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Fire Protection of Underground Facilities with innovative Water Mist Systems

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- SOLIT² Research Program Review
- Objectives
- Partners
- Project in General
- (first) Results
- Future Works

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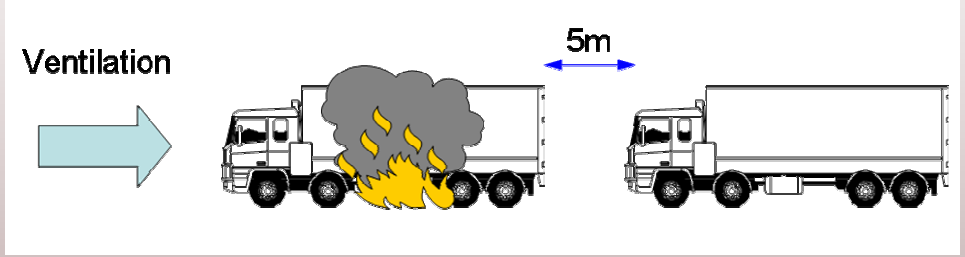
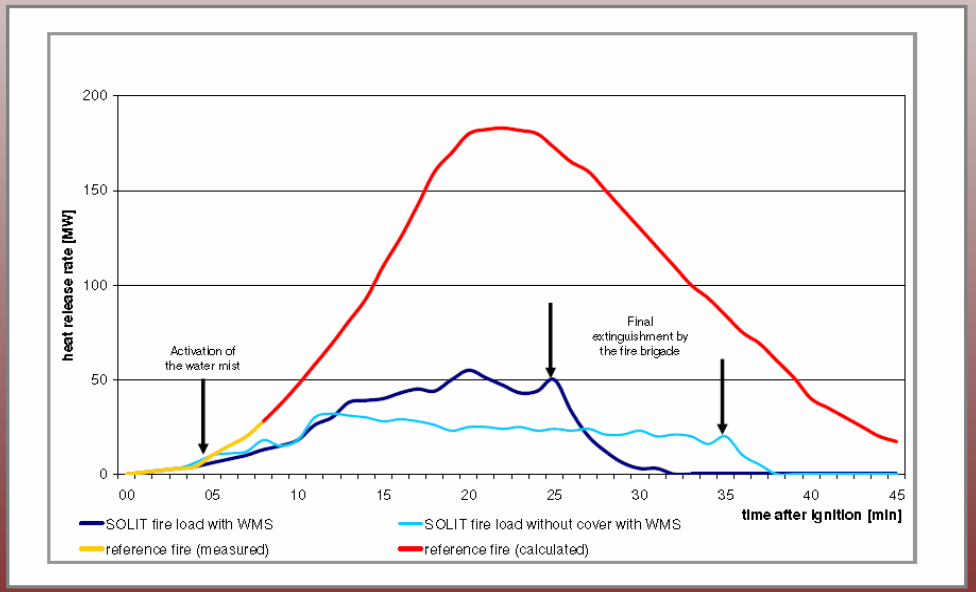
Aims of FFFS in tunnels

- **Fire Suppression and reduction of fire spread**





- **Improvement of self-rescue conditions**

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Water Mist FFFS in road tunnels

- Easier and safer work for resuce services (fire brigade, etc.)
- Reduction of damages on the building structure
- Compensation of other safety measures???

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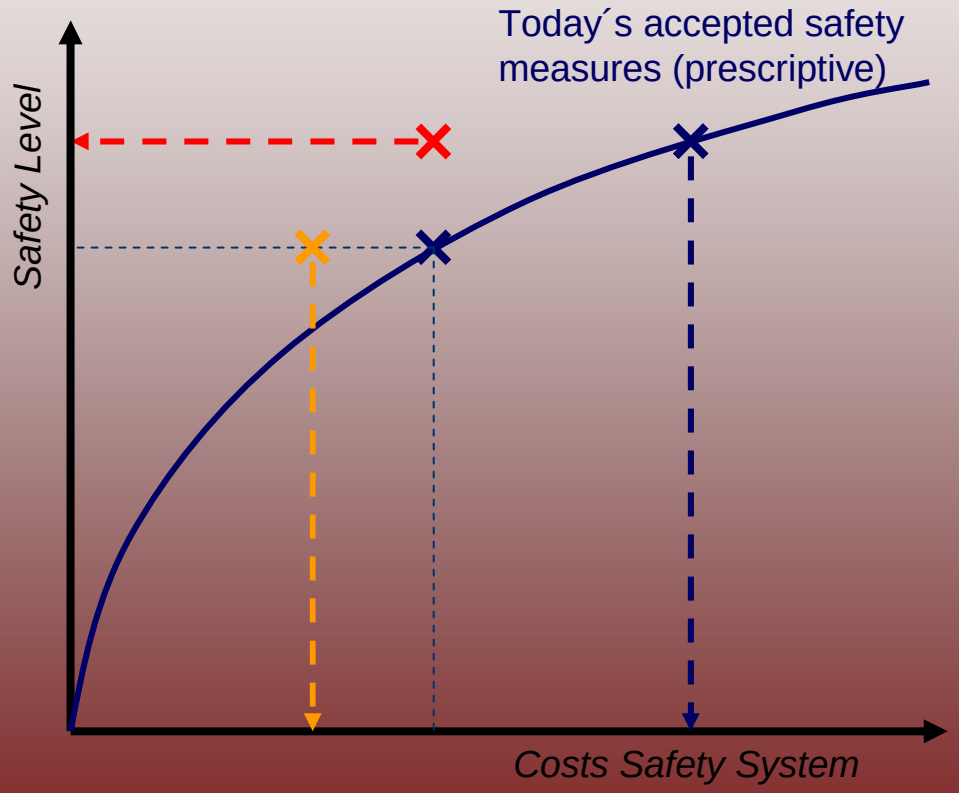
Compensation: Costs vs. Safety Level



Today: prescriptive based model:

Increasing Safety Level → higher costs

Increasing Safety Level → same costs

Same Safety Level → less costs

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European Roadtunnels with WN-FFFS

- Virgil (Virgolo) Tunnel , A22 Brenner Highway
- A 86 ,Paris
- M30 Ring road, Madrid
- Felbertauerntunnel
- A73 Roertunnel
- New Tyne Crossing (NTC), Newcastle
- …

More are in planning and tender process.

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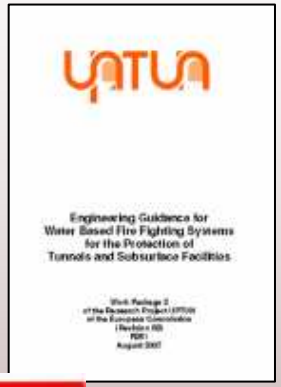
Guidlines and Standards

- **UPTUN 251: “Engineering Guidance for Water Based Fire Fighting Systems for the Protection of Tunnels and Subsurface Facilities”**

- **NFPA 502 (2008): “Standard for Road Tunnels, Bridges, and Other Limited Access Highways”**

- **PIARC: “Road Tunnels – An Assessment of Fixed Fire Fighting Systems (FFFS)”**



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Potential for compensation

Compensatory Measure:

Measure that ensures the same level of protection than with standard measures required by guidelines or state-of-the-art.

- **Increase the efficiency of ventilation systems**
- **Improvement of self-rescue conditions**
- **Fire suppression and temperature reduction**
- **Improvement of fire brigade intervention**

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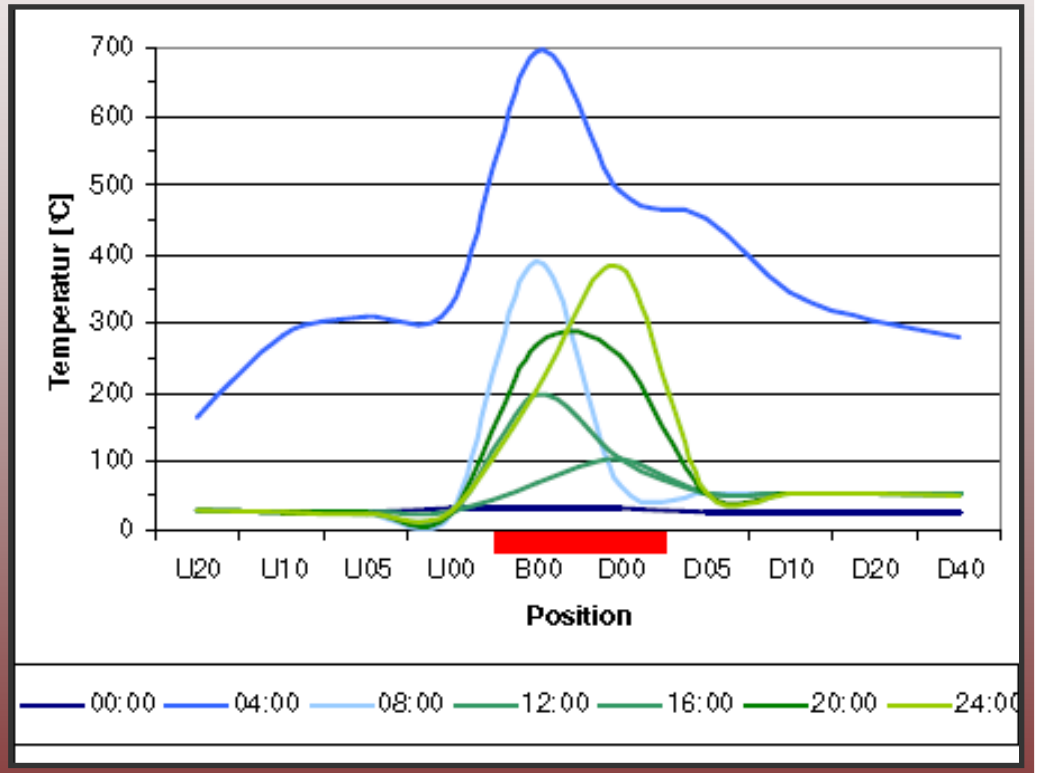
Reduction of Temperatures / Reduction of damages



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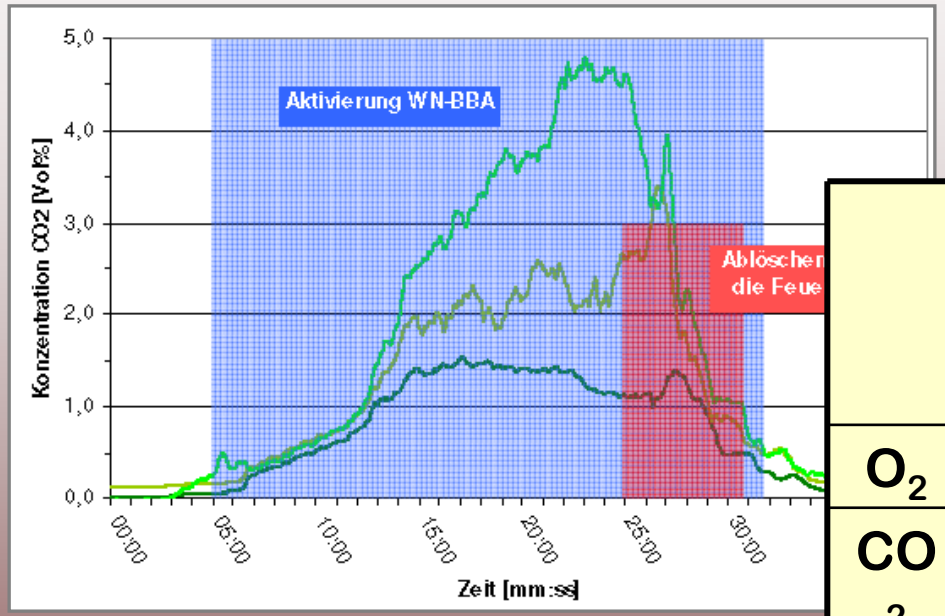
Improvement of self-rescue conditions



Prescriptive based analysis

	Min./Max. concentration at breathing height Vol%	Fixed Limit Value for 30 min. exposure Vol%	Free burning Fire (150 MW) Vol%
O_2	19,41	15	
CO_2	1,53	6-7	7-9
CO	0,22	0,14 – 0,16	0,4 – 3,0

Fractional Effective Dose according ISO 13571

$$FED = \Delta t \sum_{i=1}^{n} \sum_{t_1}^{t_2} \frac{C_i}{(Ct)_i} \Delta t$$

Performance based analysis

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SOLIT² - Research Project

Compensation of safety measures by FFFS

Integration of FFFS into a holistic tunnel safety system

- Run time: 10/2010 – 09/2011
- Supported by the German ministry of economy and technology
- Budget: ~ 4 Mio €
- Large scale fire test program in 2011
- Workshop/Conference in 2011
- Scientific advisory board

Information at www.solit.info

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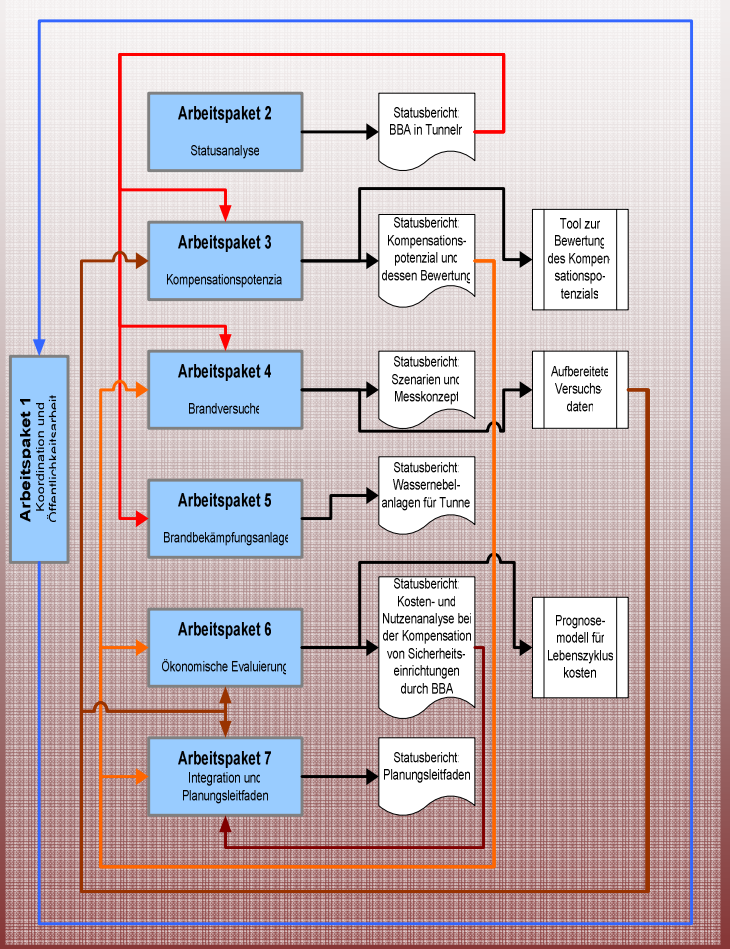
SOLIT² - Major Work Program

- State of the art analysis
- Potential of Compensation

  Simulation /

  Base data for risk analysis
- Effects of FFFS
- Economical Evaluation (LCC)
- Integration and Engineering

  Guidance



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SOLIT² - Partners

FOGTEC FIRE PROTECTION — FFFS, Project Manager

BUNG Beratende Ingenieure — Engineering, Simulation, Compensation

STUVA — Engineering, Simulation, Literature

RUB Ruhr Universität Bochum, Lehrstuhl für Tunnelbau, Leitungsbau und Baubetrieb TLB — Economical Evaluation, Integration

TÜV SÜD Rail, Mehr Sicherheit. Mehr Wert. — Integration, Reliability, Guidance

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INSTITUT der FEUERWEHR Sachsen-Anhalt — Full Scale Fire Tests, Measurments, Data evaluation

SOLIT² - Test Program

TEST PROGRAM - SOLIT² RESEARCH PROGRAM

TEST SCHEDULE

Week	Tunnel Rent	Date	Testnumber	Scenario	Ventilation	FFFS
21	1	Mo 23.05.	110523-1	Truck with cover	Longitudinal TBD m/s	Layout 1
	1	Di 24.05.	110524-1	Truck with cover	Longitudinal reduced TBD m/s	Layout 1
	1	Mi 25.05.	110525-1	Truck without cover	Longitudinal TBD m/s	Layout 1
	1	Do 26.05.	110526-1	Pool 30 MW	Longitudinal TBD m/s	no FFFS
			110526-2	Pool 30 MW	Longitudinal TBD m/s	Layout 1
			110526-3	Pool 30 MW	Longitudinal reduced TBD m/s	Layout 1
	1	Fr 27.05.	110527-1	Pool 100 MW	Longitudinal TBD	Layout 1
			110527-2	Pool 100 MW	Longitudinal reduced TBD m/s	Layout 1
			110527-3	Pool 100 MW	Longitudinal TBD	FFFS with 1-2 m distance b
		Sa 28.05.		BREAK		
		So 29.05.		BREAK		

- 34 full scale fire tests (at least)
- Consumed water ~ 1200m³
- Palettes 5300
- Class A / class B fires
- 7400 liter Diesel
- 30 / 100 MW
- 80 files measuring data, 0,5 GB
- longitudinal ventilation / semi transversal ventilation
- ~ 700 files video data, ~ 67 GB
- 0 – 6 m/s air velocity

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SOLIT² - Measurements

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SOLIT² - Measurements

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SOLIT² - Measurements and Testing

60MW pool fire

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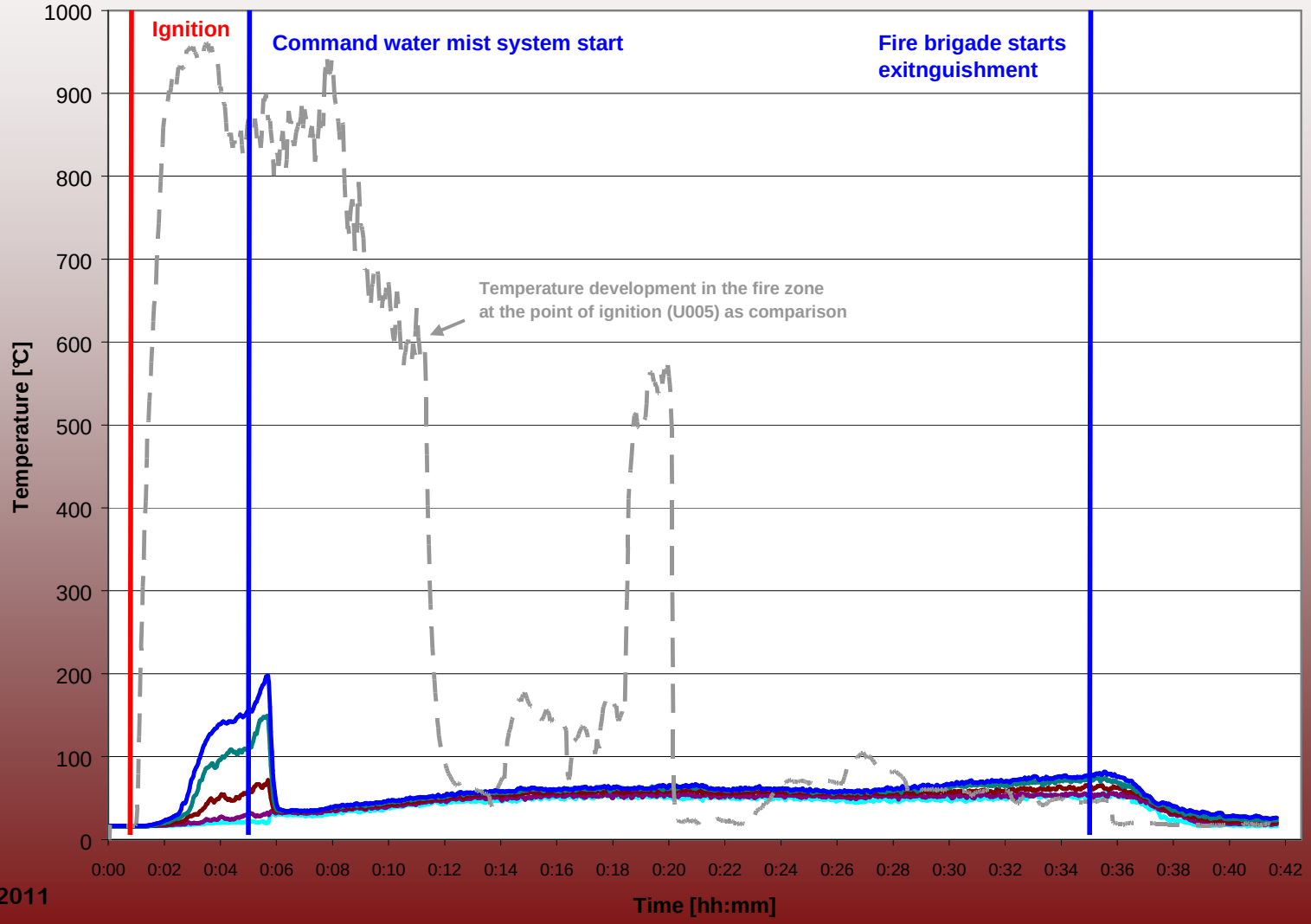
Results - Efficiency

- Truck Fire 150MW - temperatures 10 m behind fire Load



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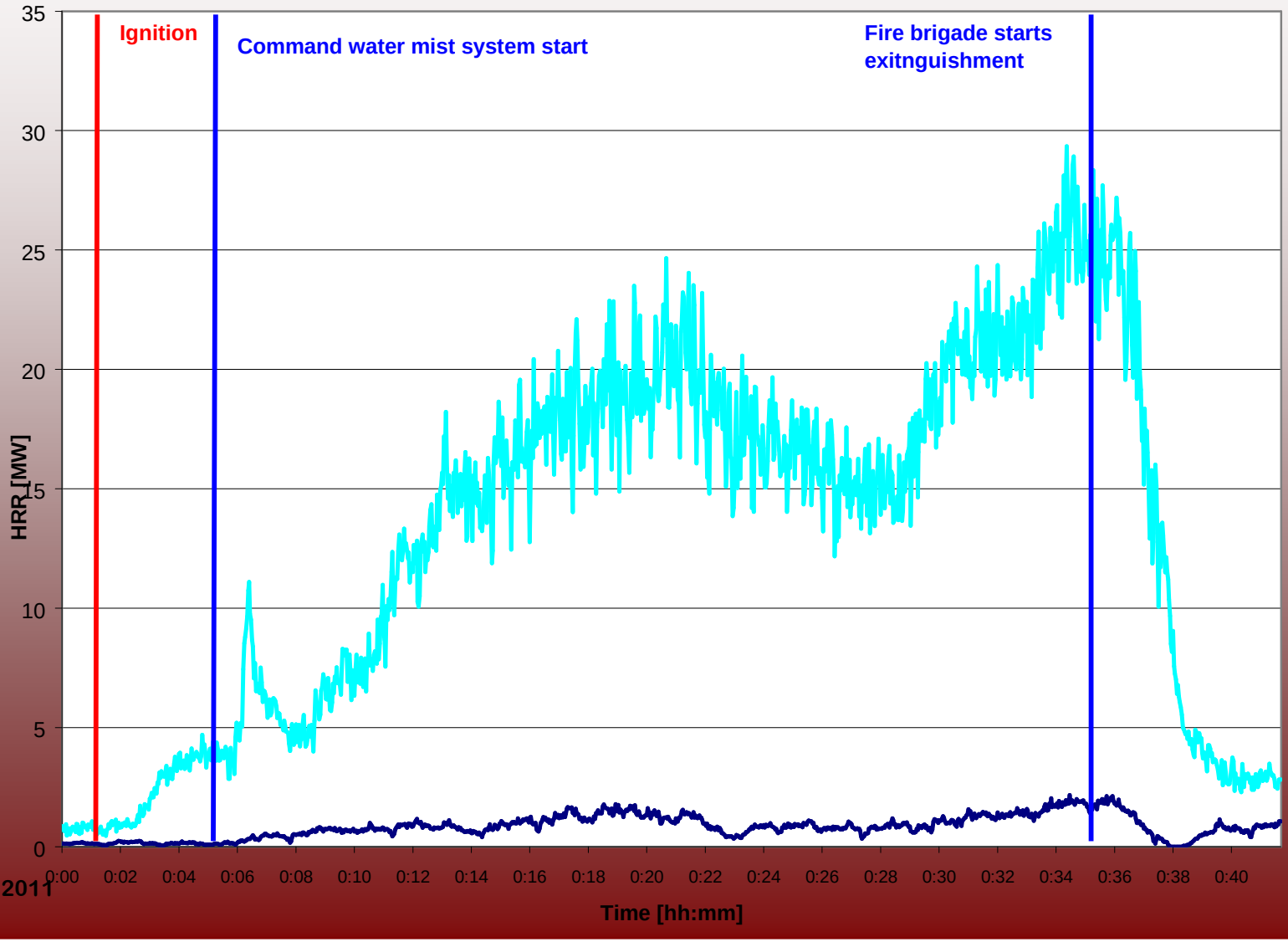
Results - Efficiency

- Truck Fire 150MW - HRR



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Results - Efficiency

- Development of fire
  - Extinguishment of fire
  - Cooling of surfaces
  - Reduced heat flux
  - Reduction of back layering

Results – Compensation Ventilation

- Thermal imager film

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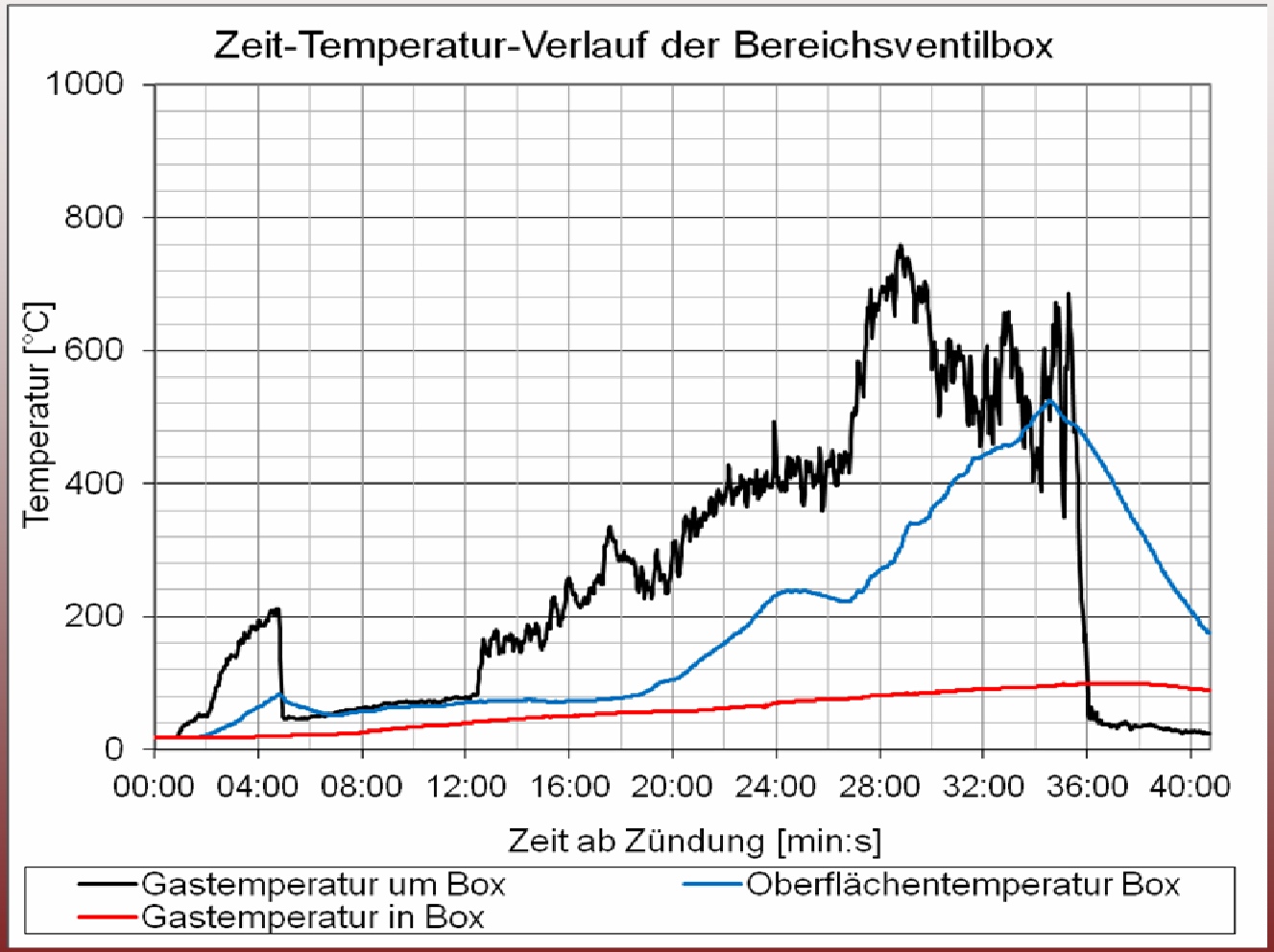
Results – Compensation Structural Protection

- Components
  - Concrete plate on ceiling
  - Main pipe
  - Section pipe with nozzles
  - Section valve with insulation box

- Location
  - In the fire zone and between fire load and target

Results – Compensation Structural Protection

- Temperatures of section valve box



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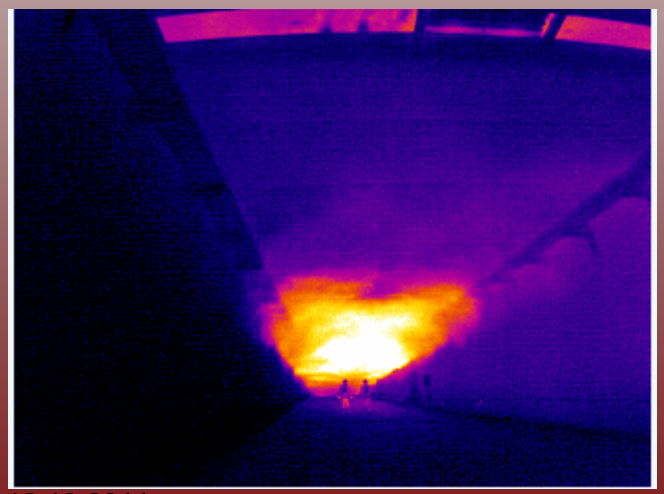
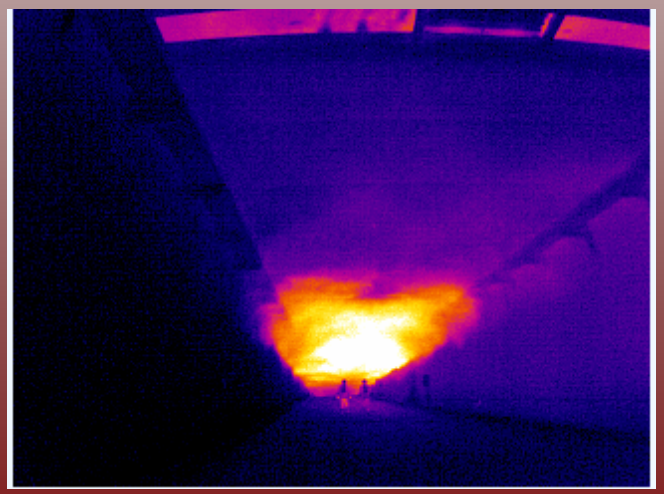
Results – Compensation Structural Protection

Results – Operation Conditions

- Operation conditions
  - *Within the activated water mist sections*
    - Visual range: up to 4 m
    - Possible orientation by light sources: yes
    - Influence of heat radiation: low
  - *During the fire suppression*
    - Possible distance to suppress the fire manually : 2 m
    - Suppression of the fire by the water mist system: strong





Comparison of HPWM vs. Deluge

- HPWM
  - Better barrier for temperatures and heat radiation

- LP
  - Flames hit ceiling

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Comparison of HPWM vs. Deluge

Safety Objectives		HPWM		LP	
		Layout 1	Layout 2	Layout 1	Layout 2
Fire protection of tunel architecture	Reduced ceiling temperatures	from 10 m behind FL	from 10 m behind FL	from 40 m behind FL	from 10 m behind FL
	Reduced heat flux	✓✓	✓✓✓	✓	✓✓
	Prevention of fire spread	✓✓	✓✓✓	**FAIL**	✓✓
Before fire load (upstream)	Fire fighter‘s access/ Self rescue	✓✓✓ Unrestricted possible			
Behind the fire load (downstream)	Fire fighter‘s access	✓✓ from 40 m behind FL	✓✓✓ from 10 m behind FL	✓ from 100 m behind FL	✓✓ from 40 m behind FL
	Self rescue	✓✓ from 60 m behind FL	✓✓✓ from 40 m behind FL	**FAIL** from 200 m behind FL	✓✓ from 60 m behind FL

✓✓✓ fully fulfilled ✓✓ fulfilled to a limited extend ✓ barely fulfilled

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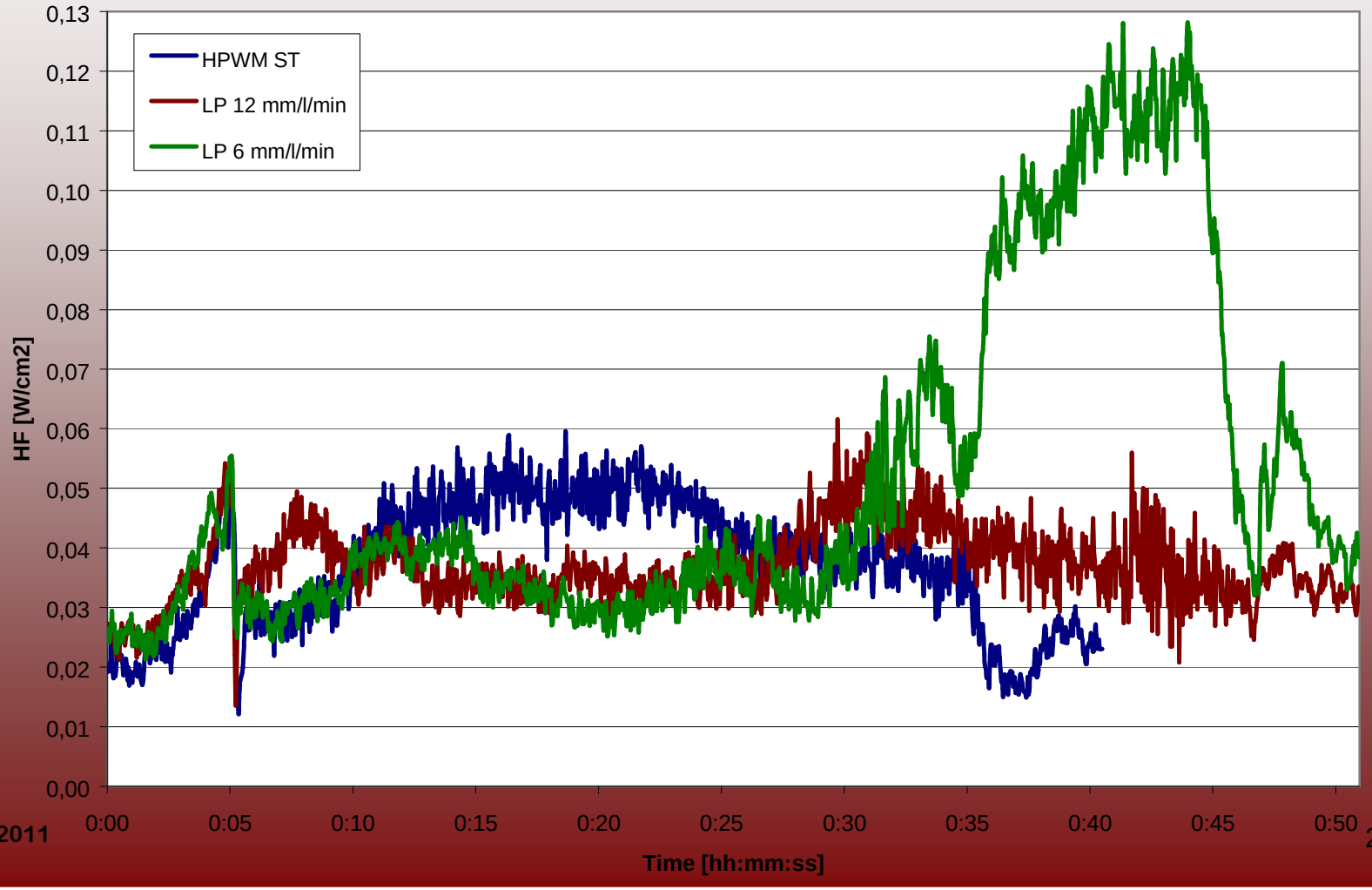
Comparison of HPWM vs. Deluge

- Example Heatflux



Conclusions

- FSSS are accepted as state of the art measure to improve safety in tunnels
- Until today the systems are used as additional safety measure
- The major aim of FFFS in future is either reduce costs with the same safety level or improve safety with same costs as today
- SOLIT² focuses on the integration and compensation
- SOLIT² will generate data as base for risk analysis
- SOLIT² will publish a engineering guidance
- <u>Assumption: Transfer of findings on other underground facilities</u>

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Thank you very much for your kind attention!