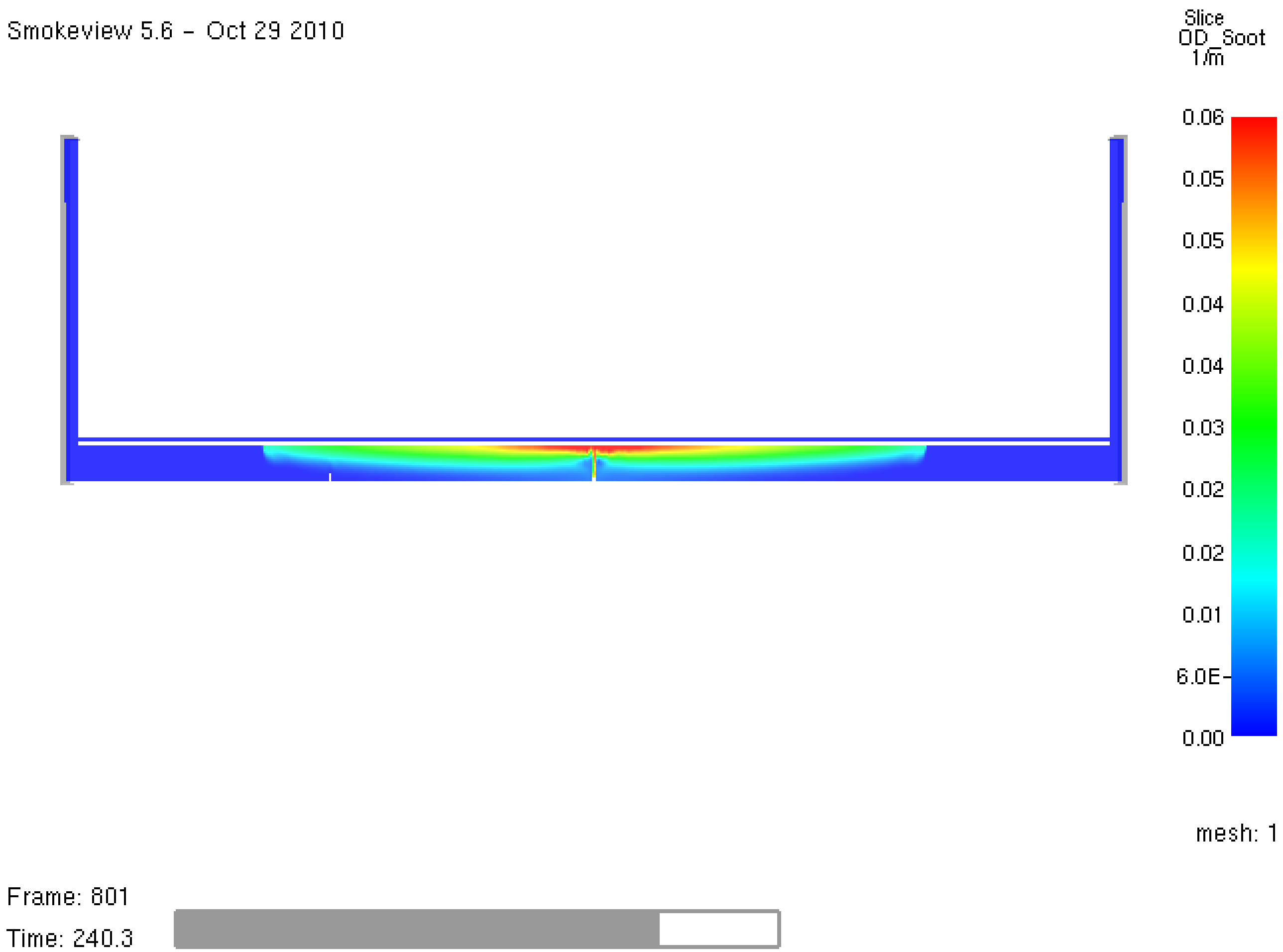
Frame: 702
Time: 210.6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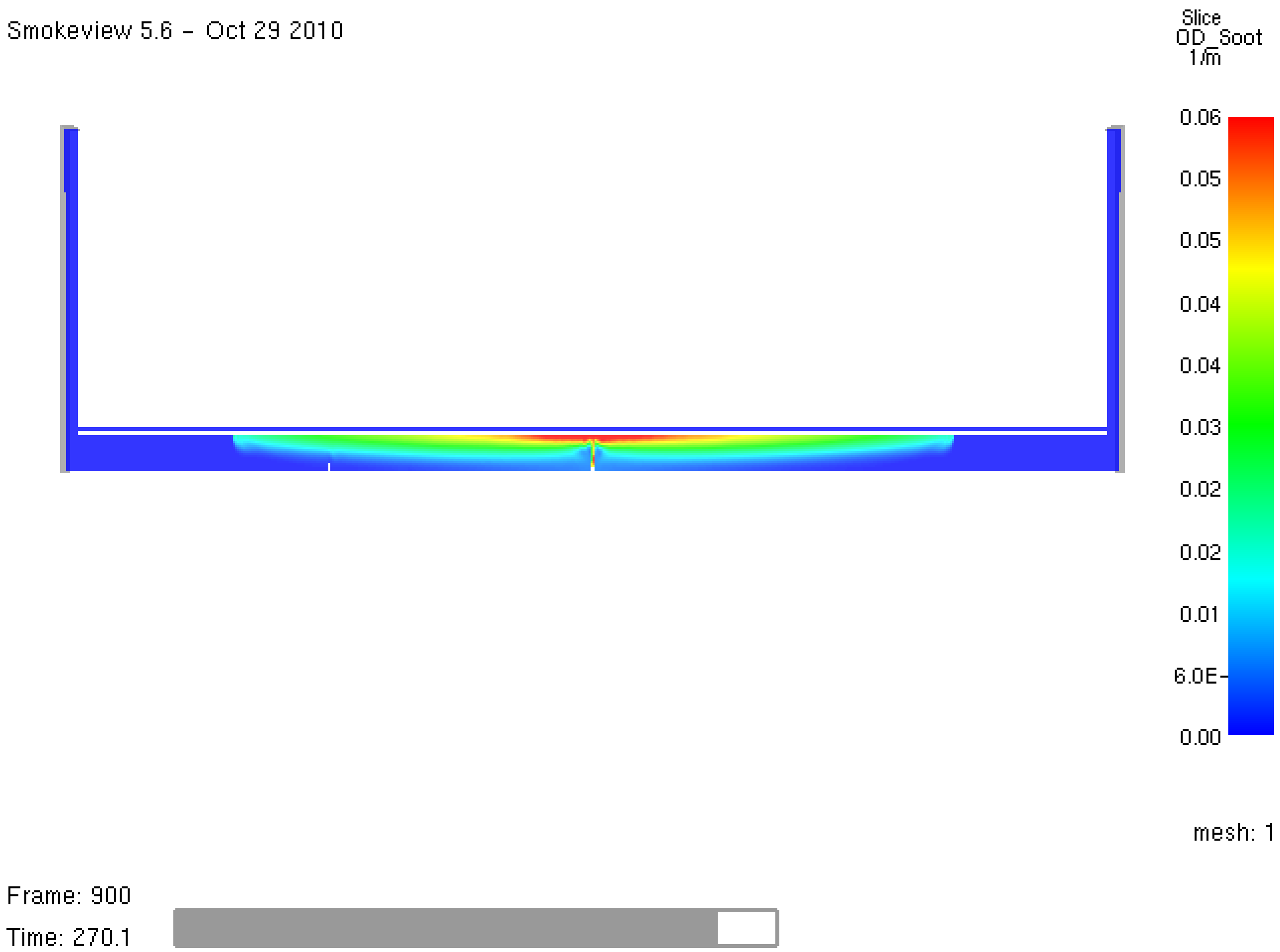
mesh: 1
Frame: 801
Time: 240.3


Smokeview 5.6 - Oct 29 2010
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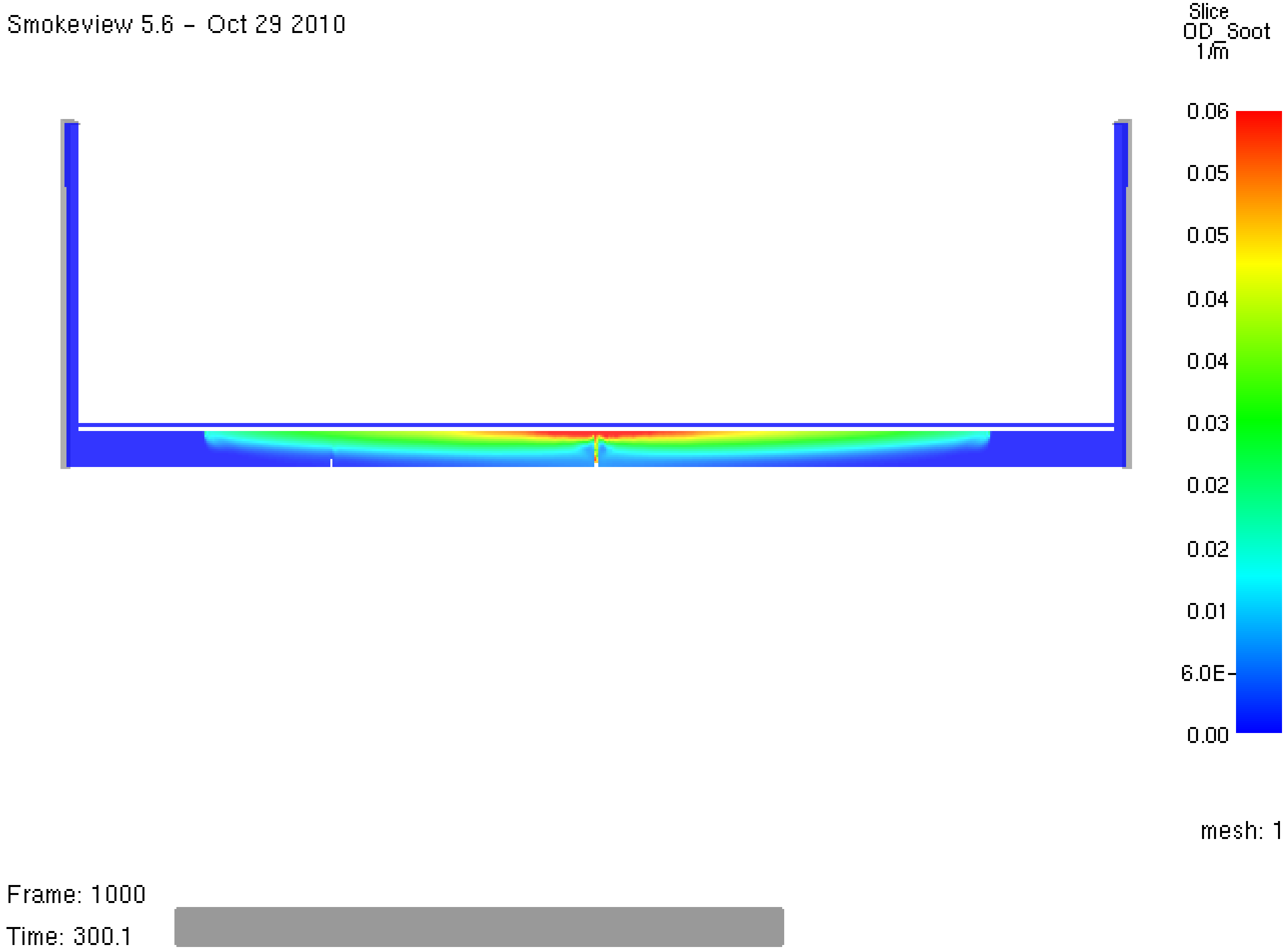
Frame: 900
Time: 270.1

In this scenario initial smoke front velocity was ~1m/s…but everv scenario is different



Conclusion

- Fires in tunnels have recently proved to be extremely severe, and given bad surprises to designers and managers sincerely convinced that the fire hazard was acceptably low.
- There is no room for believing that some solution is safe or not. Each solution and variant has to be quantified and checked with analysis tools against realistic worst case scenarios.
- Operability in case of accident must be proved and be simple and error proof.

- Once the results of the analysis are satisfactory, the analysis report can then be used to support the request of a construction permit, and allow the National Authorities to express positively.

Thank you!

Questions?

Frejus 2005 - 2 fatalities

- 12km long - HGV fire at km.5

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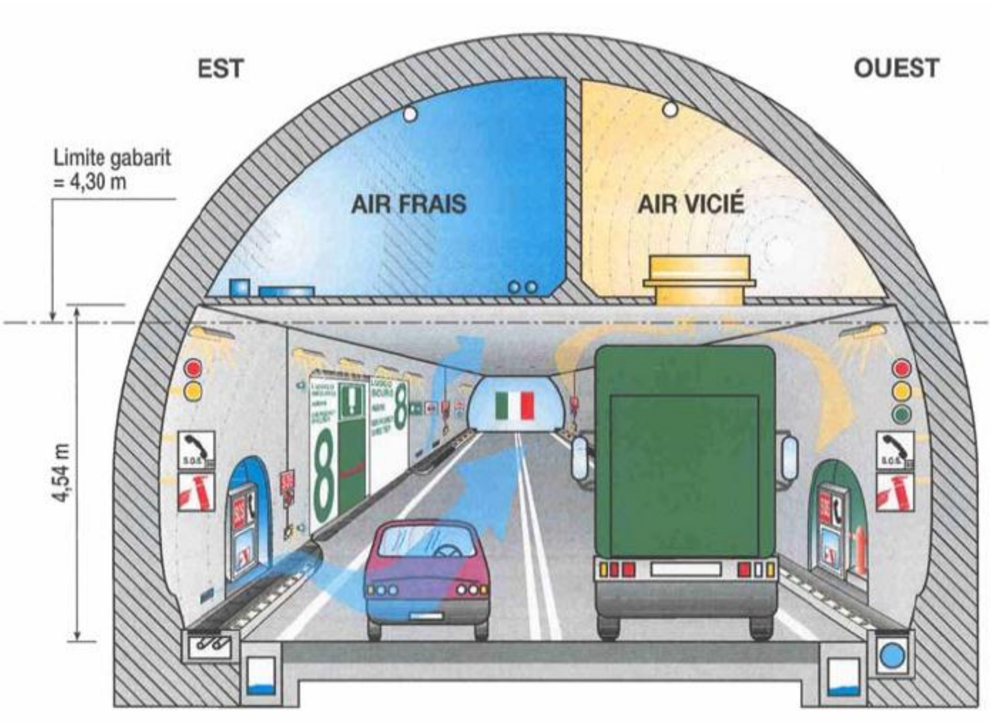
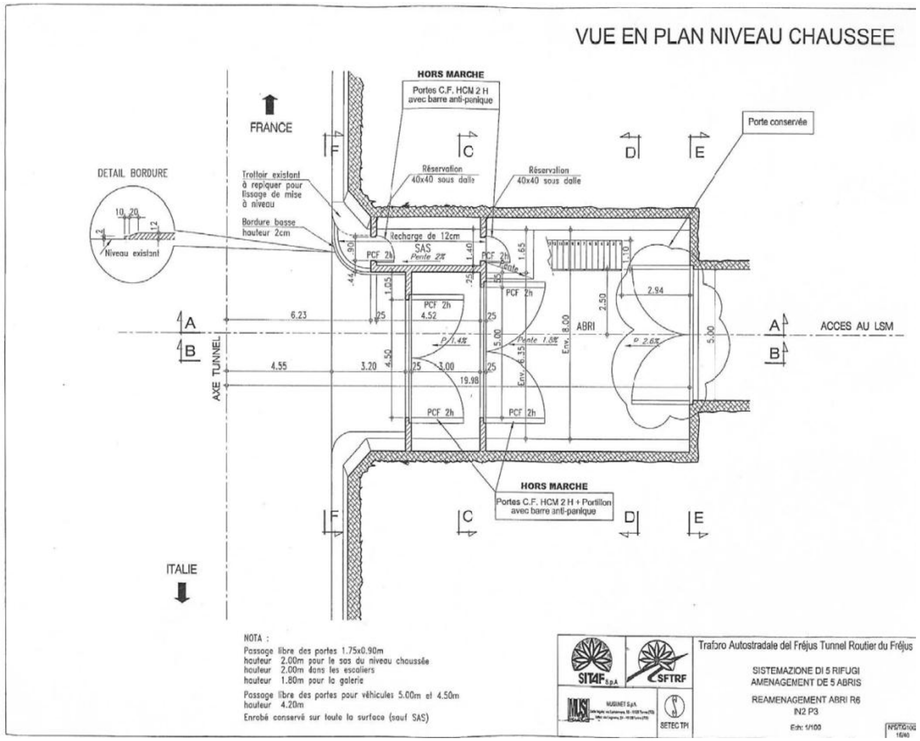
Frejus tunnel: profile and shelters

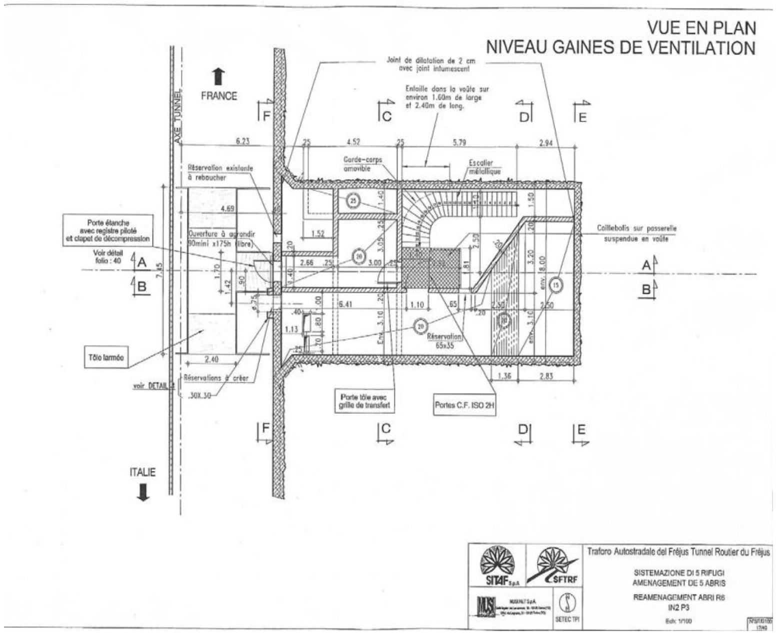
http://www.bea-tt.equipement.gouv.fr/IMG/pdf/RapportProvisoire_BEATT_2005_006_cle742b9b.pdf

- Tranversal ventilation scheme
- Fire detection misconfigured
- Smoke , partially mismanaged moved downwind towards the Italian side for 5 km



Shelters connected to fresh air ducts





- Smoke detection not functional
- Fire larger than expected
- Malfunctions and difficulties in localizing precisely the point where concentrating extraction of the smoke
- Distance between refuges was judged to be excessive (not <400m);
- Marking of the refuges was limited, several drivers missed the escape doors

- Distance form emergency niches to protals lowered to 250m,
- Fresh compressed air provided to niches
- Second duct was completed in 2011.

www.igt-engineering.com-fileadmin-docs-publikationen-TheFireCatastropheintheTauerntunnel.pdf.url http://www.nce.co.uk/second-bore-to-be-built-alongside-fire-hit-tauern-tunnel/835160.article

http://www.lindstrandtech.com/innovation_centre.html

26 July 2011 South Wales 370 m