Sensing Car

Den skannande bilen

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Teknologiasta liiketoimintaa

Need for Advanced Sensor Systems in Vehicles

- Driver assistance and driving safety have been the main motivators for the adoption of advanced sensor systems in vehicle development
- Driver errors account for more than 90 % of accident causes

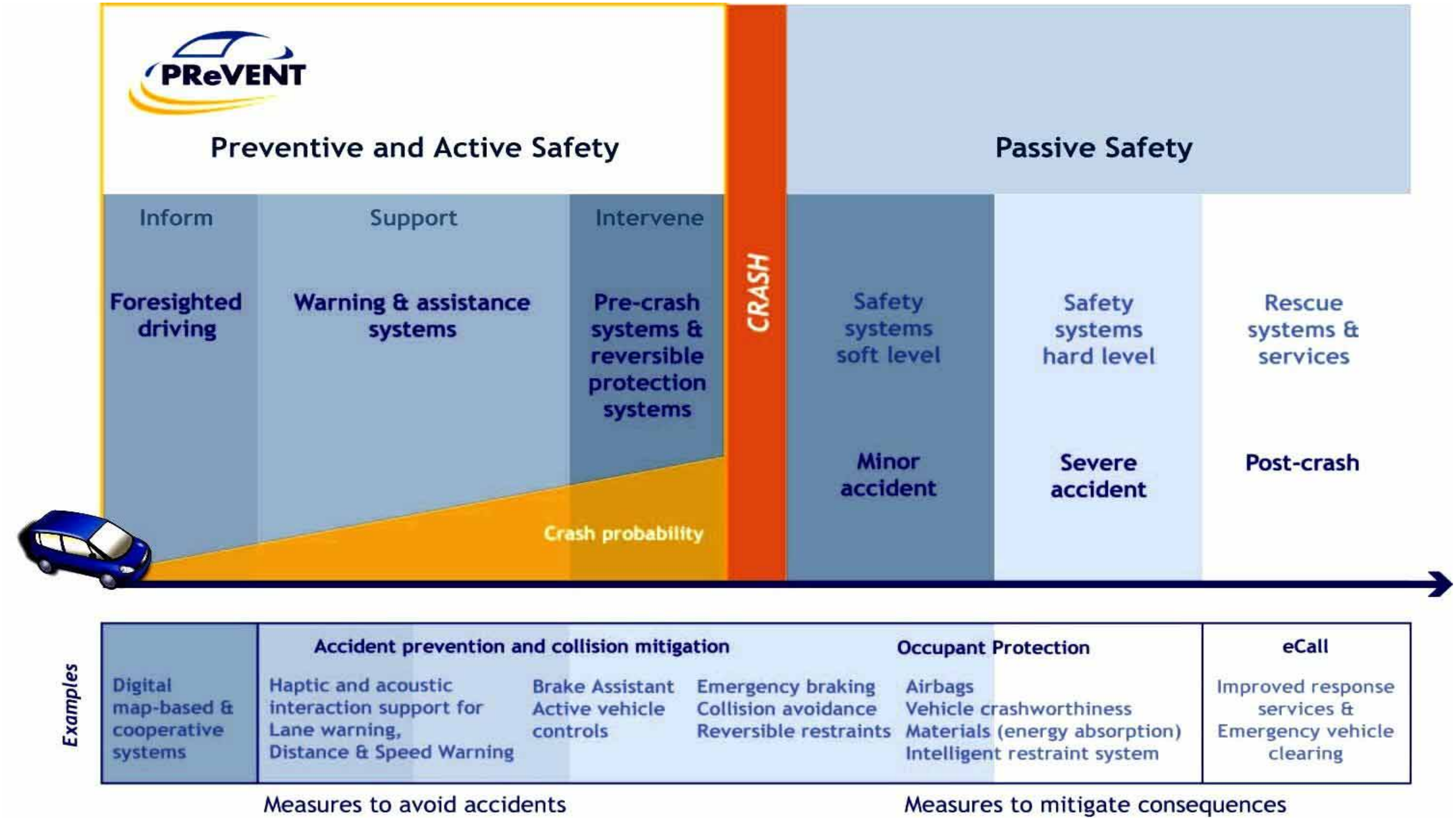
1. Environmental sensing (e.g. camera, laser scanner) for detection of obstacles, other road users, weather conditions, even threats
2. Driver monitoring (e.g. measuring gaze direction with a camera) for detecting sleepiness, distraction and drunk driving. Also for being able to adapt the vehicle HMI
3. Other sensing such as vehicle diagnostics, driving situation identification, mobile phone ringing, map-based calculations, cooperative systems, road tolls, vehicle identification etc

→ Assist in foresighted driving, warn when necessary and activate safety systems

PReVENT

- Preventive and active safety, ‘ennalta ehkäisevää ja aktiivista turvallisuutta‘
- Large 55 M€ Integrated Project (IP), consisted of several subprojects including driver assistance system prototypes, sensor technology, legal and safety aspects
- February 2004 – March 2008

- Mainly the applications were based on environmental sensing and utilizing map data. Also some cooperative functions were demonstrated.
- „Virtual safety belt“ around the vehicle
- Environmental sensing is never 100 % reliable so much effort was put in eliminating false alarms and considering accident types where assistance systems can be most effective and reliable.
- Fully autonomous operation is still far away in the future.


PReVENT
Preventive and Active Safety
Passive Safety
Inform
Support
Intervene
CRASH
Foresighted driving
Warning & assistance systems
Pre-crash systems & reversible protection systems
Crash probability
Safety systems soft level
Safety systems hard level
Rescue systems & services
Minor accident
Severe accident
Post-crash
Examples
Accident prevention and collision mitigation
Occupant Protection
eCall
Digital map-based & cooperative systems
Haptic and acoustic interaction support for Lane warning, Distance & Speed Warning
Brake Assistant Active vehicle controls
Emergency braking Collision avoidance Reversible restraints
Airbags Vehicle crashworthiness Materials (energy absorption) Intelligent restraint system
Improved response services & Emergency vehicle clearing
Measures to avoid accidents
Measures to mitigate consequences

Comparison of Sensors for Active Safety

- **Radar, Lidar**
  - Accurate range and velocity data, but doesn’t measure the target shape (point measurement)

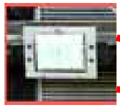
- **Laser scanner**
  - Good range and lateral resolution, but bulky and rotating mirror required. Currently still expensive (> 10 000 euro) but price dropping
  - Recent developments: improved operation in bad weather conditions (rain)

- **Stereo Vision / Camera systems**
  - High resolution, but depth information error-prone
  - High computational requirements
  - Also driver monitoring

- **Other**
  - Ultrasound sensors for close range measurements
  - 3D imaging e.g. with prototype low cost CMOS camera & laser
  - Special sensors available e.g. for detecting biological hazards

Fitting the Sensors into Vehicles

CMOS camera



Radar

Short range radars

Radar

Laser scanner

Ultrasound sensors

Alternative Approach… a Measurement Vehicle…

PReVENT Applications:
Collision Mitigation Systems

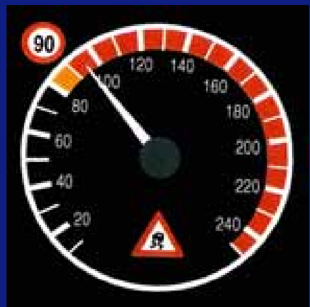
Collision mitigation benefits

- Vehicle is allowed to take action when crash is unavoidable – „innovation“
- Fast reaction time, optimal braking power
- Pre-tensioning of safety belts
- If collision speed is reduced by 20 km/h, the positive effect in fatalities can be as large as 10-20%

Challenges

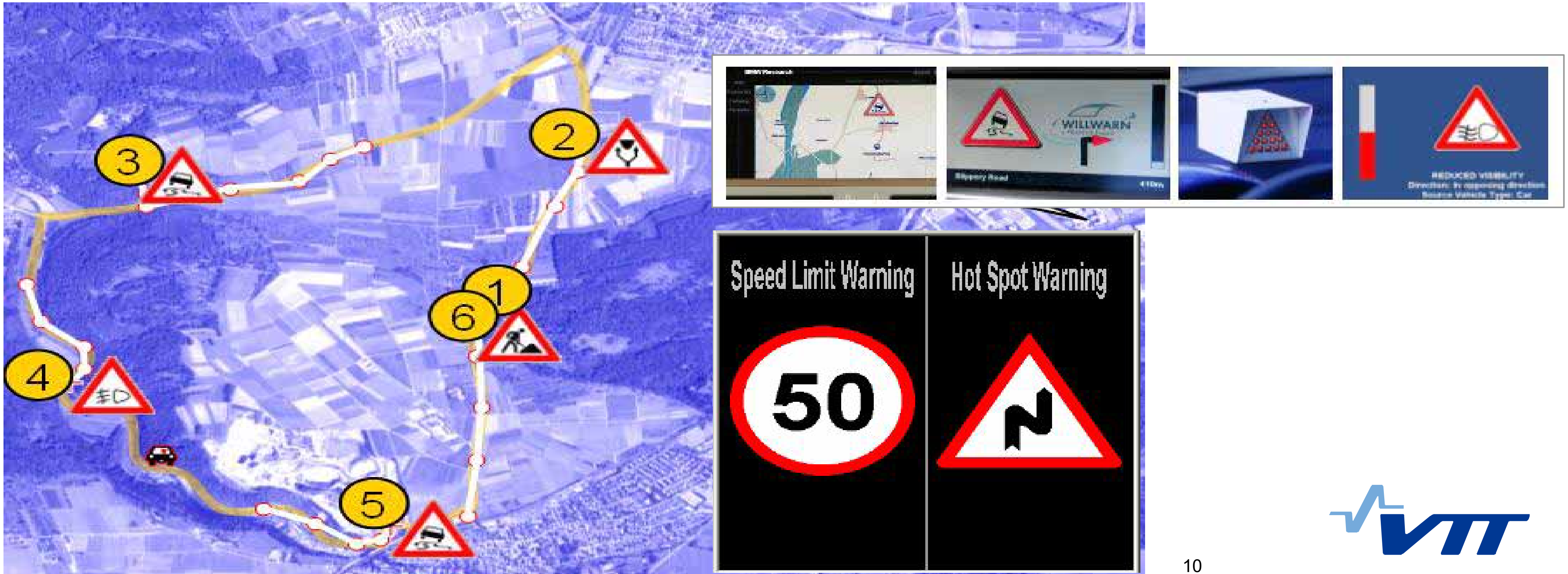
- The reliability and accuracy of environmental sensing (e.g. detecting pedestrians in night time), classification of objects (pedestrian carrying a 42“ LCD?)
- Classification of driving situations: the likelihood of collision when road friction and driver‘s performance not known
- The behavior of other road users?

PReVENT Applications:
Safe Speed and Distance

	Normal condition	Safe speed < speed limit	Too short (1 - 2 sec)	Much too short (< 1 sec)
Visual				
Acoustic	-	-	-	“Warning, keep distance”
Haptic	Pulsating pedal or Force feedback *At speed limit*	Pulsating pedal or Force feedback *At safe speed*	Pulsating pedal or Force feedback	Pulsating pedal or Force feedback

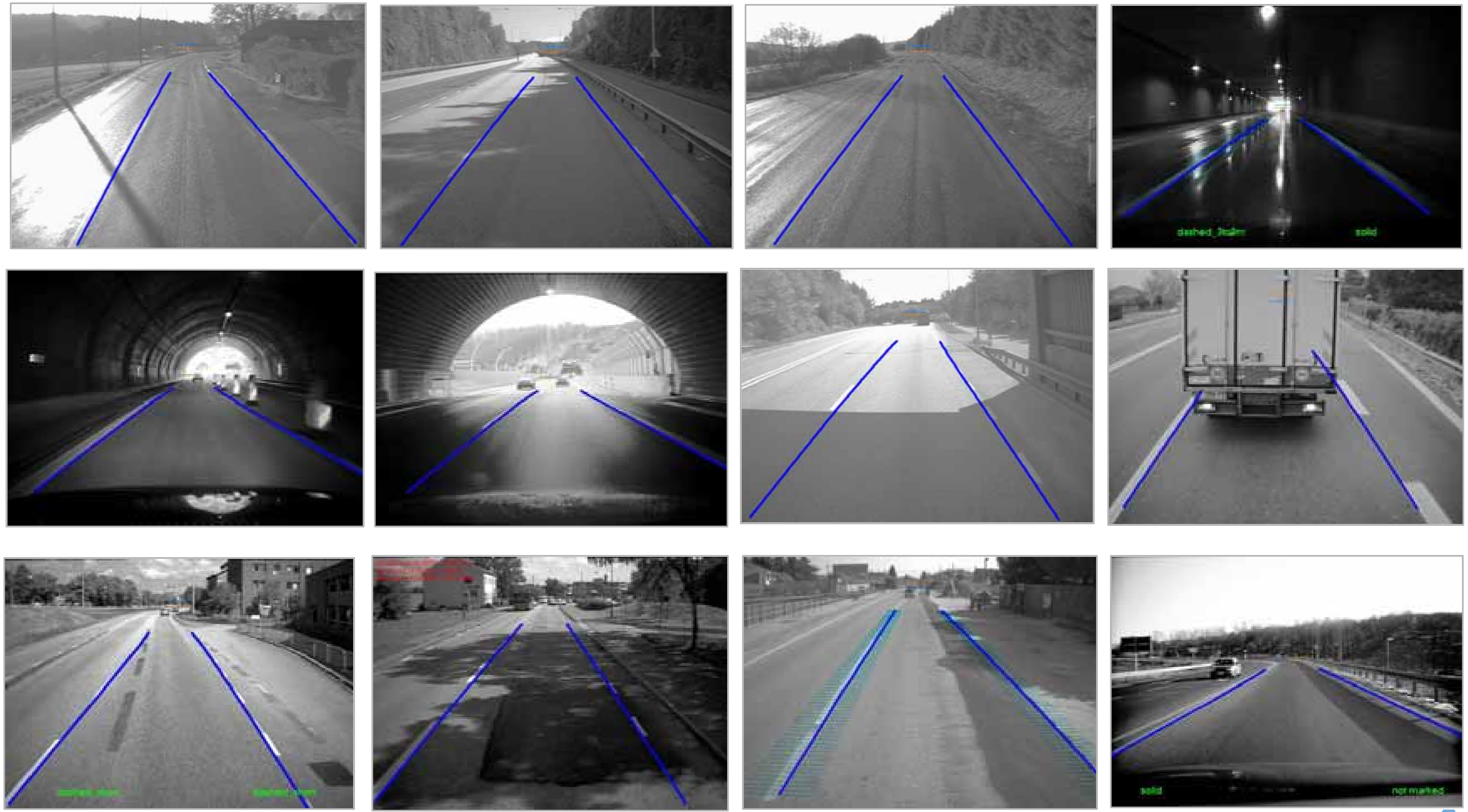
PReVENT Applications:
Map and Sensor Based Warning Systems

- Map-based warnings of road works, dangerous locations (hot/black spots, obstacles, low friction, low visibility)
- Speed limit information and warnings
- Warnings on navigator display. HMI should be informative and not disruptive
- Cooperative demonstrations: warnings sent by other vehicles over a radio link



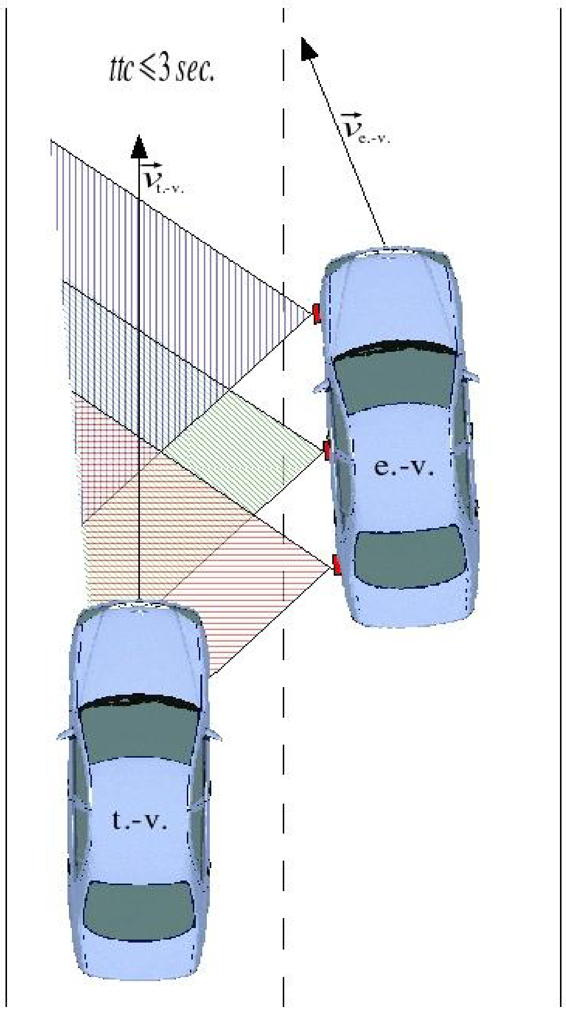
PReVENT Applications: Lane Keeping

- Improvements in adverse weather conditions and situation awareness. Vibrating steering wheel warns the driver.

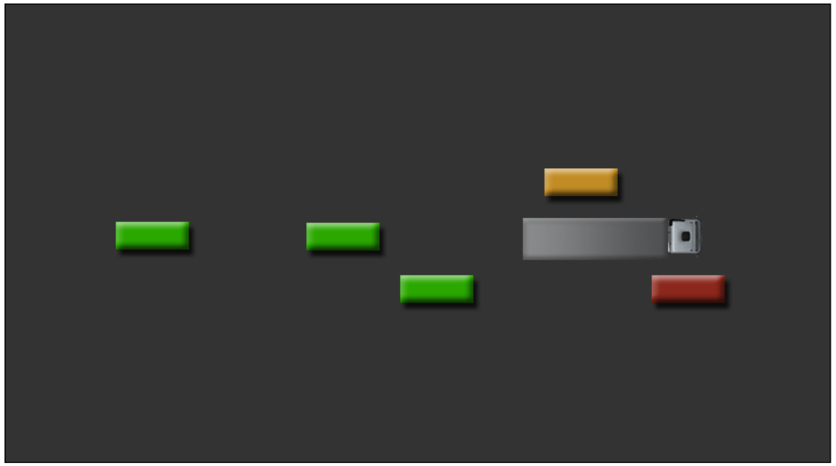


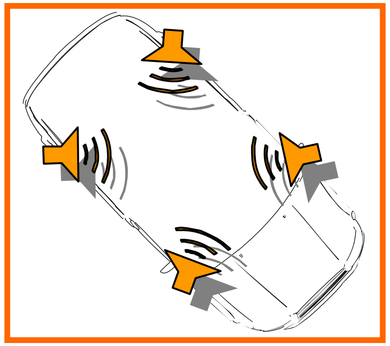
PReVENT Applications: Lateral Safety, Blind Spot Warning

Lane change



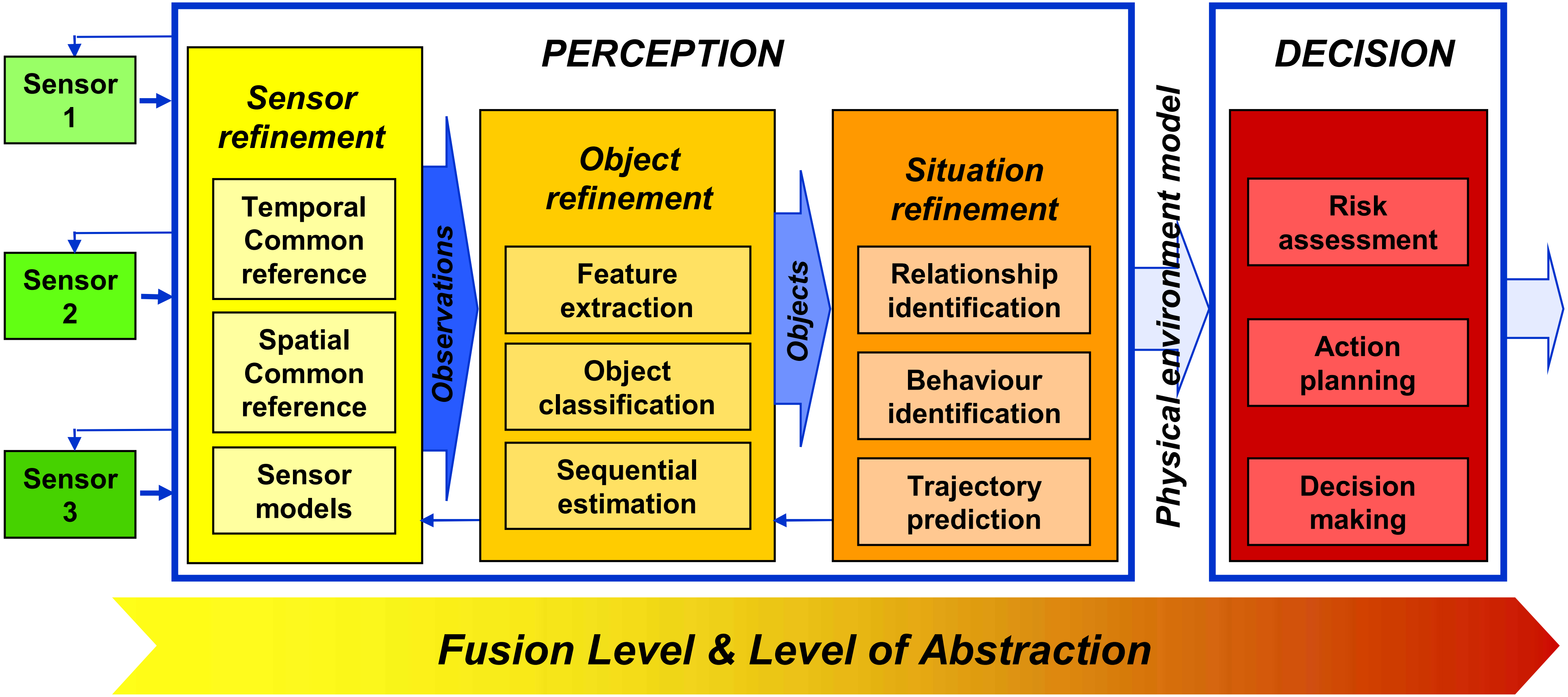
Monitoring space





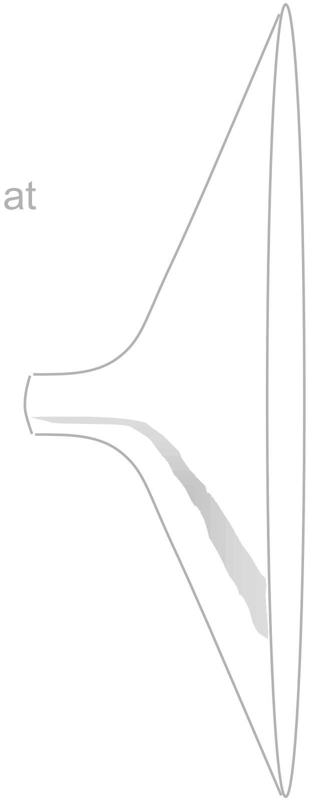
Data Fusion

- Data fusion requires to combine information from several sources
- Mainly detecting and classifying objects and measuring their movement.
- Can be based on dynamical map approaches
- Validity/certainty of detection always required



PReVENT INSAFES:
Interaction of Warning Systems

Correct warning at
Correct time



Collision Warning!

Collision mitigation!

Pre crash!

Lane change warning!

Blind spot alert!

You are about to leave the lane!

Upcoming hazard!

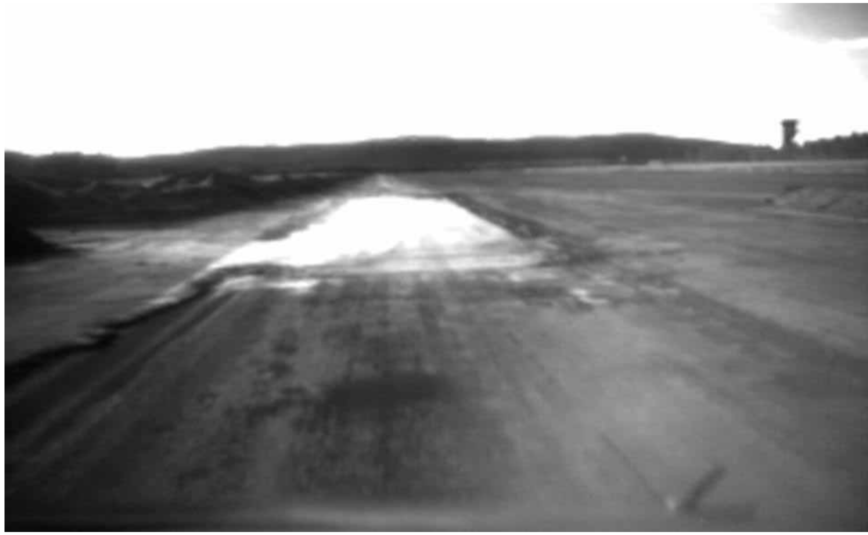
Keep the recommended speed!

Measuring Tyre-Road Friction 1/3

- One of the remaining unknowns in ADAS (e.g. collision avoidance, curve speed warning)
- Motivation: all forces applied through tyre-road contact
- Measured friction could be used in cooperative systems; however it is tyre specific and depends on path => more or less only weather conditions can be transmitted
- *With current measurement technology not all applications can be supported*

Measuring Tyre-Road Friction 2/3

- Friction is a complex phenomena (e.g. friction of ice depends on if sun is shining and has it been polished by braking) and difficult to measure without braking/cornering.
- 5th wheel approaches or similar not welcome
- *Used friction relatively easy to measure*
- *Friction potential only in certain conditions (e.g. acceleration > 0.3 G)*
- Friction potential visible in tyre transformations and vibrations. The changes are however small and difficult to measure. Sensors are hard to integrate into tyres.
- *Photo shows ice through a 1600 nm filter on a test track*



Measuring Tyre-Road Friction 3/3

- No single sensor provides good enough information => data fusion
- Results:
  - Current, maximum available (potential) and future friction. Only current used friction available continuously
  - Road weather
  - Risk of aquaplaning
  - Tyre forces

- Sensor price and combining environmental sensing with basic inertial measurements important in friction detection

Driver Monitoring

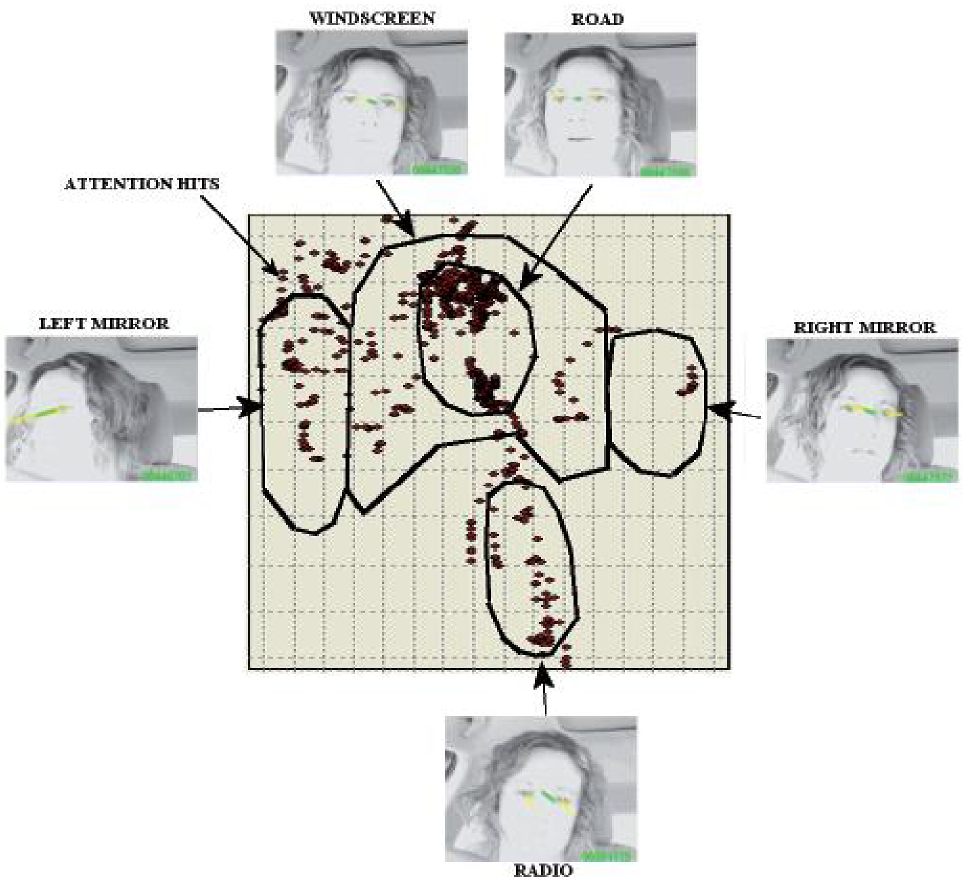
Goals:

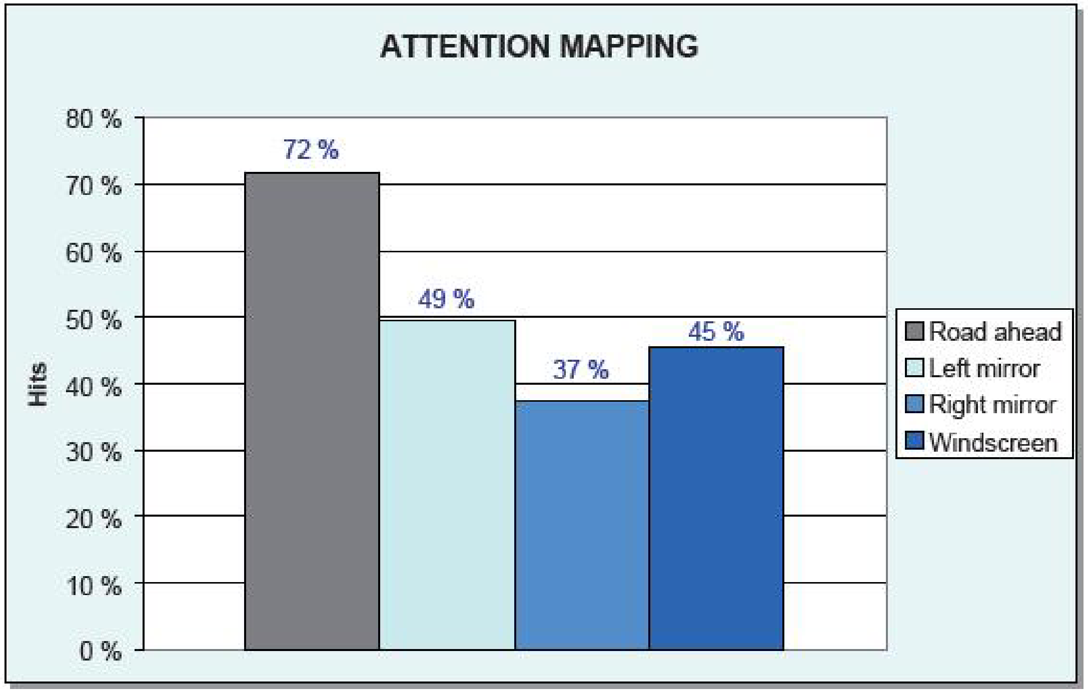
- Improving traffic safety
- Making driving more comfortable
- Driver warning if vigilance is degraded
- Enforcement (e.g. detecting drunk driving, etc.)
- Ultimately also personalising the vehicle dashboard outlook and fuctionality

- Monitoring of driver status can be divided into the two main branches: distraction detection and identifying sleepiness.
- Driver behavioural analysis (e.g. percent of eye closure, limb, gaze or head movements, etc.) can be fused with driving performance measures (e.g. lane keeping or steering wheel reversal rate)

Driver Monitoring Examples: Attention Mapping Algorithm

The algorithm is based on the driver's head and gaze directions (yaw and pitch angles)





Driver Monitoring Examples : Seat Foil Sensor

- Emfit (charged cellular ElectroMechanical Film) pressure sensitive seat foil with 64 electrodes
- Application development for driver drowsiness monitoring
  - Driver movement classification
  - Body relaxity indication

SENSATION

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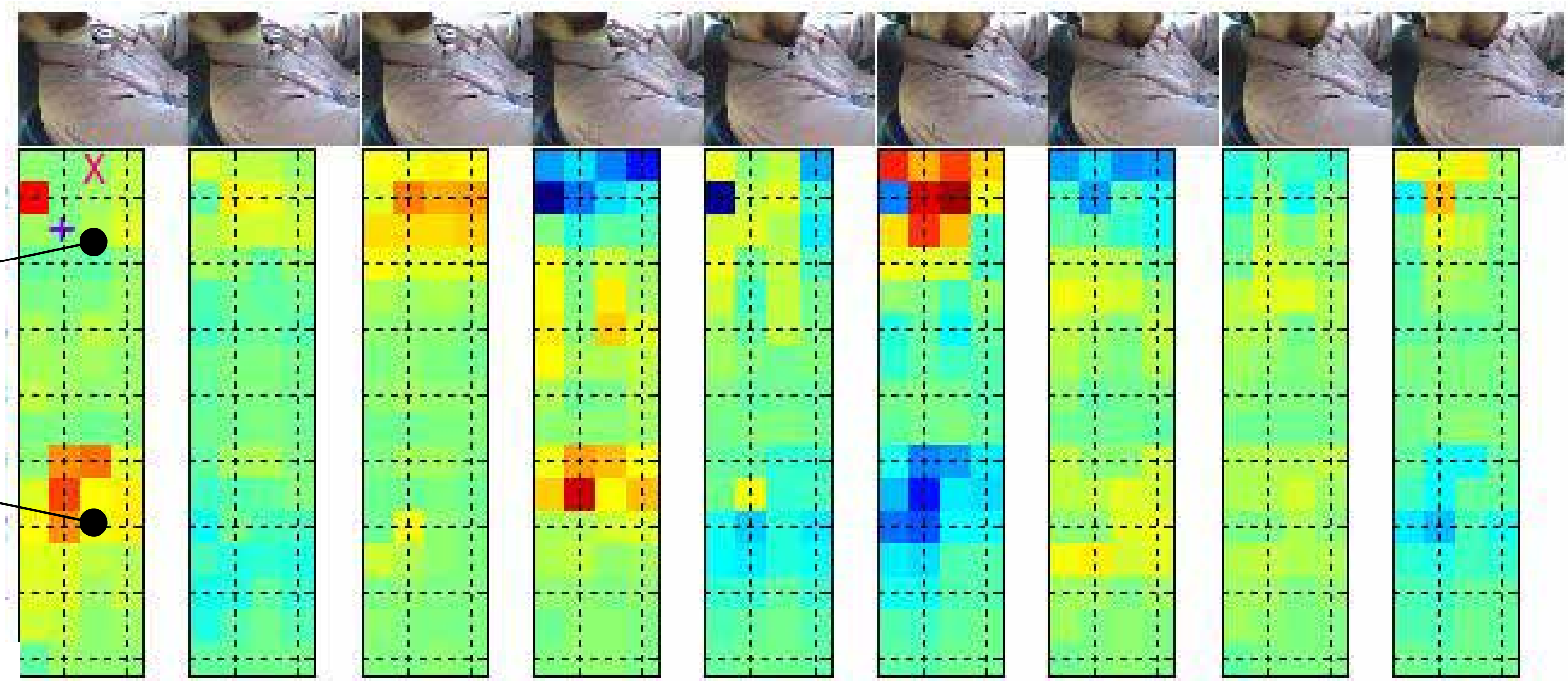
Driver Monitoring Examples : Seat Foil Sensor
The driver's head nods

Resultant force of head nodding is found from pressure sensing elements from both upper back and lower seat area

backrest
and
seat area



Time to Market and Conclusions

- Introducing new technology is slow. Also the presented technologies are prototypes. Products may be simplified versions.
- This means 5 years at earliest and considerable safety effects only around 2020. First (tests?) in top models.
- Sensor size and prices must go down (to 50-200 euros)
- Map-based warning systems, blind spot information warning (lateral safety), lane keeping are among the first products. Highest impact would come from collision mitigation?
- Environmental sensing has become a hot topic in automotive industry. Previously this research has been more active in robotics. PReVENT increased the awareness and knowledge.
- Developing environmental sensing is demanding and 10 years is a short time. Sensors cannot match human performance => Traffic situations where systems would work at least 99 % are the main targets and the remaining 1 % is a legal/liability issue.
- Even though the detections aren't 100 %, there's a warning light/sound or no (true/false). HMI (Human Machine Interface) development is still needed.