Young Researchers Seminar 2013

Lyon, France , June 5-7 2013

Laboratoire d'Economie des Transports
Unité Mixte de Recherche du CNRS n° 5593
Université Lumière Lyon 2 - ENTPE

bast

An Innovative Expert System for Real Time Safety Management of Road Tunnels (ESIMAS)

Dr. Kalliopi Anastassiadou, Anne Lehan

Federal Highway Research Institute (BASt), Germany

ECTRI
European Conference of Transport Research Institutes

FERSI
Road Safety Research

Table of Content

- The Project / Consortium
- Safety in road tunnels - a particular challenge
- Real Time Safety Management System for Road Tunnels (ESIMAS)
- Federal Highway Research Institute (BASt)

The Project

ESIMAS

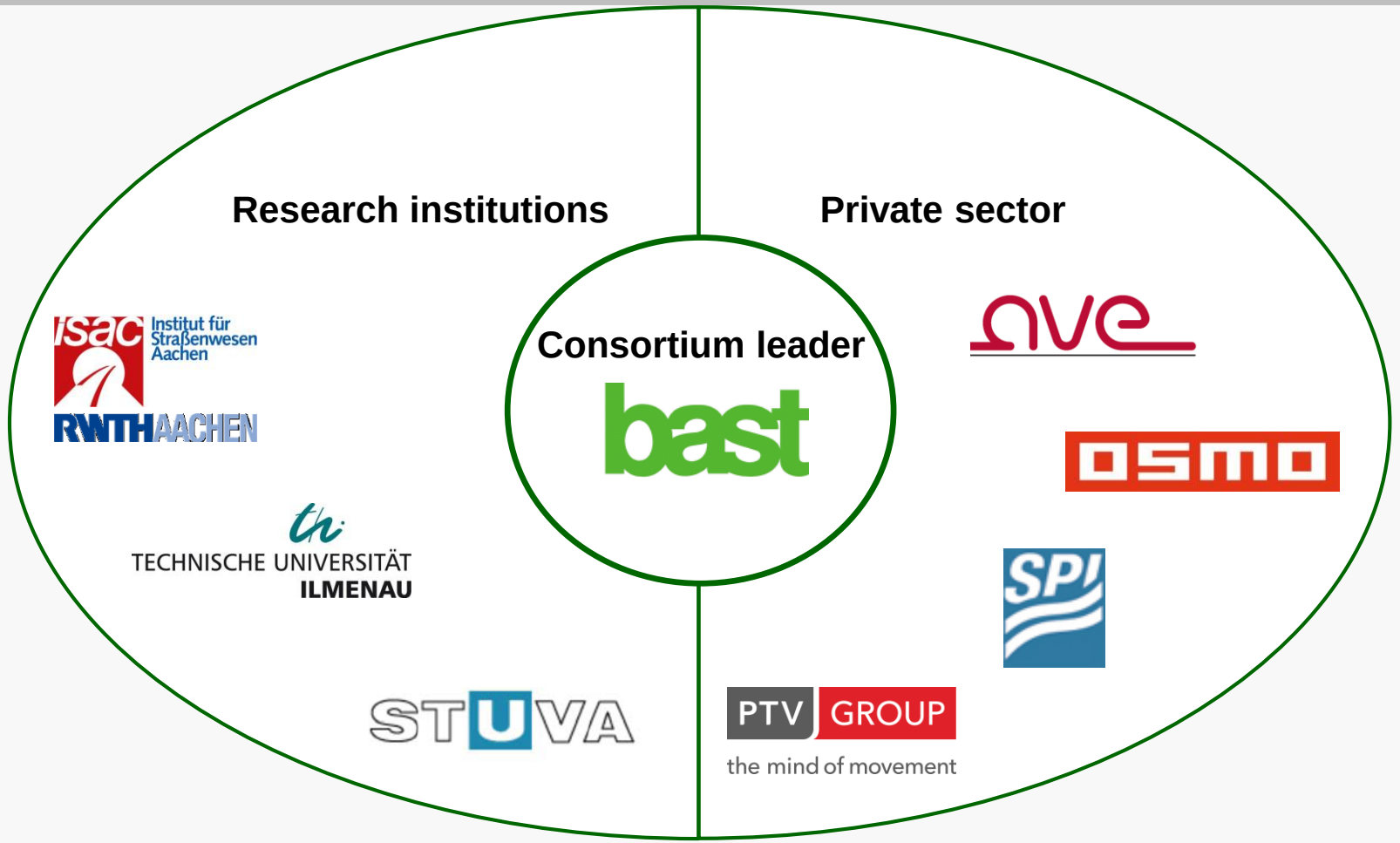
Echtzeit Sicherheits-Management System für Straßentunnel (ESIMAS)

Real Time Safety Management System for Road Tunnels

Funded by: Federal Ministry of Economics and Technology	3. Traffic Research Program of the German Federal Government: „Mobility and Transport Technology“	Promoted by: TÜVRheinland® Genau. Richtig.
Duration 3 years: 12/2011 – 11/2014		Joint project: interdisciplinary preparation by several project partners

Consortium

Joint Project



Safety in road tunnels - a particular challenge

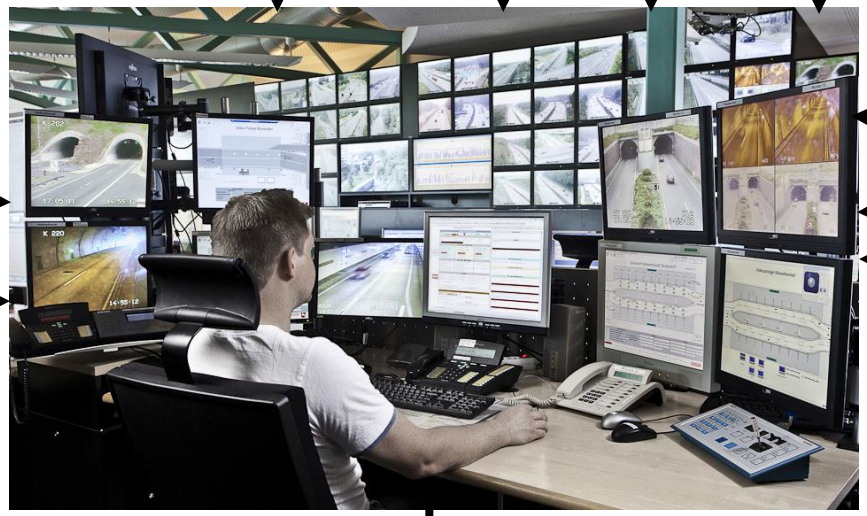
- Effective and safe transport infrastructure is essential to guarantee the mobility and supply of the population.
- Road tunnels have here a special meaning, as compared to the open road, where even smaller incidents such as overheated vehicle parts can cause major impacts, such as devastating fires with many casualties.
- Several fires in the Alpine tunnels have indicated this fact.
- To ensure the safety of road tunnels in Germany, tunnels with a certain length have to be monitored permanently by a tunnel control center (RABT 2006 & Directive 2004/54/EG).



Safety in road tunnels - a particular challenge

Video surveillance (static)
camera 1,camera 2, … camera n

Incident detection (Fire, Smoke, CO, Emergency Call, Alarm)



Tunnel a, b, …n

In case of an incident…

Evaluation of the safety situation by the Operator

Specified instructions for action (AGAP)

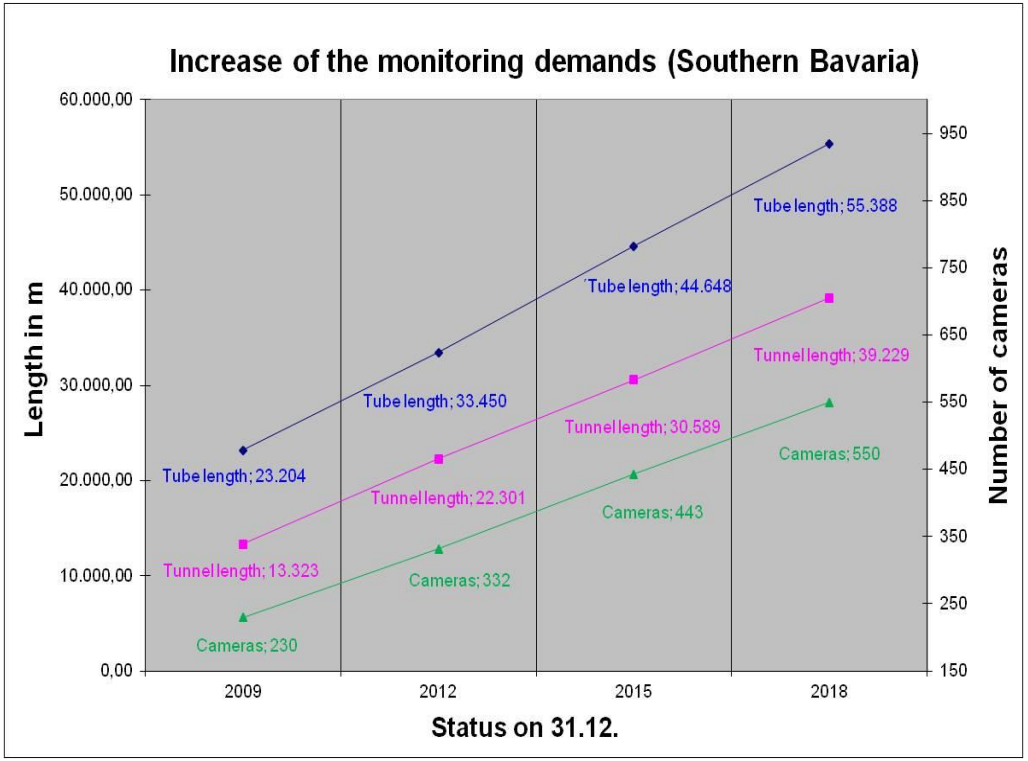
Measures

Safety in road tunnels - a particular challenge

The demand for the tunnel operators is continuously growing.

Decisive reasons for this are:

- The increase of traffic density
- The rising number of tunnels that have to be monitored
- The demand of higher safety levels

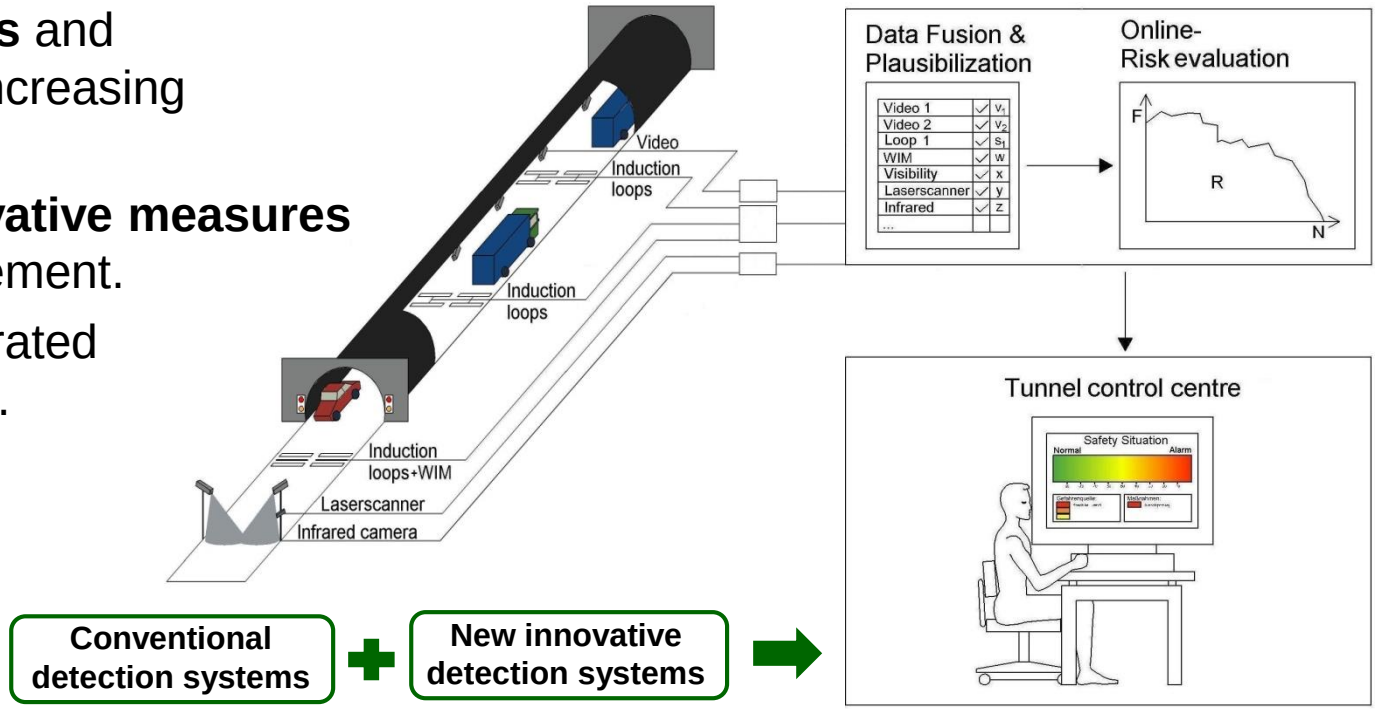


ESIMAS Goals

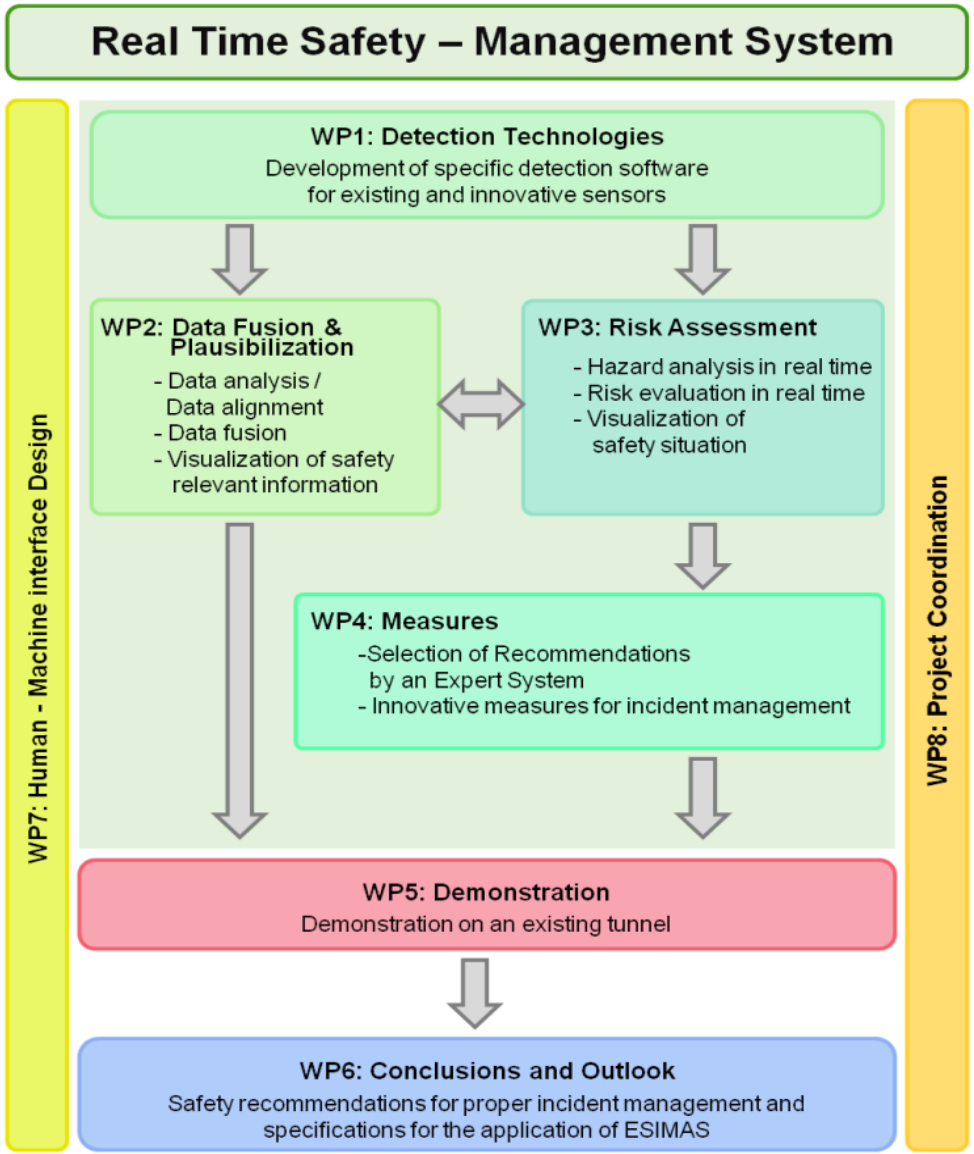
- **Decreasing the burden of the tunnel operators** by developing a partly automatic support system.
- **Holistic overview** instead of individual information.
- Continuous **risk** and **state evaluation in real-time**.
- **Prioritizing** of Information.

ESIMAS

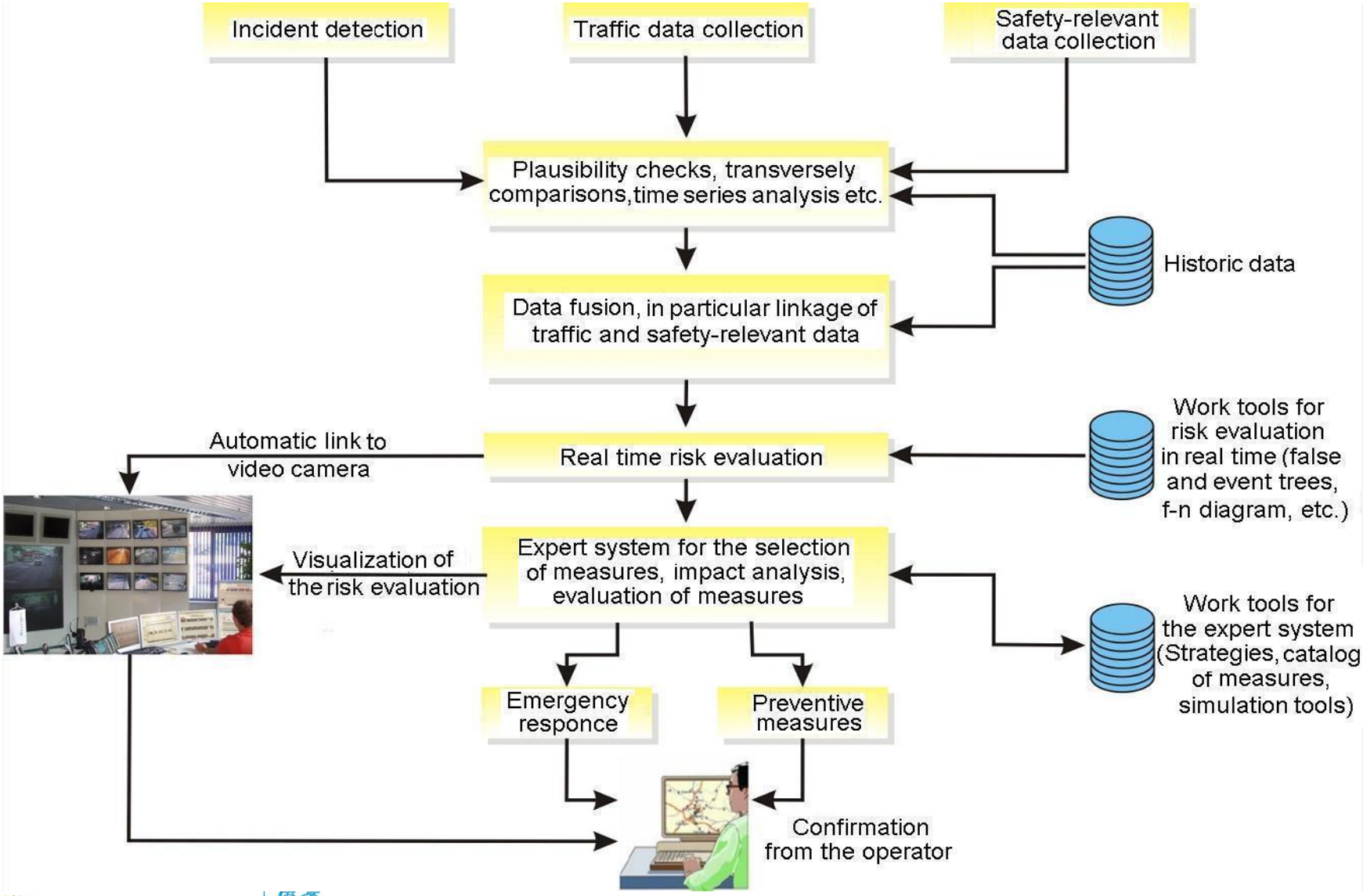
- **Automatic analysis** and **evaluation** of the increasing information density.
- Integration of **innovative measures** for incident management.
- Automatically generated **recommendations**.



Work Packages



Data flow and processing in ESIMAS



WP1: Detection technologies

- Combination conventional techniques with new detection technologies in order to increase the incident detection reliability.
- Fusion and plausibilization of the sensor data.

ESIMAS detection technologies

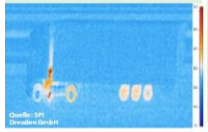
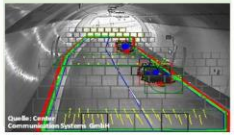
- Automatic incident detection (combination of induction loop and WIM)
- Hot spot detection (combination of infrared camera and laserscanner)
- Video detection

Conventional detection systems

CO measurement	Fire detection cable	Visibility measurement	Luminance camera
▪ Monitoring of the CO concentration	▪ Fire alarm by temperature variation	▪ Detection of particles in the air	▪ Determination the required level of illumination in the tunnel
			

Air velocity monitoring	Induction loops & Radar sensors	Video surveillance	Height control
▪ Determination of air flow velocity & direction of flow	▪ Traffic data (speed, flow, distance, composition)	▪ 24h surveillance of separate tunnel sectors	▪ Determination of the height of a vehicle
			

New detection systems

Infrared camera	Laser scanner	Automatic incident detection (Induction loop + WIM)	Video detection
▪ Detection of hot spots (e.g. overheating brakes, turbochargers)	▪ Recognition of the vehicle shape ▪ Classification of vehicles ▪ Composition of traffic flow ▪ Height control ▪ Estimation of the number of persons in the tunnel	▪ Detection of: ▪ Too low velocity ▪ Vehicle break-down / stop of a vehicle ▪ Topic traffic jam ▪ Wrong-way driving ▪ Traffic data ▪ Vehicle identification	▪ Traffic Jam ▪ Vehicle break-down / stop of a vehicle ▪ Too low velocity ▪ Objects or persons on the road ▪ Wrong-way driving ▪ Smoke ▪ Fire ▪ Accident
			
SPI Dresden GmbH	SPI Dresden GmbH	ave Verkehrs- und Informationstechnik GmbH	Institut für Straßenwesen, RWTH Aachen

WP1-2: Detection technologies

M: Main information
S: Sub-information

Detectable incidents	Conventional detection systems					New detection systems			
	Visibility measurement	CO-Measurement	Fire detection cable	Induction loop	Luminance camera	Video detection	Automatic Incident Detection	Laserscanner	Thermal imaging camera
Fire of a vehicle	S	S	M		S	M		M	M
Too low / too high speed				M		M	M		
Traffic jam				M		M	M		
Congested traffic				M		M	M		
Accident / collision				M		M	M		
Too low safety distance				M		M	M		
Reversing, turning				M		M	M		
Wrong-way driving				M		M	M		
Objects on the road						M			
Persons on the road						M			
Smoke development at a vehicle	S	S			S	M		S	S
Vehicle break-down / stop of a vehicle				M		M	M		
Overheating (vehicle parts, cargo)								M	M

WP 2: Incident classification

55. detectable incident causes classified by the operators

(Classification: 1-10
From not very relevant 1
to extremely relevant 10)

1	Overload	1,29
2	Inappropriate speed (too high / too low)	3,29
3	Too short safety distance between vehicles (e.g. by sudden braking)	3,43
4	Current traffic volumes and compositions	3,57
5	Smoke development from outside the tunnel (Smoke flow in travel direction)	4,86
6	Entry of hazardous materials inside the tunnel (combustible)	5,57
7	Technical disorder (Tunnel equipment: operating system)	6,71
8	Congested traffic	6,71
9	Poor road conditions (e.g. oil, moisture)	7,00
10	Persons inside the Tunnel (at the edge of the road, outside the danger area)	7,00
11	Conspicuous driving behavior , e.g. snaking drive, sudden lane changes	7,14
12	Traffic jam (on every traffic lane)	7,14
13	Traffic jam (on some traffic lane, e.g. at exits)	7,29
14	Stop of a vehicle (vehicle breakdown/technical defect) (car) breakdown bay	7,29
15	Wrong-way driving	7,57
16	Overheating (vehicle parts, cargo)	7,57
17	Fire of a vehicle (including cargo)	7,71
18	Accident with involment of hazardous materials (health risk)	8,00
19	Animals inside the tunnel	8,00
20	Inappropriate speed (too high / too low)	3,29
21	Too short safety distance between vehicles (e.g. by sudden braking)	3,43
22	Current traffic volumes and compositions	3,57
23	Smoke development from outside the tunnel (Smoke flow in travel direction)	4,86
24	Entry of hazardous materials inside the tunnel (combustible)	5,57
25	Technical disorder (Tunnel equipment: operating system)	6,71
26	Congested traffic	6,71
27	Poor road conditions (e.g. oil, moisture)	7,00

WP 2-3: Risk analysis and risk evaluation

Detectable incident causes

55. classified by the operators

Conventional and innovative detection technologies

Detectable incidents

1. Accident / collision
2. Vehicle break-down / stop of a vehicle
3. Overheating
4. Smoke development
5. Persons / Objects on the road
6. Fire / smoke
7. Traffic jam / Congested traffic
8. Wrong-way driving, Reversing, turning

Risk = occurrence probability * degree of damage

Initial incidents

Risk values

1. Accident / collision
2. Fire / smoke
3. Involvement or realease of hazardous materials

Initial incidents

New risk values

After taking appropriate measures

WP 4: Measures

- General emergency plans (AGAP) of each German state.
- These emergency plans are available for each tunnel and usually exist only in paper form.



- Visualization of measures and recommendations for incident management.
- Development of innovative measures for both already occurred incidents and recommendations for risk situations, where no incident has happened.
- Consideration several incidents occurring in the same time.

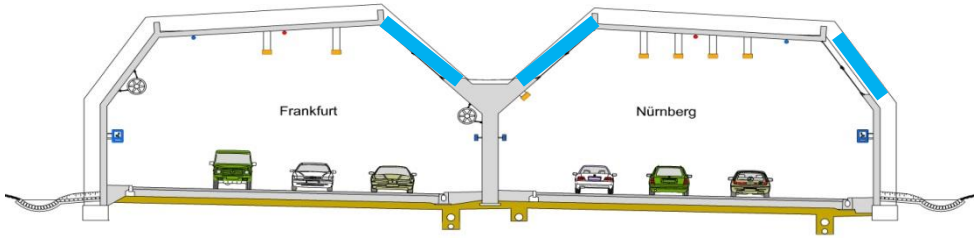
Prevention

WP 5: Demonstration

- The overhead noise barrier Goldbach-Hoesbach in North Bavaria (Highway A3)
- Tunnel sector of the north tube towards Frankfurt (L > 1.3 Km)
- High traffic density (DTV>80.000)
- Specific construction characteristics

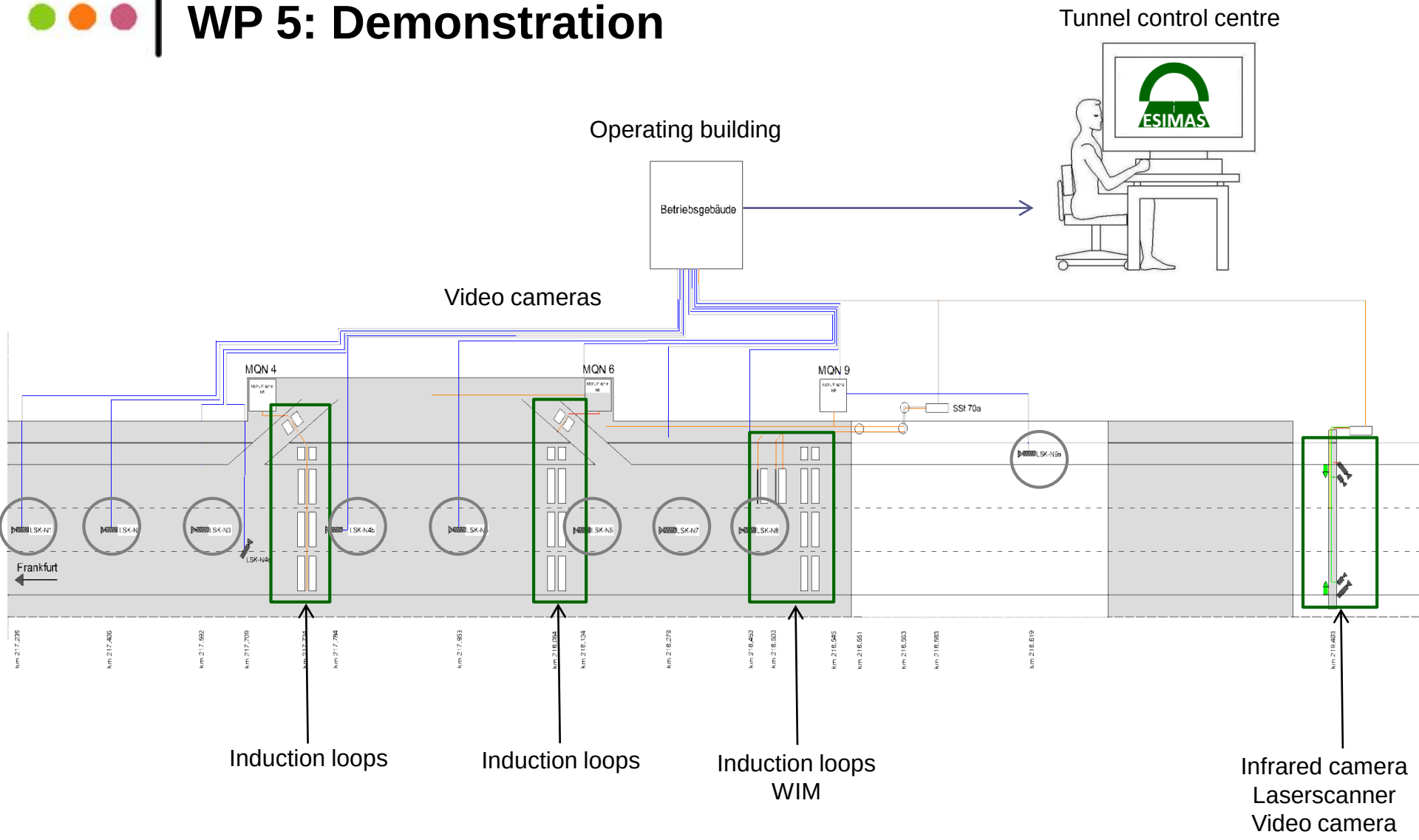
  e.g.
  - 1.440 hydraulic windows
  - Box cross section







WP 5: Demonstration



WP 5: Demonstration

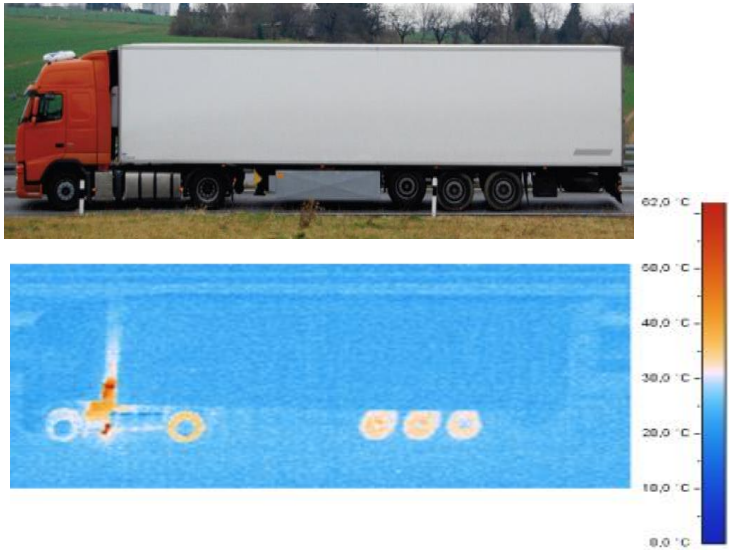
AID (combination of Induction loop & WIM)



Hot spot detection (combination of infrared camera & laser scanner)

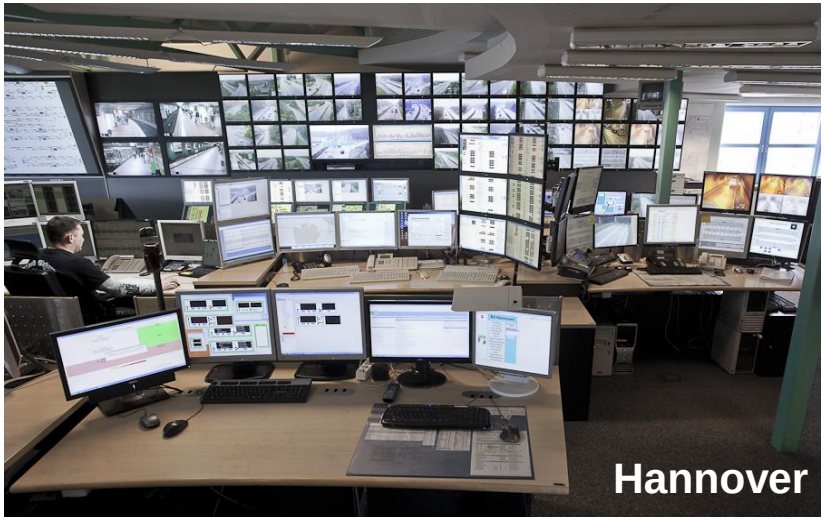


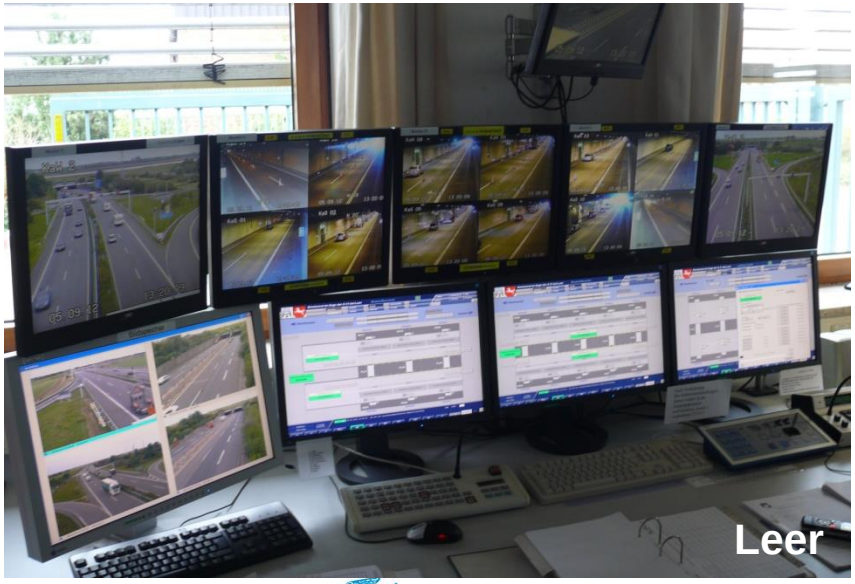
Video detection (3D Tracking)



Tunnel control centres in Germany

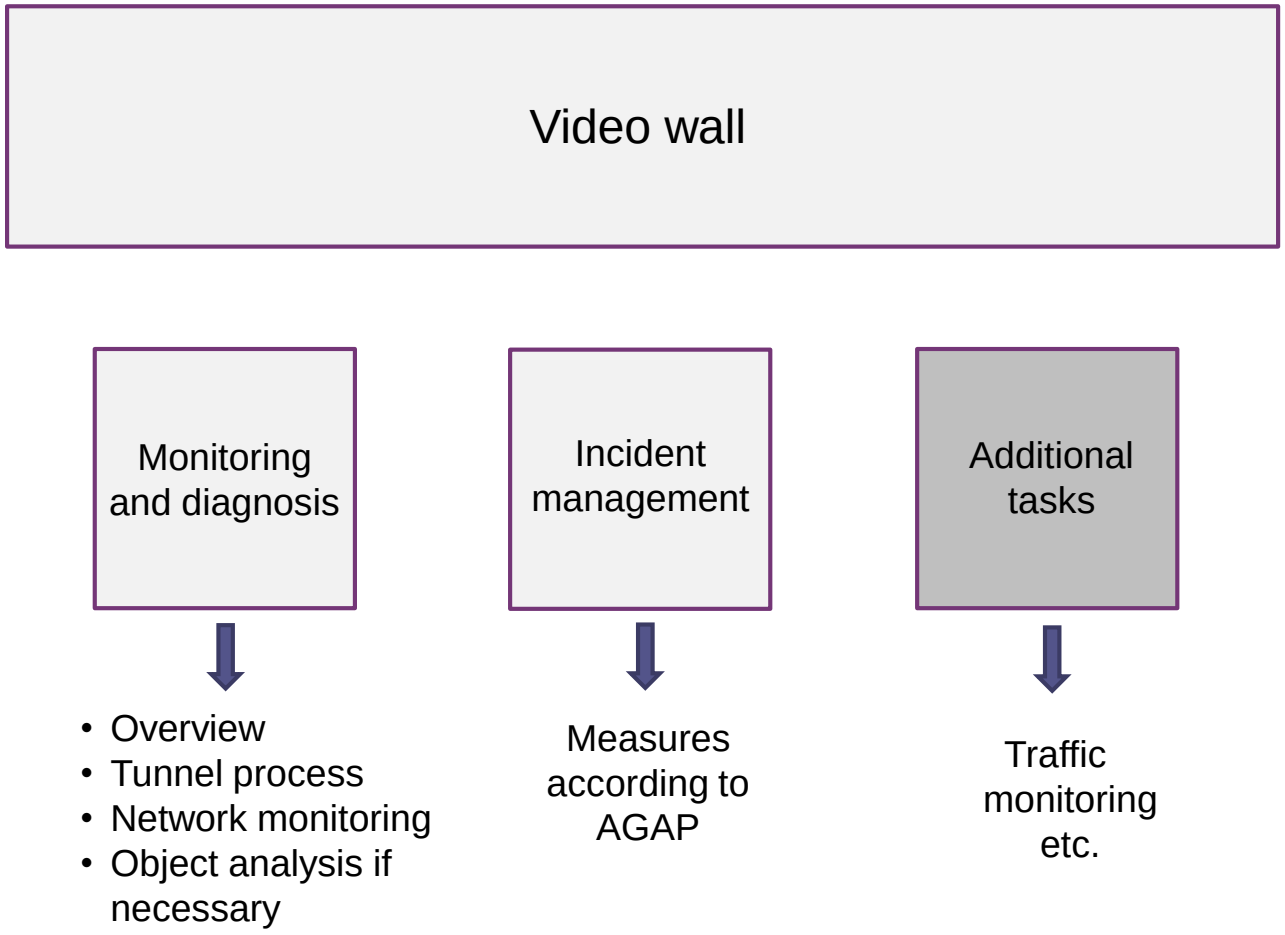




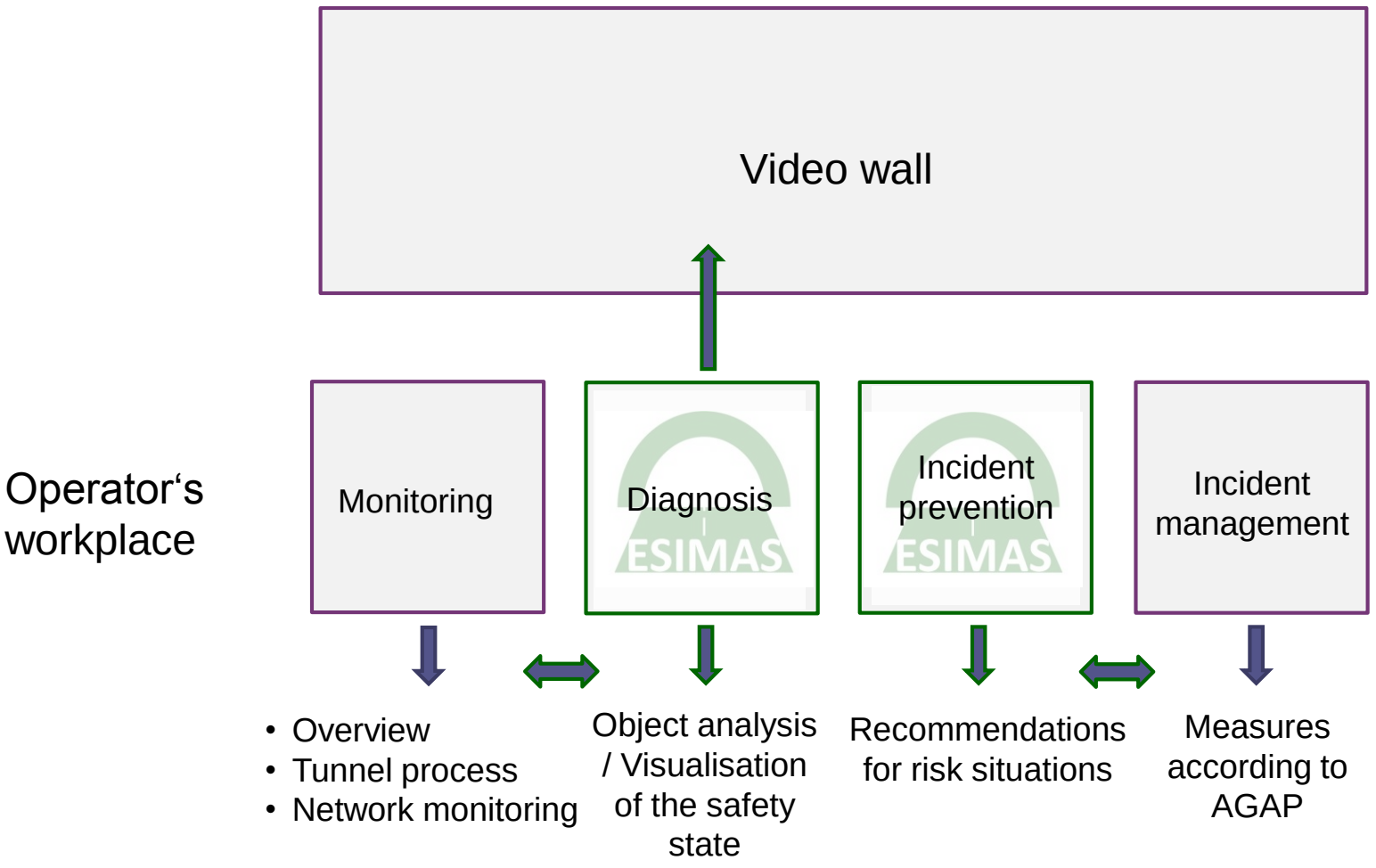




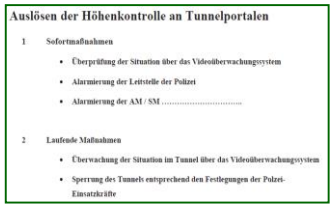
Tunnel control centre: Status Quo

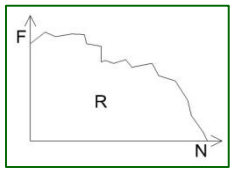


Tunnel control centre: with ESIMAS

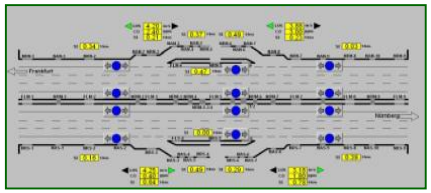


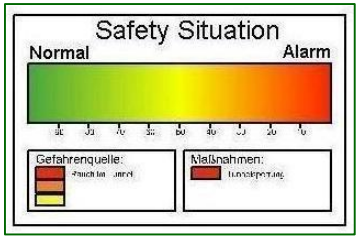
Visualization Concept

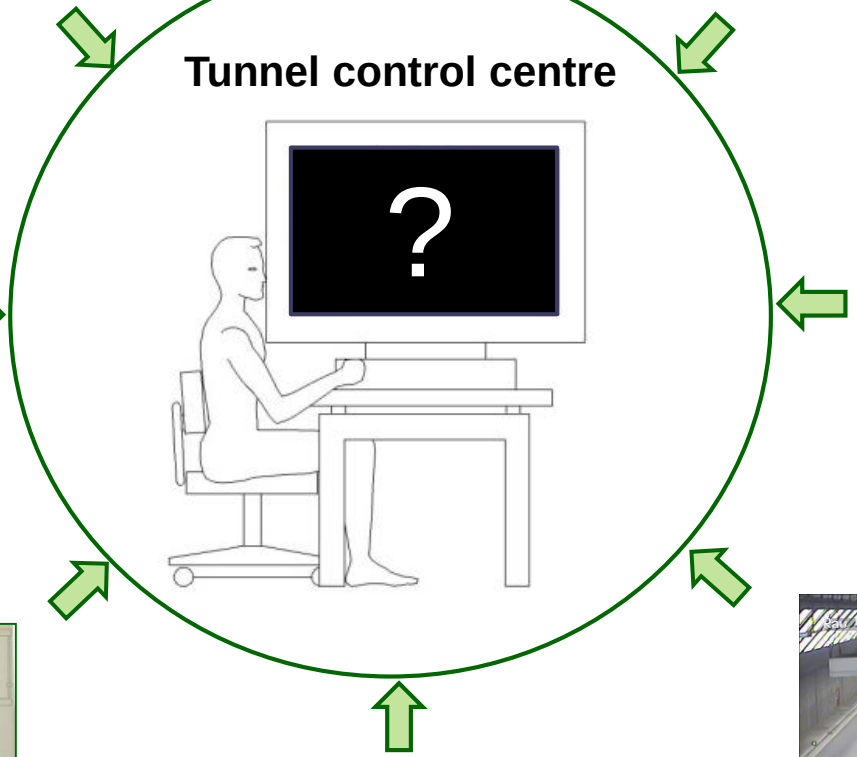


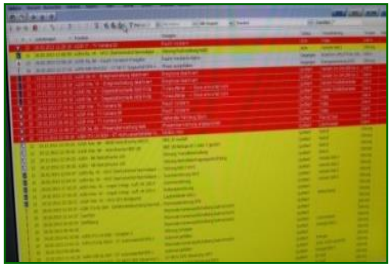


Video 1	✓	v_1
Video 2	✓	v_2
Loop 1	✓	s_1
WIM	✓	w
Visibility	✓	x
Laserscanner	✓	y
Infrared	✓	z
...		









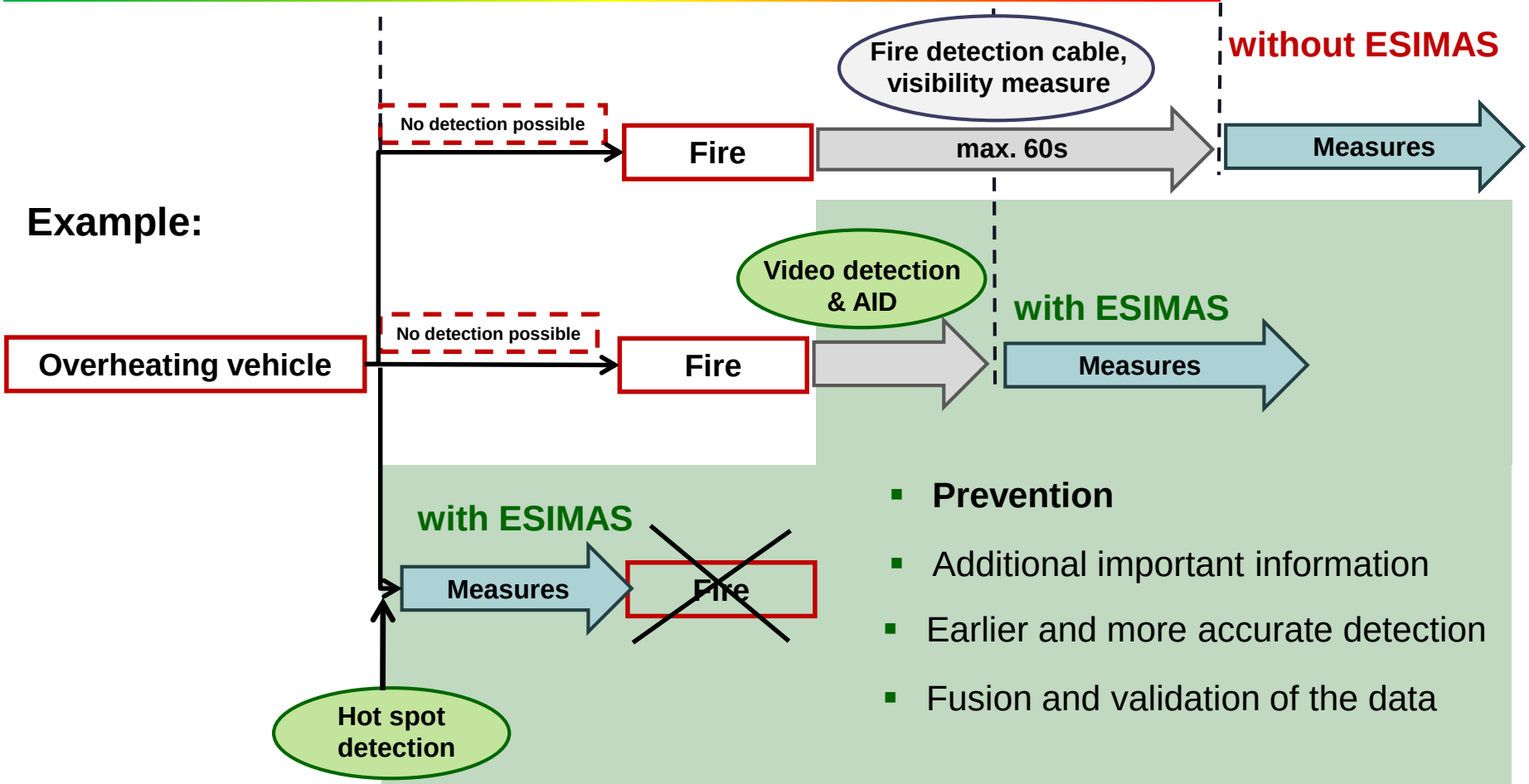






Conclusion and outlook: ESIMAS Safety aspects

Factor: Time



- **Prevention**
- Additional important information
- Earlier and more accurate detection
- Fusion and validation of the data

Conclusion and outlook

- The essential scope of the ESIMAS Expert System is to increase safety in road tunnel by minimizing significantly the work load of the operators in the tunnel control centers.
- Through the use of new and improved detection systems and integrated risk assessment in real time, the operator shall be provided with a tool to gain an overview of the entire safety situation of all monitored tunnels.

Considerations

- Significant attention has to be given to the minimization of false alarms, as it is expected with any other acceptance of the operators of the system.
- However, especially in the first test phase where the system will be set with a very sensitive mode, it is to be expected that in particular for the detection of risk situations a continuous calibration and parameterization must be performed.
- Hopefully after a successful testing and operational phase at the demonstration tunnel, the developed expert system will be modified and used for other tunnels.

Acknowledgements

The project is funded by the German Federal Ministry of Economics and Technology (BMWI) under the program "Mobility and Transport Technology". The contributions by all members of the consortium are gratefully acknowledged.

For further information about ESIMAS please visit www.esimas.de or direct contact esimas@bast.de.

Federal Highway Research Institute (BASt)

- Technical and Scientific Research Institute
- Responsible to the Federal Ministry of Transport, Building and Urban Development (BMVBS)
- Approximately 400 Employees
- Place of Training and Education

Responsibilities

- Scientifically Sound Decision Support on Technical Issues and Questions of Traffic Policy for the Ministry
- Drawing up of Regulations and Standards at National and European Level

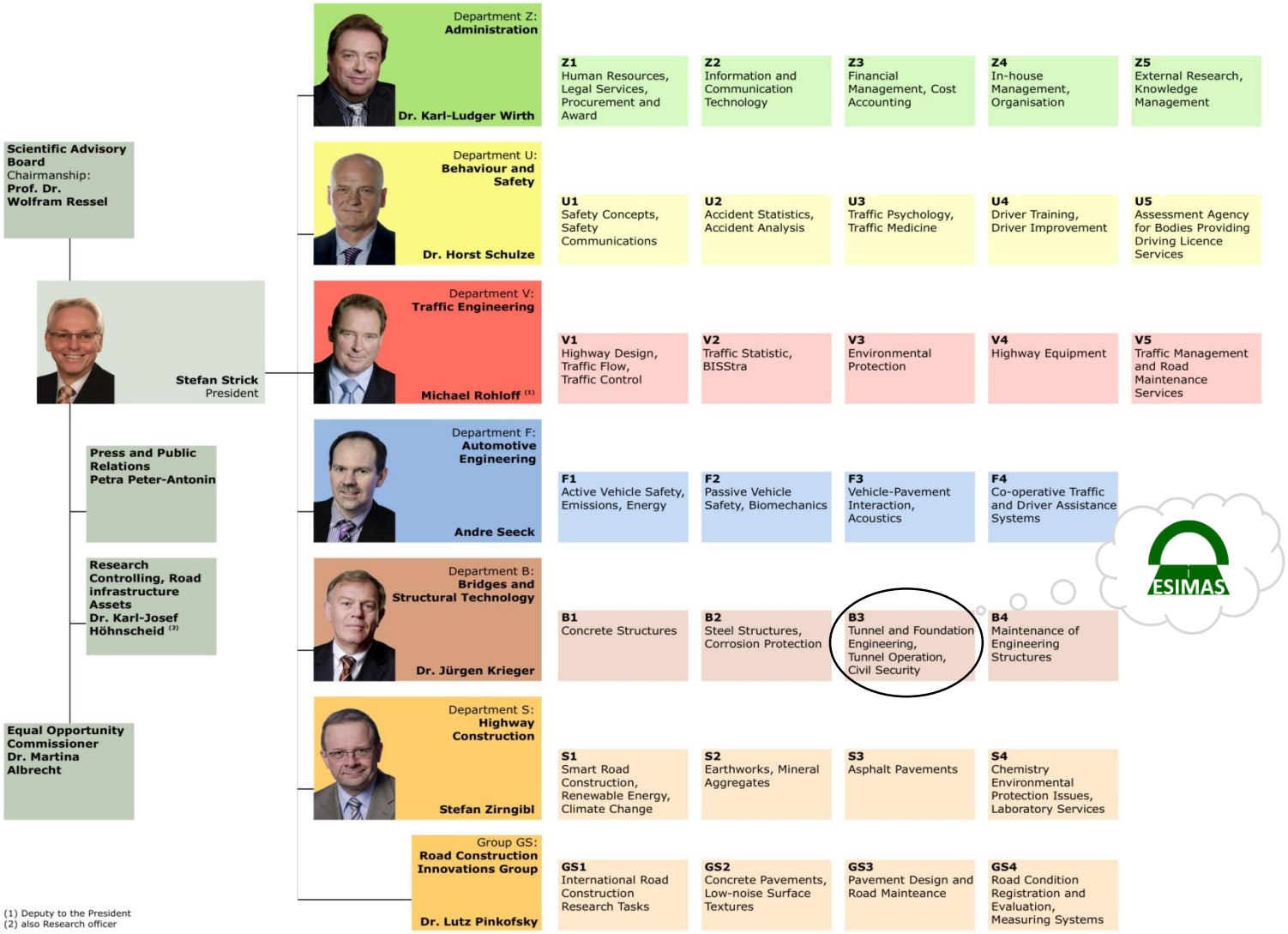
Location and Tasks



- Founded in 1951
- Since 1983 in Bergisch Gladbach - Bensberg near Cologne
- Office and Laboratories
- 10 Halls with Testing Facilities

- Research
- Advice
- Tests
- Standards

Devisions & Sections



Thank you for your attention!