



**Experts in Tunnel Fire Safety**



# Smart Concepts - Compensation potential with fixed fire fighting systems

**Examples from watermist installations in rail and road tunnels**

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**BENELUX  
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**WWW.FOGTEC.COM**

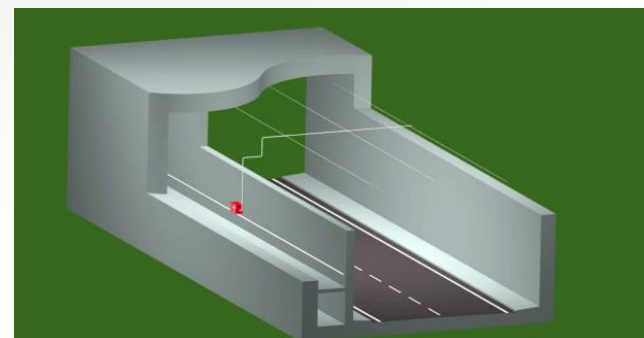


### FOGTEC – Business Activities

- Consulting
- Development & design
- Fire tests & simulations
- RAMS (LCC) & CFD
- Project management
- Integration into the overall concept
- Training of fire brigades
- After sales service

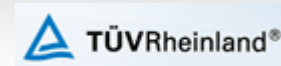


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## Experts in Tunnel Fire Safety





### SOLIT2 - Objectives

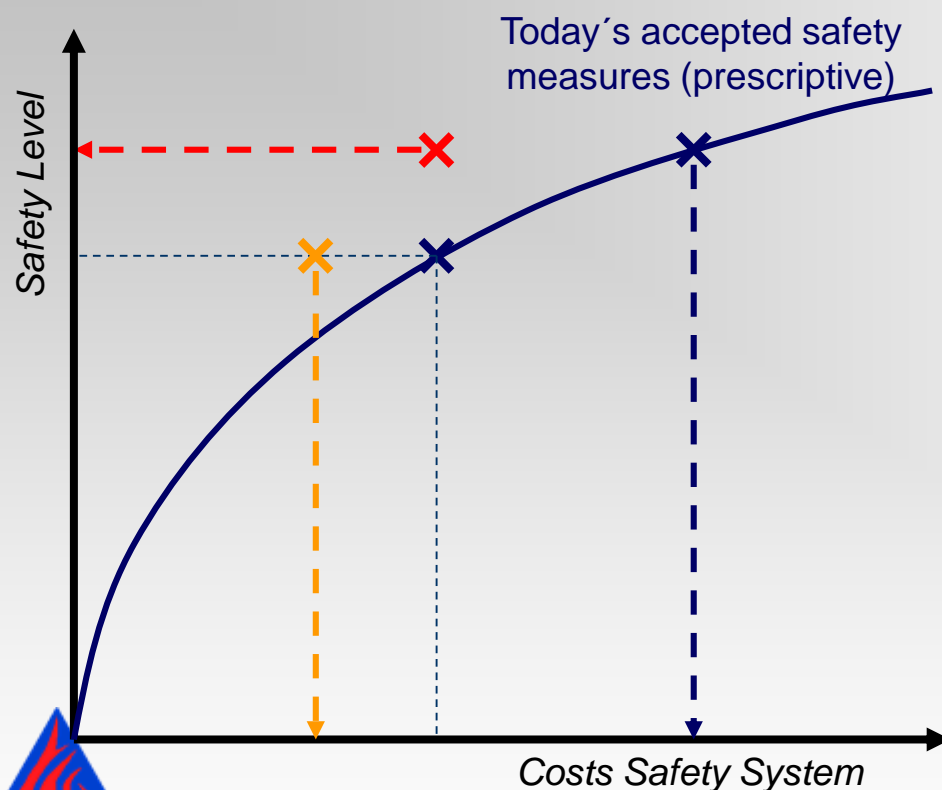
- Integration of FFFS into the overall tunnel concept
- Compensation of existing deficits
- Life Cycle Costs of the overall safety concept
- Transferability of the outcomes to other tunnels
- Engineering guidance for safety systems in tunnels

→ Holistic approach





## Compensation of other systems with FFFS



**Today: prescriptive based model:**

Increasing Safety Level  
→ higher costs

**Tomorrow: performance based model:**

Increasing Safety Level  
→ same costs

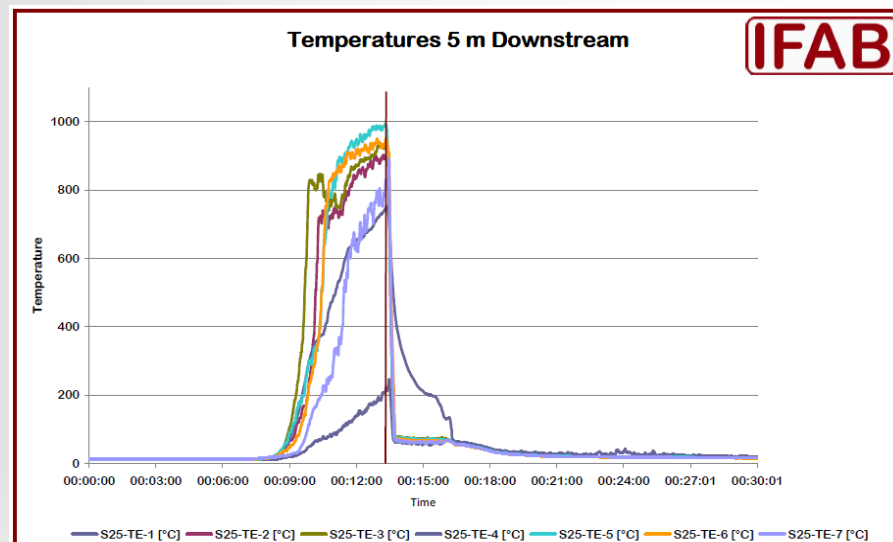
Same Safety Level  
→ less costs





## SOLIT2 - Fire tests

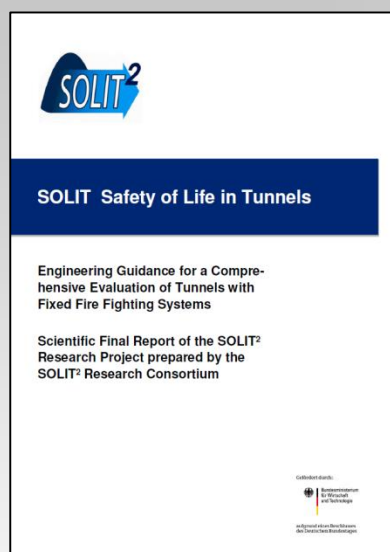
- Class A fires: HRR 150 MW
- Class B fires: HRR 30-100 MW
- Different ventilation settings





## SOLIT2 - Conclusions

[www.SOLIT.info](http://www.SOLIT.info)



- ◉ Compensation potential, e.g.
  - ◉ Less ventilation capacity needed
  - ◉ No passive protection
  - ◉ Impact on emergency exits
- ◉ Life safety
  - ◉ Tunnel users
  - ◉ Fire fighters
- ◉ Structural protection
  - ◉ Minimization of damages to tunnel
  - ◉ High availability of the tunnel
- ◉ Positive impact on Life Cycle Costs



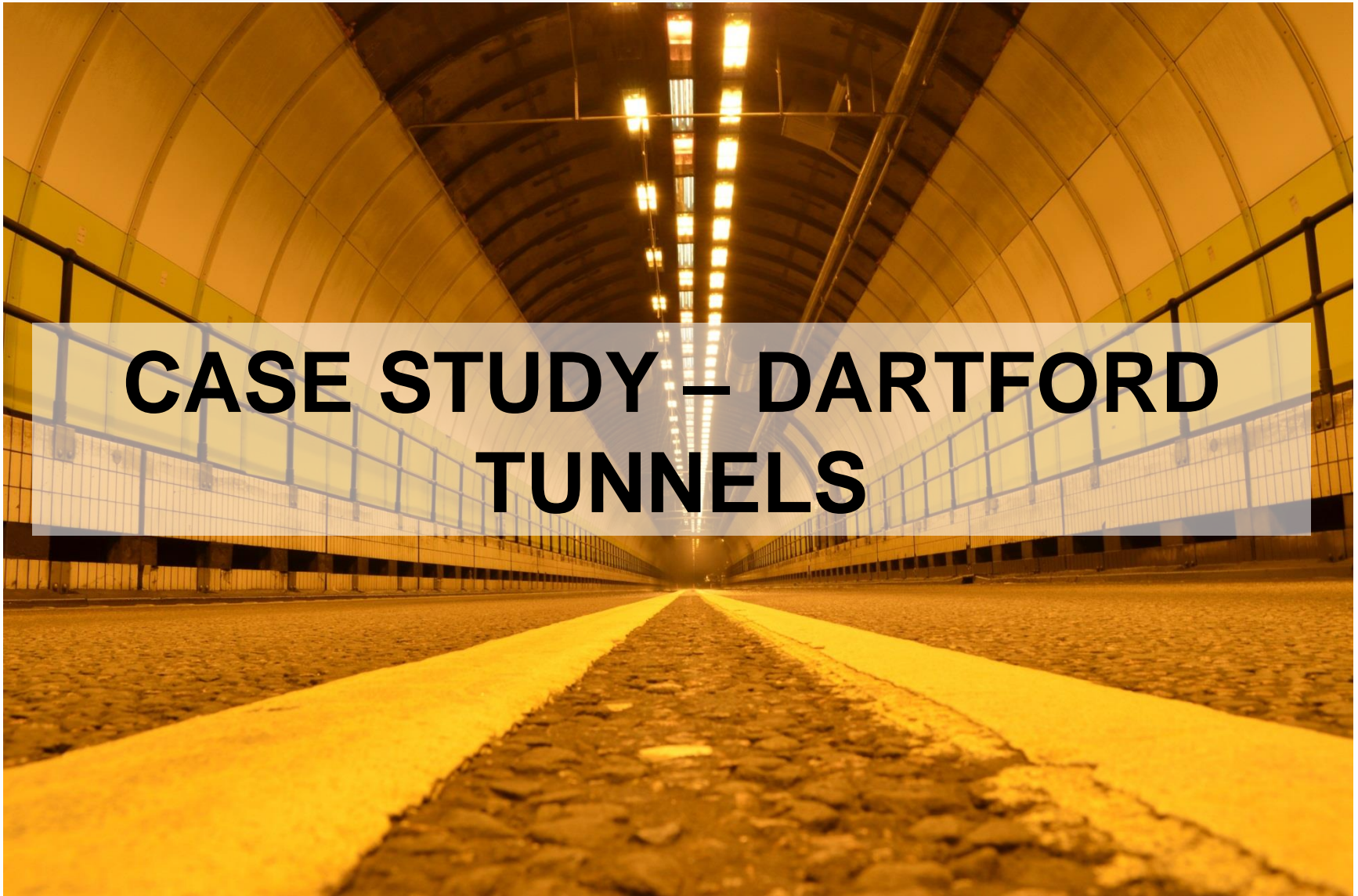




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# **CASE STUDY – DARTFORD TUNNELS**

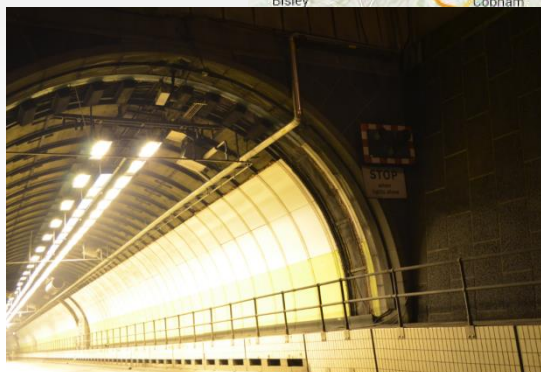
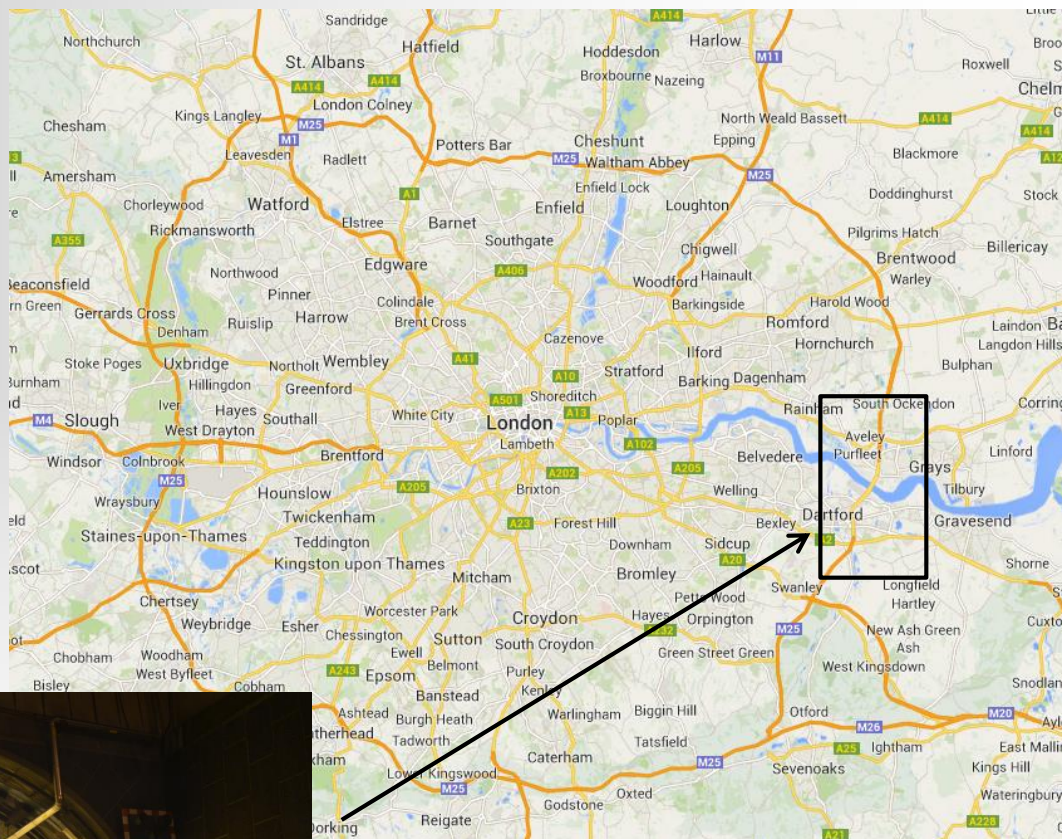






## Dartford crossing – M25 highway, UK

- 2 tunnels á 1.4 km, 1 bridge
- Up to 150.000 vehicles / day
- Tunnels pass under the river Thames
- Very important for operator and society
- Opening in 1963 (first tunnel)





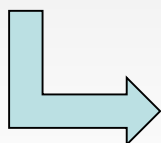
# Dartford tunnels - Refurbishment Process

## Objectives

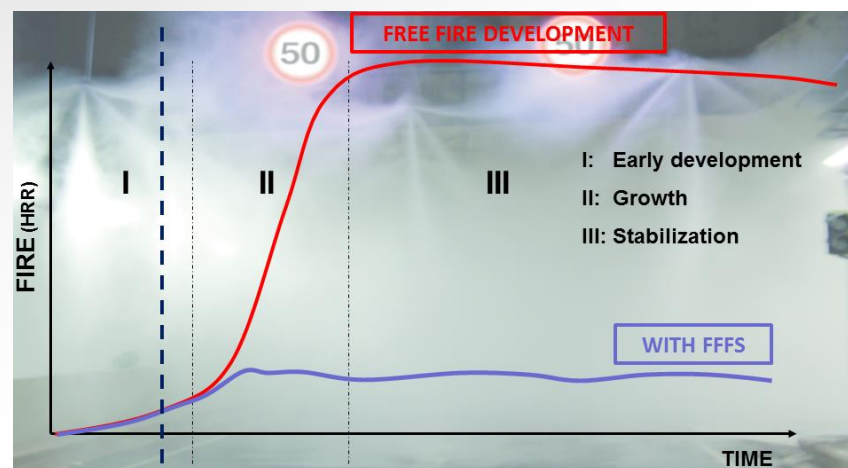
- Preservation of the tunnel structure & Availability of the tunnel
- Safety of human lives
- Improvement of the conditions for the emergency services

## Considerations

- Cast iron tunnel
- Passing under the river
- Short installation time



**HIGH PRESSURE  
WATER MIST**





## Dartford tunnels- Safety concept

### Full scale fire tests



### Measurements

- Temperatures
  - Smoke gas concentrations
  - Visibility
  - Thermal radiation
- 
- System activation after 30MW
- 
- CFD calculation to evaluate temperature in cast iron





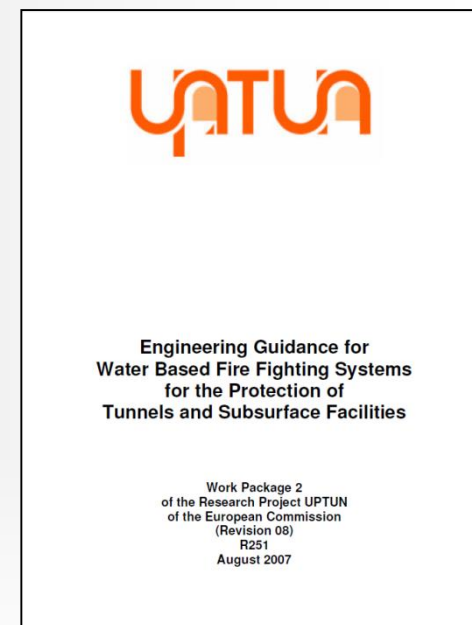
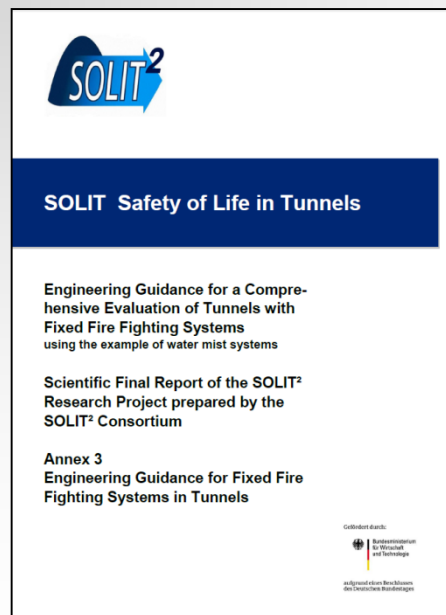


## Dartford tunnels – Design basis

Full scale fire tests

UPTUN Guideline

SOLIT Guideline





### Dartford tunnels - Requirements

- Very high availability → **SIL (Safety Integrity Level) 2** was required
- First Fire Fighting System in the world with a SIL2 rating
- High quality requirements and redundancies
  - Redundant pump room
  - 3/2 way valves (remote service valves)
  - Welded pipes
  - High quality materials
  - Maintenance free nozzles
  - ...







## Dartford tunnels - System layout

### Redundant pump rooms

- 2+1 diesel driven pump units per pump station

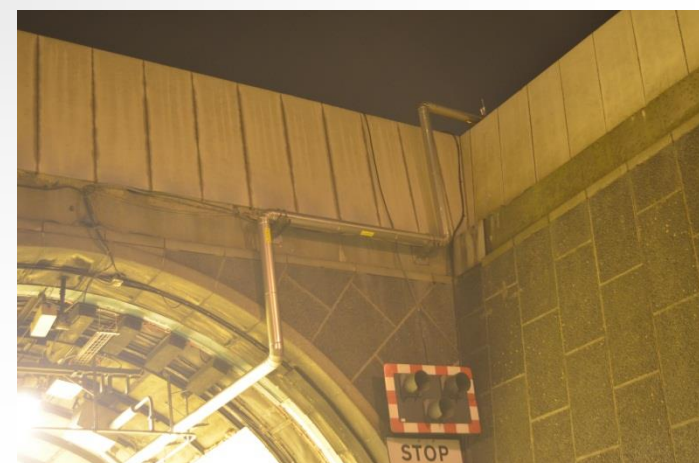
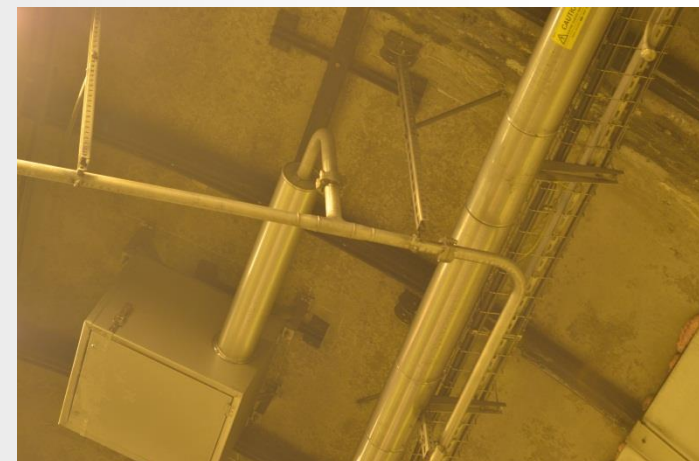




# Dartford tunnels - System layout

## Piping

- 1.4462 main pipe DN 80 (trace heated)
- 1.4571 section pipe
- Section valve in fire protected box





## Dartford tunnels - System layout

### Sections

- Section length: 25m each
- Activation of 3 sections simultaneously



Recent spray tests

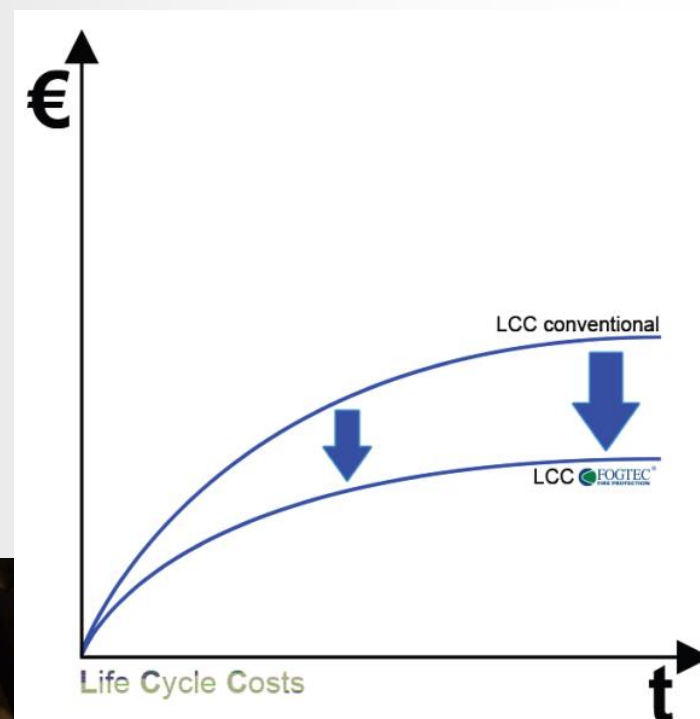






### Dartford tunnels - Conclusion

- Very high availability
- Low life cycle costs
- First FFFS with SIL2 rating in a tunnel





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# **CASE STUDY – EUROTUNNEL SAFE PROJECT**







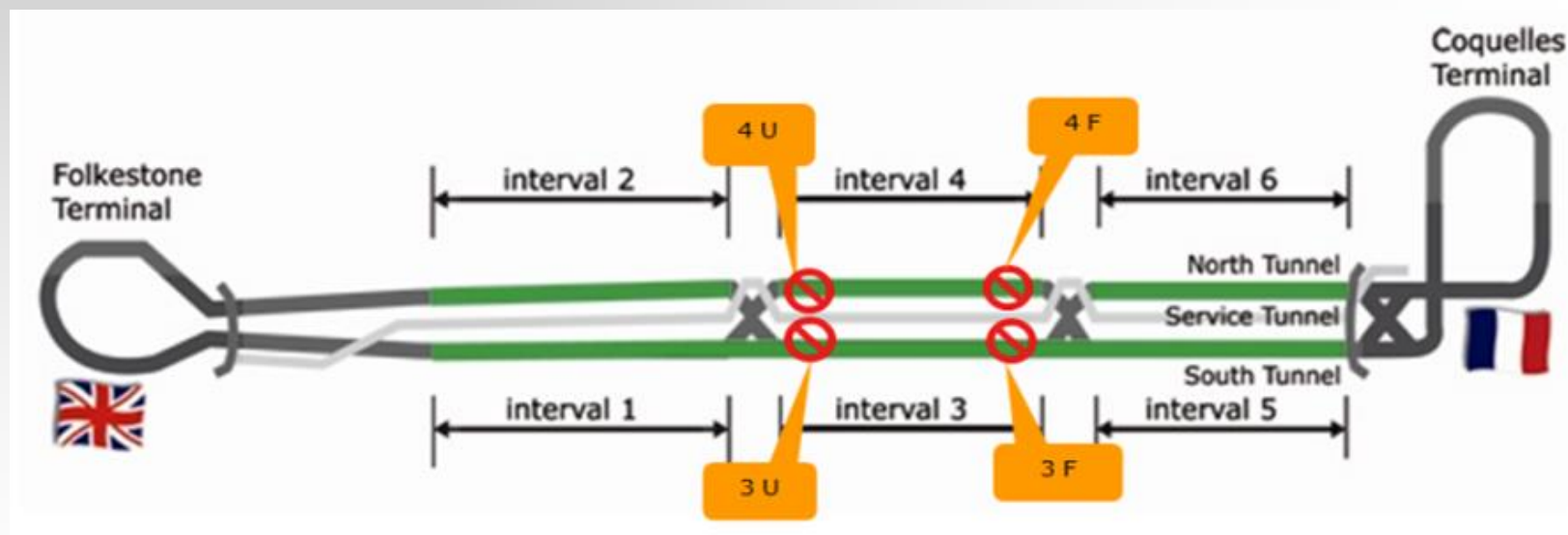
## Eurotunnel – Major fires





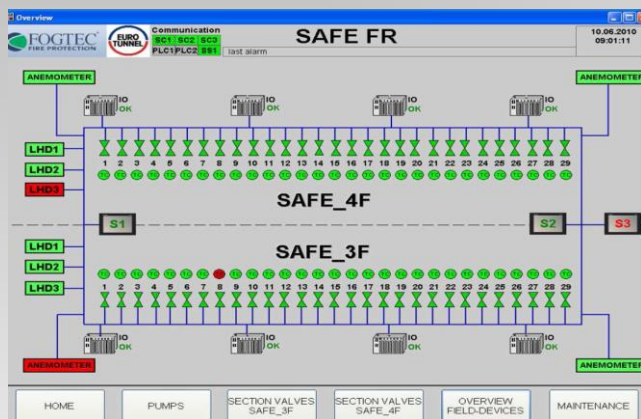
### Eurotunnel - SAFE project

- A high-pressure water mist system was evaluated as the best solution.
  - No major modifications to the infrastructure were necessary
  - Short recovery time after a fire
  - High availability





## Eurotunnel - SAFE project



- 4 SAFE stations are installed in 2 locations
  - Protection for shuttle trains carrying trucks
  - All SAFE stations are 870m long
  - 3 x 30m long sections activated simultaneously
- The SAFE stations include:
  - Integrated fire detection/ localization system
  - Control / SCADA system
  - Video surveillance system

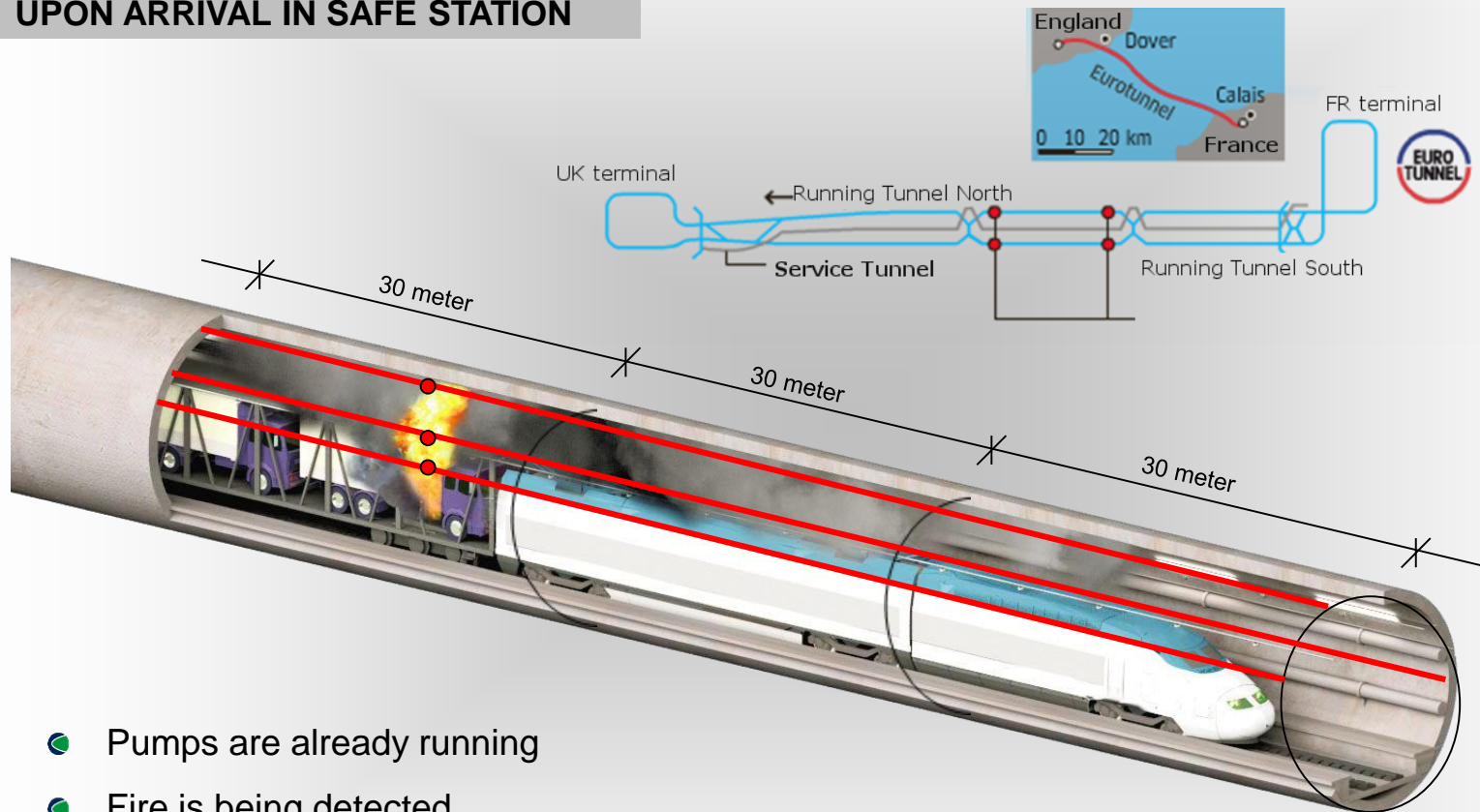






# Experts in Tunnel Fire Safety

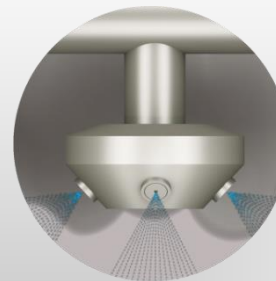
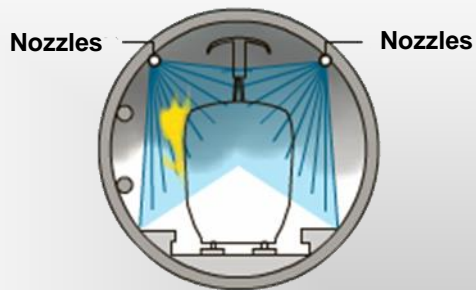
## UPON ARRIVAL IN SAFE STATION



- Pumps are already running
- Fire is being detected
- Corresponding section valves are being opened

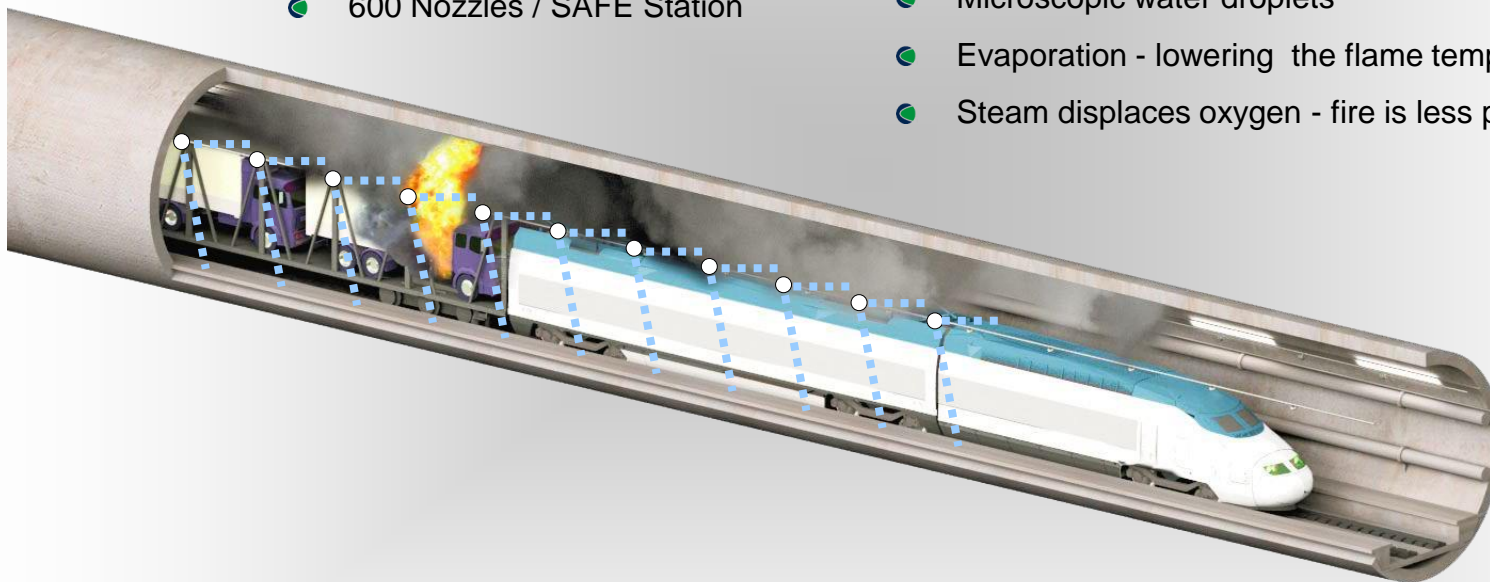


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600 Nozzles / SAFE Station

- Microscopic water droplets
- Evaporation - lowering the flame temperatures
- Steam displaces oxygen - fire is less powerful



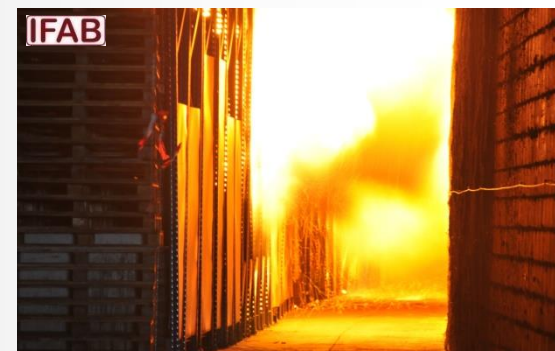
- Water mist is activated in the detected section and the adjacent sections



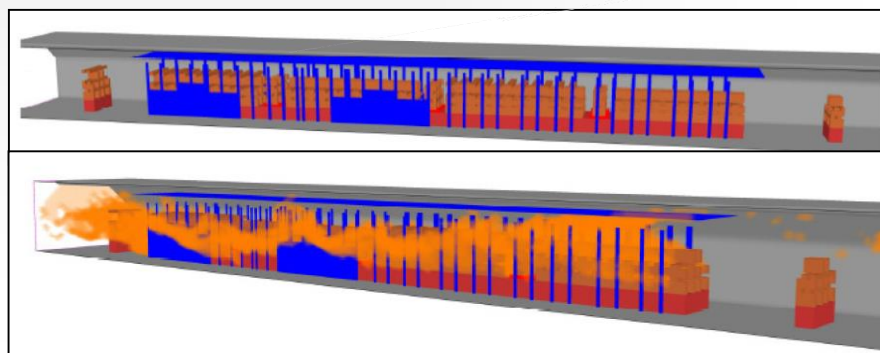
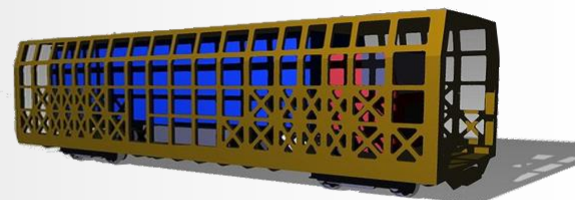


### Project SAFE – Fire tests

- Full scale fire tests in Spain by IFAB
- Challenges
  - Over 200MW Class A fire developed
  - The tunnel structure and the test equipment was pushed towards their limits
- No reference available from previous tests in this magnitude with FFFS



## Project SAFE – Fire tests Mock-up







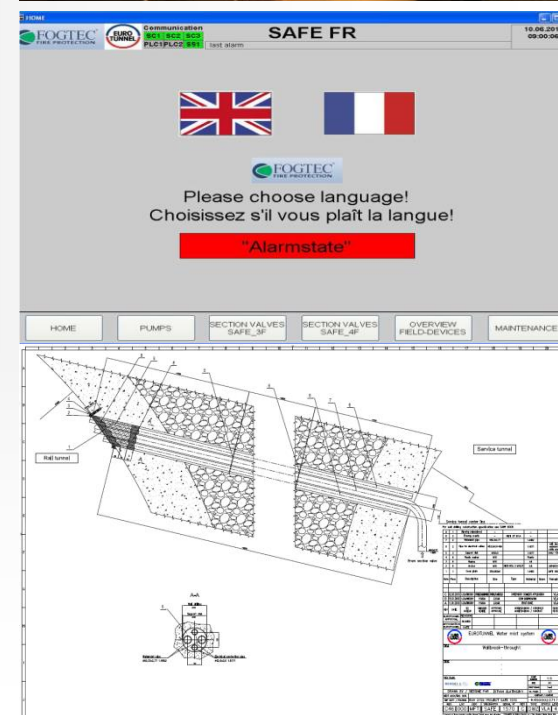
## Experts in Tunnel Fire Safety





### Project SAFE Implementation – Challenges

- Very limited installation times for the rail tunnels
  - Integration into the Eurotunnel control systems
  - Design aspects
    - Harsh environment
    - Extreme high availability 99.98%** (RAMS studies)
- Robust and maintenance free components







# Experts in Tunnel Fire Safety



## Eurotunnel installation







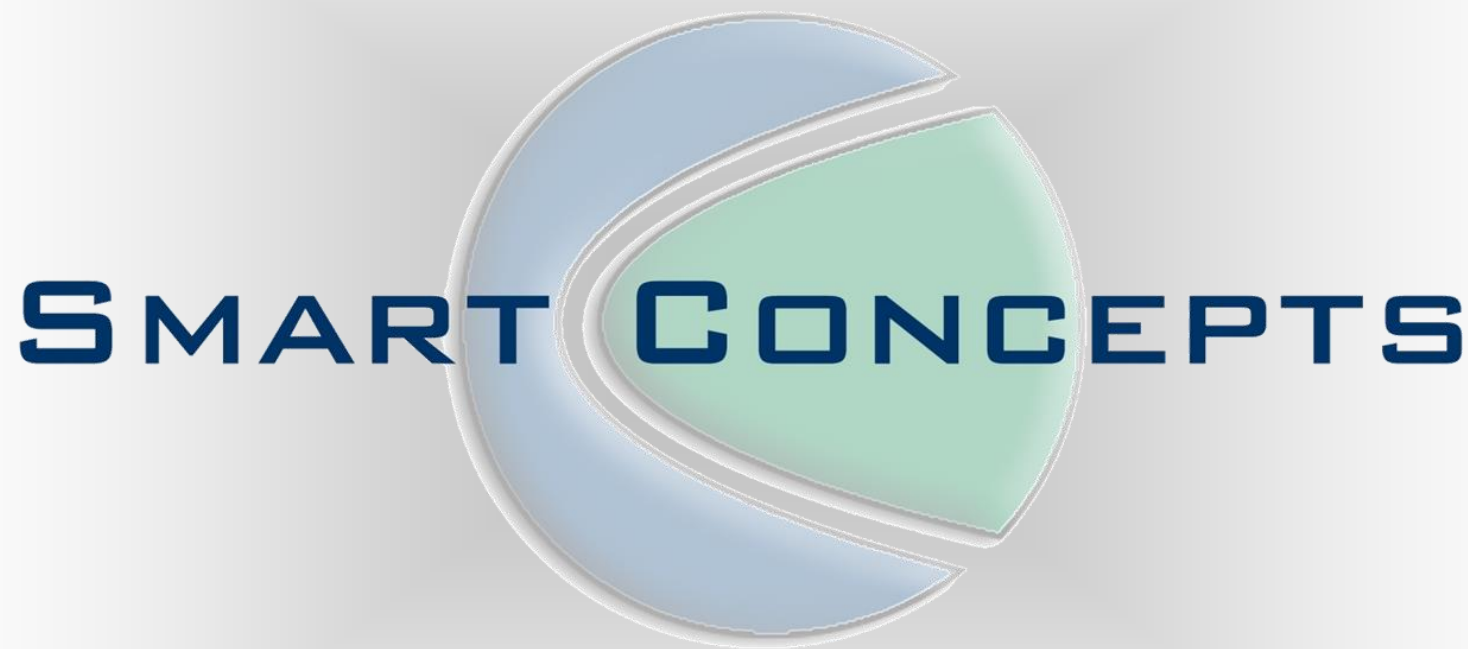
### Eurotunnel - Conclusion

- Sufficient visibility for fire services and evacuation
- Water mist is equally spread in the activated area
- Ventilation effect very minor to the water distribution
- Eurotunnel is very satisfied with the system





**Experts in Tunnel Fire Safety**



**USE OF FIRE PROTECTION SYSTEMS SAFELY AND EFFECTIVELY**  
**Cost reduction by additional fire protection**



### FOGTEC Smart Concepts

- Smart Concepts – general description,
- Goal of Smart Concepts – Cost Reduction
- Fire verification tests
- FOGTEC references applying Smart Concepts



### FOGTEC Smart Concepts/ Current situation

- Lack of holistic approach for fire protection system design
- Vehicles and stations often considered separately
- Fire scenarios of rail vehicle used as basis for design and planning of stations
- Expensive infrastructural design and planning
- Change in philosophy in fire protection coinciding with 150th anniversary of underground trains



# FOGTEC Smart Concepts

**„Fight the cause, not the effect!“**

- What does this mean in detail?

**Integration of innovative fire fighting technology to positively influence the fire scenario**

- Fire fighting or reduce of impact directly at the fire source
- Compensation from the infrastructure's side
- Reduction of infrastructural requirements
- Overall view of three product areas: rail vehicle, underground station, and tunnel





## FOGTEC Smart Concepts

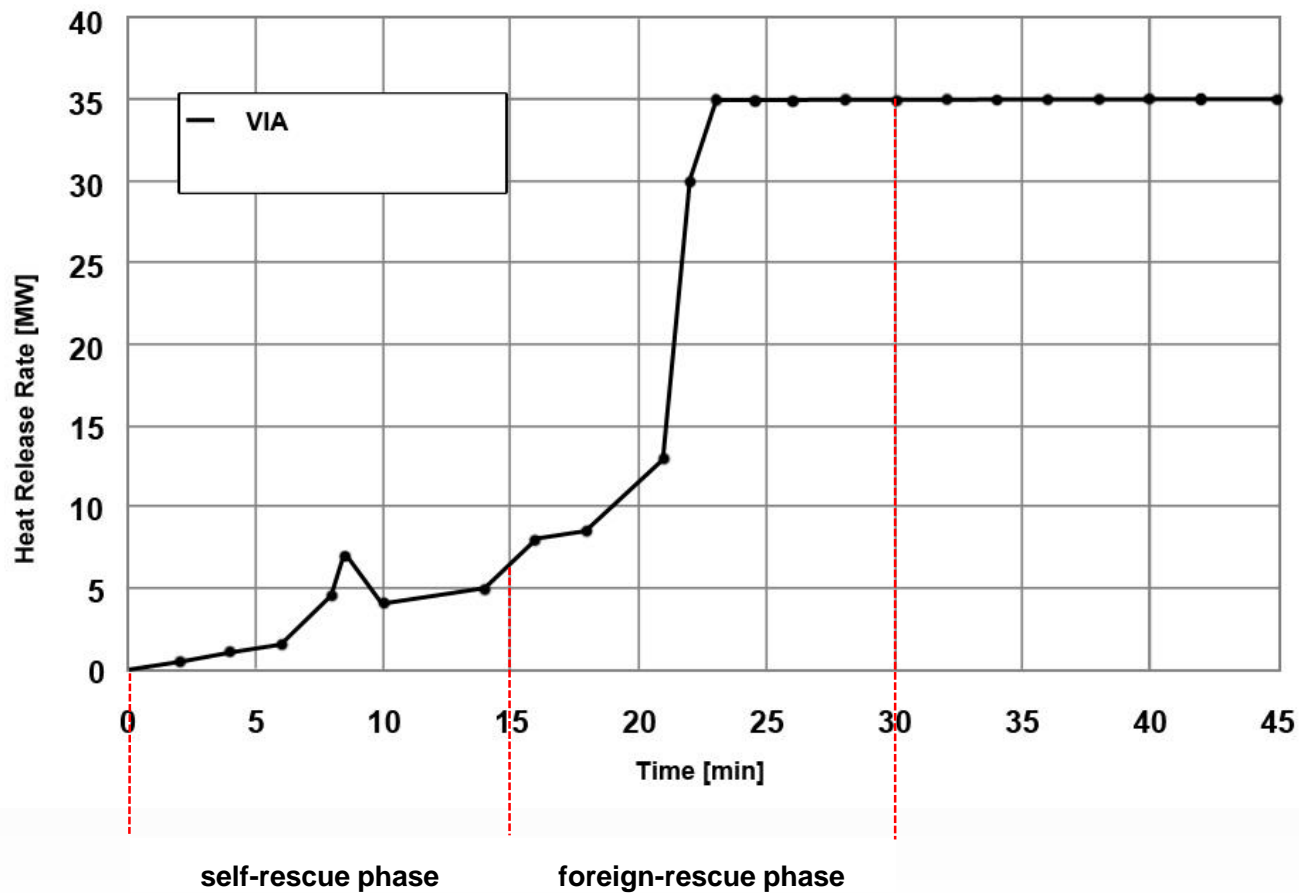
- **Application of on-board systems**
- Actual status of fire scenarios
- On-Board Fire Protection Solution with FOGTEC
- Verification fire tests
- Target status of fire scenarios





## FOGTEC Smart Concepts

### ➤ Heat release rate: 35 MW





## FOGTEC Smart Concepts Fire Test



1:1 Reproduction of a rail vehicle



## **FOGTEC Smart Concepts Fire Test**



**IMO cushions on the seating area**

**1. Fire Test HPWM active**

**2. Fire Test HPWM not active**





## FOGTEC Smart Concepts

### 2. Fire test HPWM not active

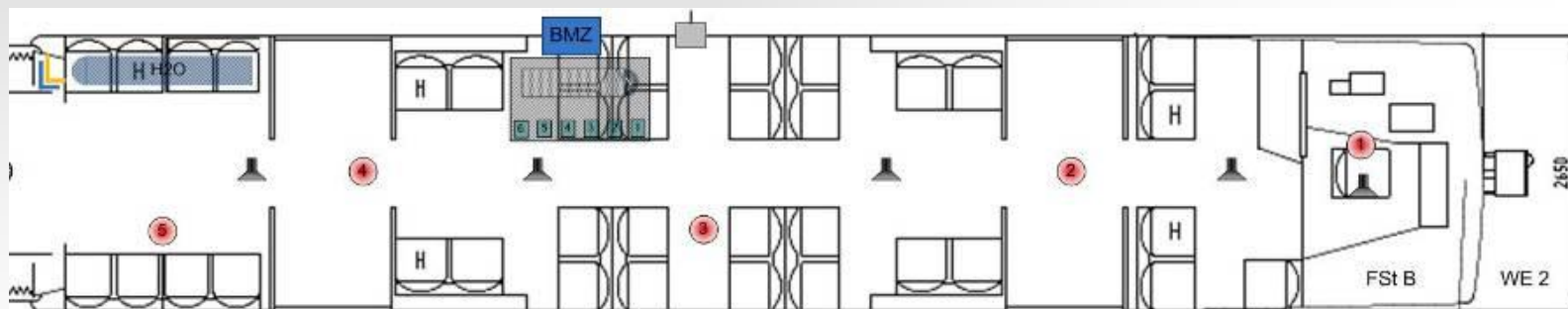
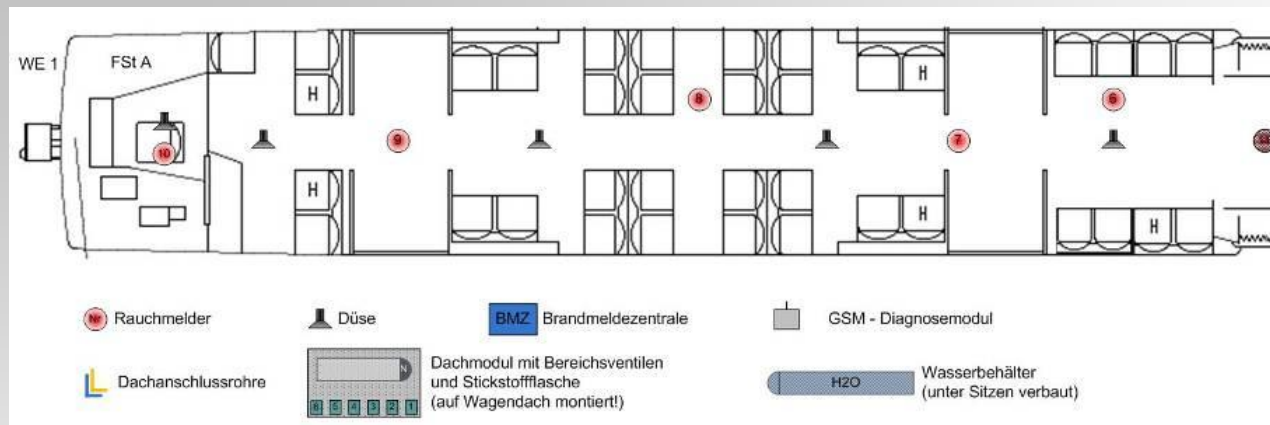


**Stop of fire test after 11 minutes**

**Strong damage to the facilities**



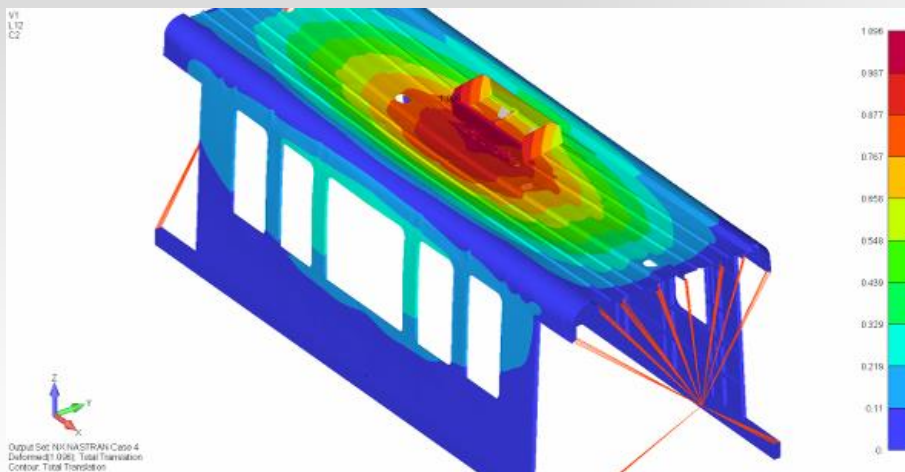
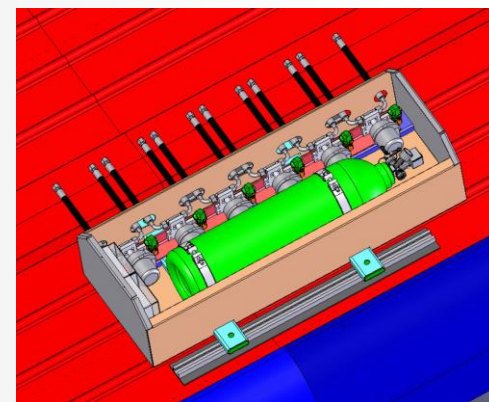
## Prototype





## Prototype

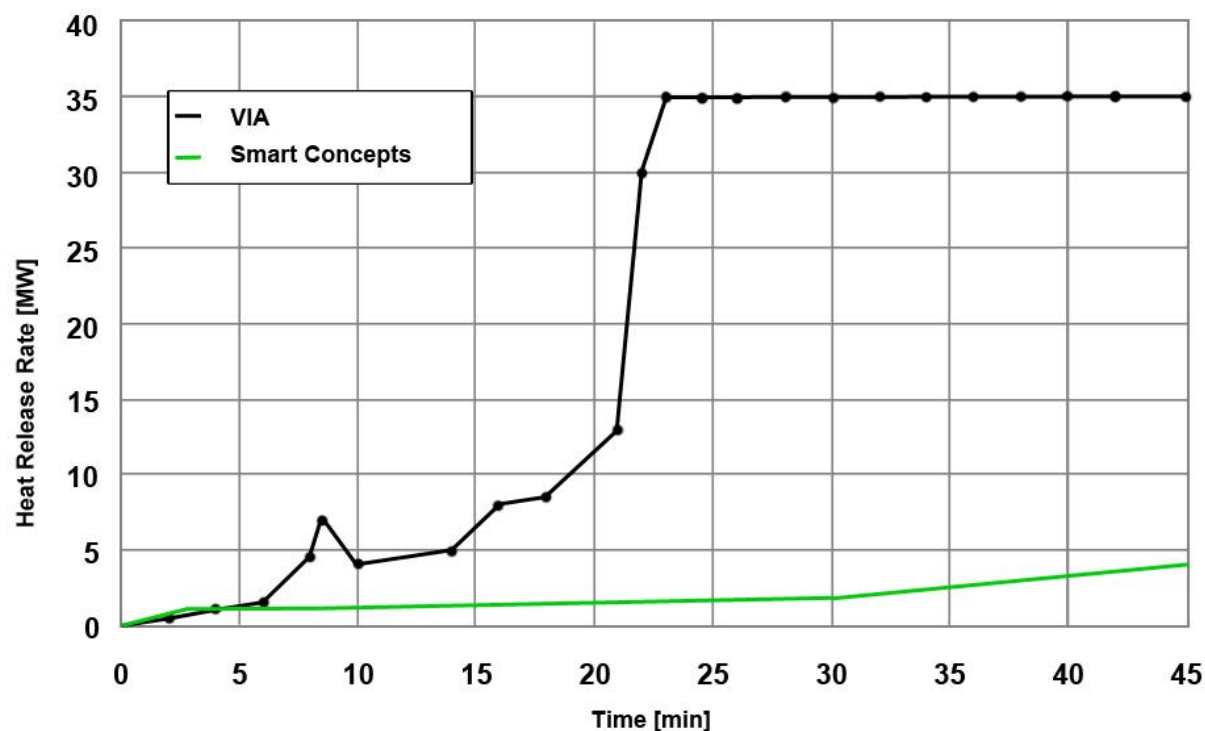
- Integration on the roof of the vehicle
- Roof reinforcements necessary





## FOGTEC Smart Concepts

### Target status of fire scenario



**Very low heat release rate**

**Only small measures required at the stations**

**Reducing investment costs up to 80%**





## FOGTEC Smart Concepts



First time in 2004 fully proven technology for compensation (e.g. Stadler Flirt)



Compensation of fire doors



In 2005, consideration of effects of fire on the infrastructure (evacuation, emergency exits, smoke extraction)



Implementation of escape concept





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Thank you for  
your attention!

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