interactIVe

Accident avoidance by active intervention for Intelligent Vehicles


# Commercial Vehicle Sensor Data Fusion Applications

**Grant Grubb**

**interactIVe Summer School**

**4-6 July, 2012**

# Agenda

- Introduction to Commercial Vehicle Sensor Data Fusion
- Challenges Developing for Commercial Vehicles
- Production SDF Applications – Examples
- Research SDF Applications – Examples
- Lessons Learned and the Future

# Introduction to Commercial Vehicle Sensor Data Fusion

- Data fusion in the context of Advanced Driver Assistance Systems (ADAS)
  - Perceiving the environment around a vehicle

- ADAS are systems that support the driver in their task, for increased:
  - Safety
  - Efficiency
  - Comfort

- Examples:
  - Adaptive cruise control (comfort, safety, efficiency)
  - Lane change support (safety)
  - Collision warning (safety)

# Introduction to Commercial Vehicle Sensor Data Fusion

- ADAS must be error free over millions of km of driving in many different environments
  - Places high demands on sensing the driving environment

- Why sensor data fusion?
  - Single sensor coverage limitations (range, field of view)
  - Complementary information (exploit different sensor properties)
  - Redundancy (increase reliability)
  - Object refinement (state estimation of entities)
  - Situation refinement (estimation inferred relations among entities)

# Introduction to Commercial Vehicle Sensor Data Fusion

- One should differentiate commercial vehicles from passenger vehicles

- Many different types of commercial vehicles:
  - Trucks (long haul, distribution, rigid, tractor-trailer, double)
  - Busses (city, coach)
  - Construction equipment








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# Challenges Developing for Commercial Vehicles

- Professional drivers have different expectations to that of passenger vehicles
  - →Drivers spend longer in vehicle
  - →Different visibility constraints

- Many different vehicle configurations
  - →Large variation in sensor set to cover required zones
  - →OEM usually does not manufacture cargo trailers/containers

- Suspension of vehicle/cabin is different to passenger vehicle
  - →Sensor performance varies depending on mounting points
  - →Cannot simply carry over ADAS systems between car and commercial vehicle

- Vehicles typically fleet owned rather than personally
  - →Direct link to cost must be apparent (eg safety saves money)

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# Production SDF Applications

- Applications typically only:
  - Warn the driver
  - Perform gentle vehicle control
  - Function in simplified environments (eg highway)
  - Limited speed range
- Applications are usually developed from sensor systems dedicated to that specific application
  - Minimal sharing of sensor data between applications
  - Additional functions usually require additional sensors

# Production SDF Applications - Examples

## Adaptive Cruise Control

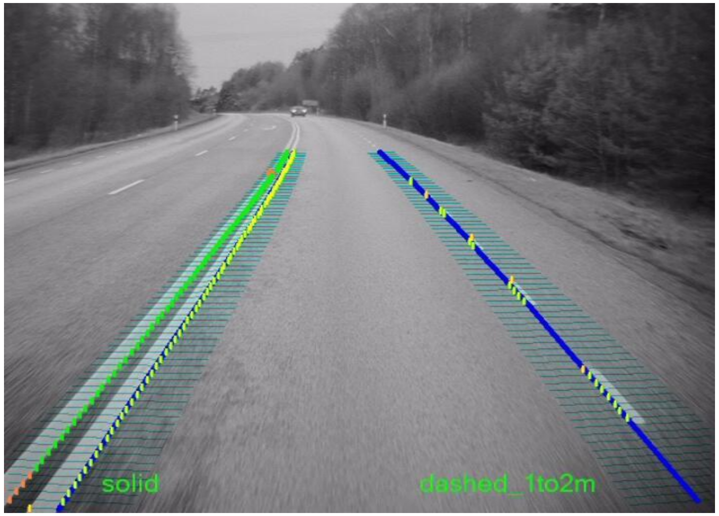
- Fusing:
  - Radar (77GHz LRR)
  - Ego vehicle dynamics (velocity and yaw rate)

# Production SDF Applications - Examples

**Lane Departure Warning and Driver Alert Support**

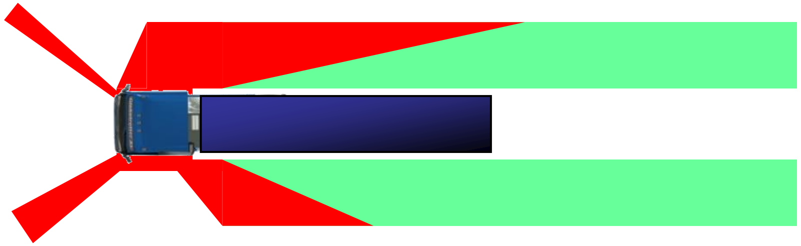
- Lane Departure Warning: warn when moving out of lane
- Driver Alert Support: warn when driver is perceived to be tired

- Fusing:
  - Lane position from camera systems
  - Ego vehicle dynamics (velocity, yaw rate steering angle, indicators)

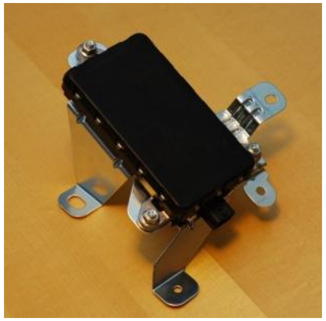


# Production SDF Applications - Examples

**Lane Change Support**



- Surveillance of blind spot areas to assist when changing lanes
- Fusing:
  - Short range radar
  - Ego vehicle dynamics



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# Research SDF Applications

- Applications which have a higher level of intervention
  - Steering
  - Hard braking

Requires higher reliability and confidence from perception!

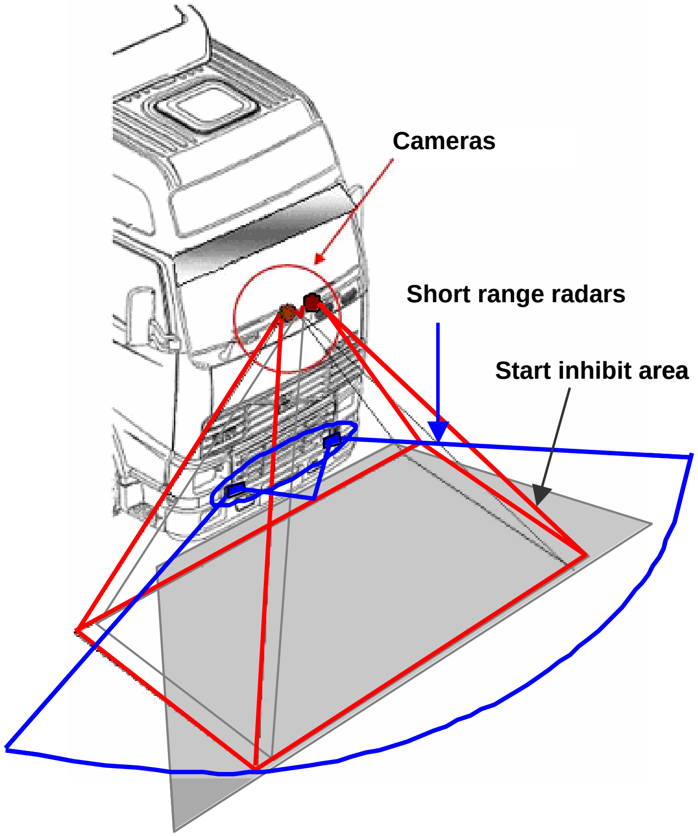
- Address a wider range of scenarios
  - Full speed range
  - More complex environments (eg. urban)
- More complete environment representation. Fusing:
  - Radar, camera, lidar, V2X, eHorizon, ego vehicle dynamcis
- Shared fused representation between different ADAS functions

# Research SDF Applications - Examples

## Start Inhibit Functions (PReVENT EU FP6)

- 2004-2007
- Detection of VRU in the blind zone ahead
- Ignore driver start requests when VRU is present

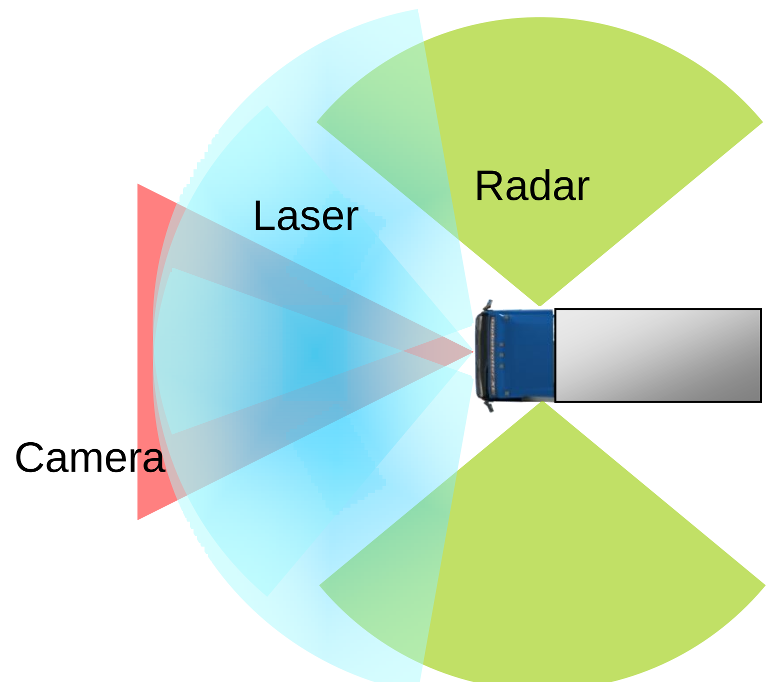
- Fusing:
  - Stereo vision system
  - Short range radar (24 GHz)



# Research SDF Applications – Examples

**Automated Queue Assistance (HAVEit FP7 EU)** HAVEit

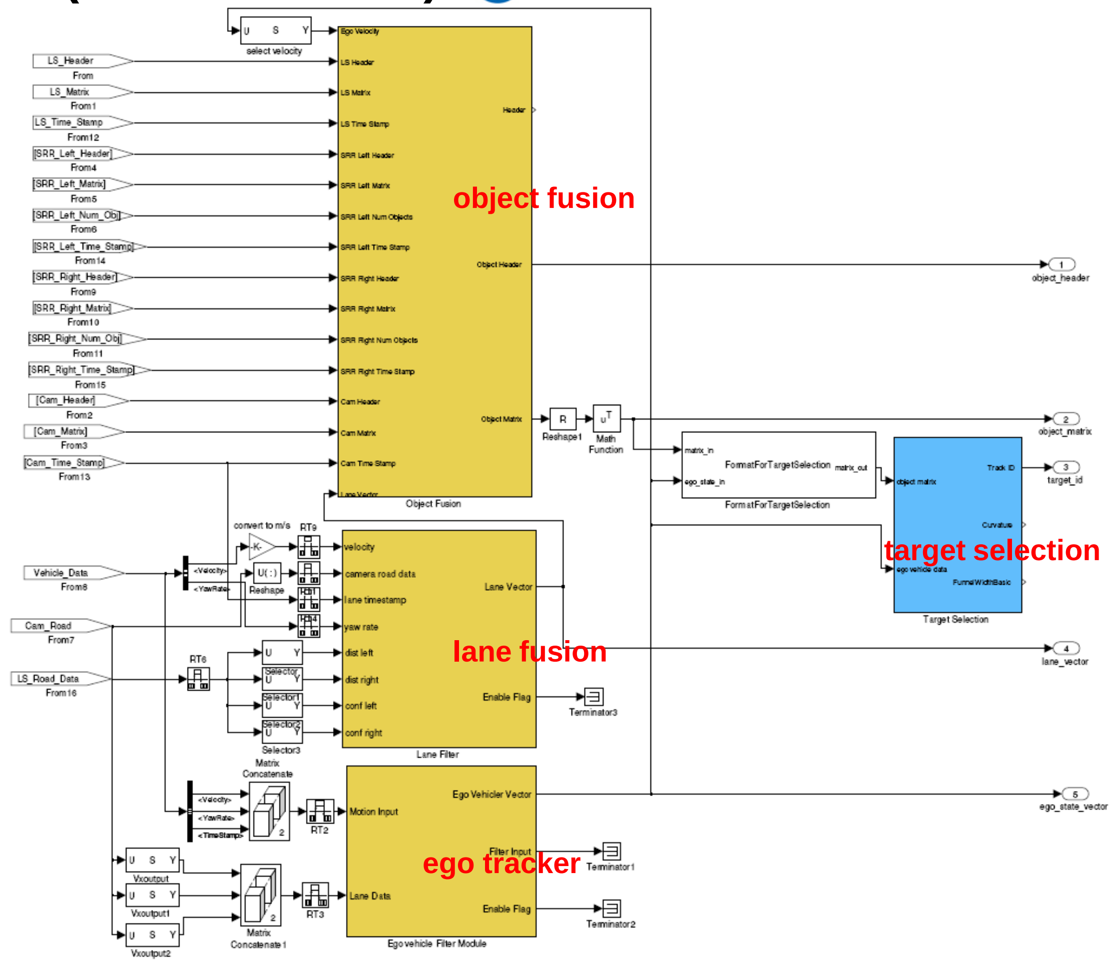
- 2008-2011
- Low Speed ACC + Stop & Go + Lateral Control
- Fusing
  - 3 x Laser (110º, 200m range)
  - Camera (54º, 60m range)
  - 2 x Radar (110º, 8m range)



# Research SDF Applications – Examples

**Automated Queue Assistance (HAVEit FP7 EU)** HAVEit

- Track-to-track object fusion LS + cam + radar
- Lane fusion from camera + LS
- Implemented in Simulink with C++, on xPC real-time workshop

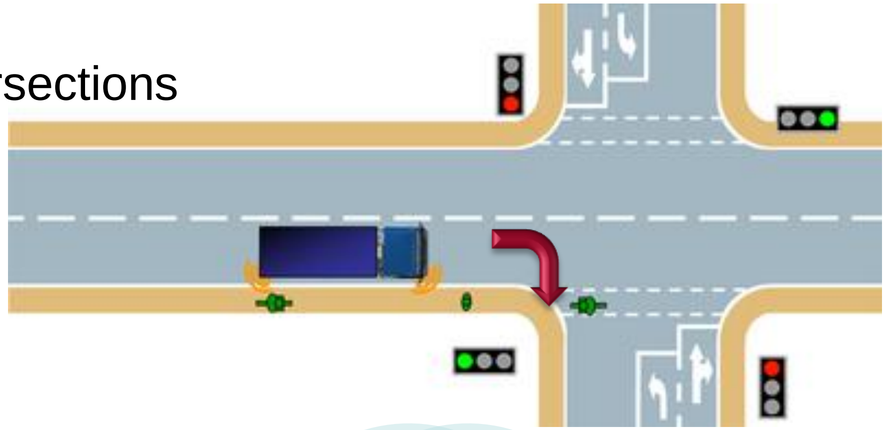


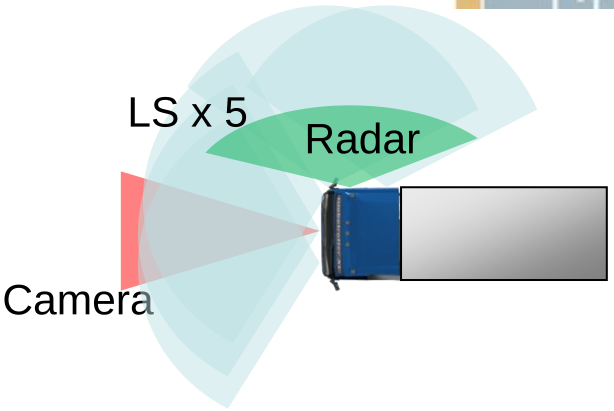
# Research SDF Applications – Examples

**Right-turn Assistance (Intersafe-2 FP7 EU)**

INTER SAFE2

- 2008-2011
- Detection of VRU in right turns at intersections
- Fusing
    - 5 x Laser (110º, 200m range)
    - Radar (110º, 8m range)
    - Camera



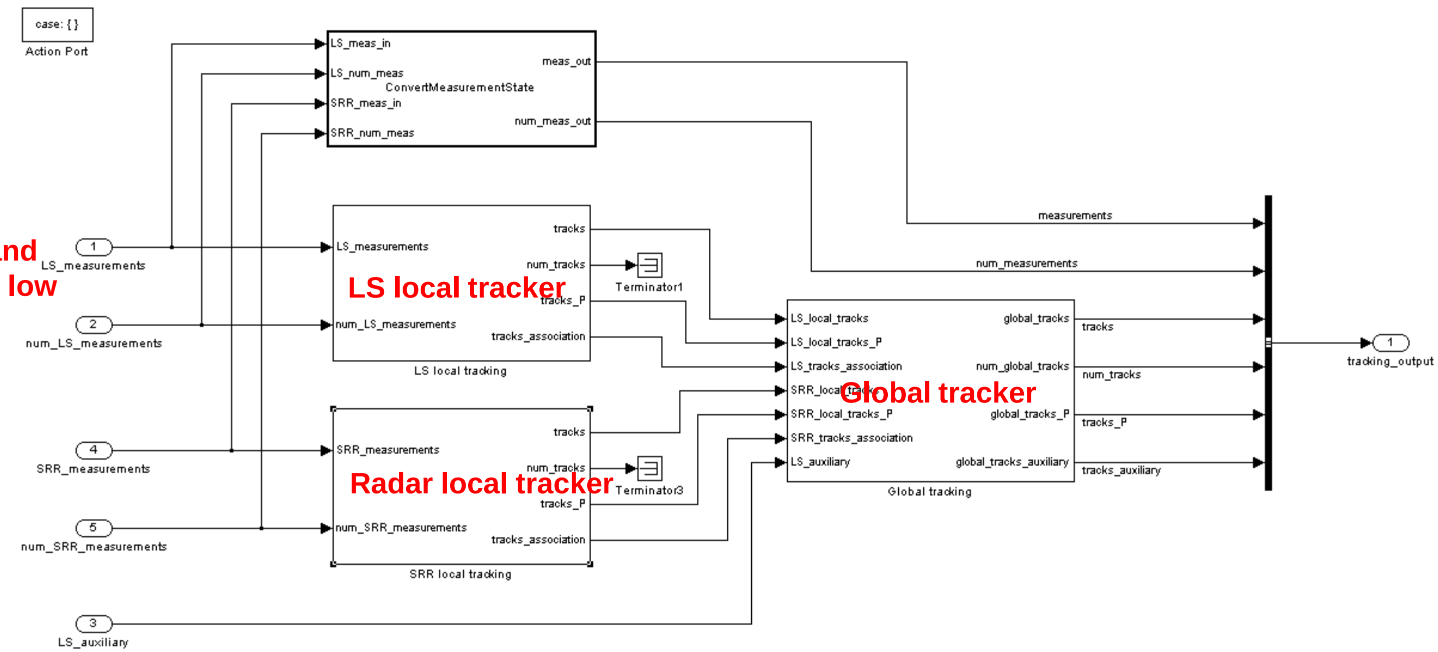


# Research SDF Applications – Examples

**Right-turn Assistance (Intersafe-2 FP7 EU)**

- Track-to-track object fusion
- Implemented in Simulink with embedded Matlab on xPC real-time workshop

**Fuse LS and camera at low level**

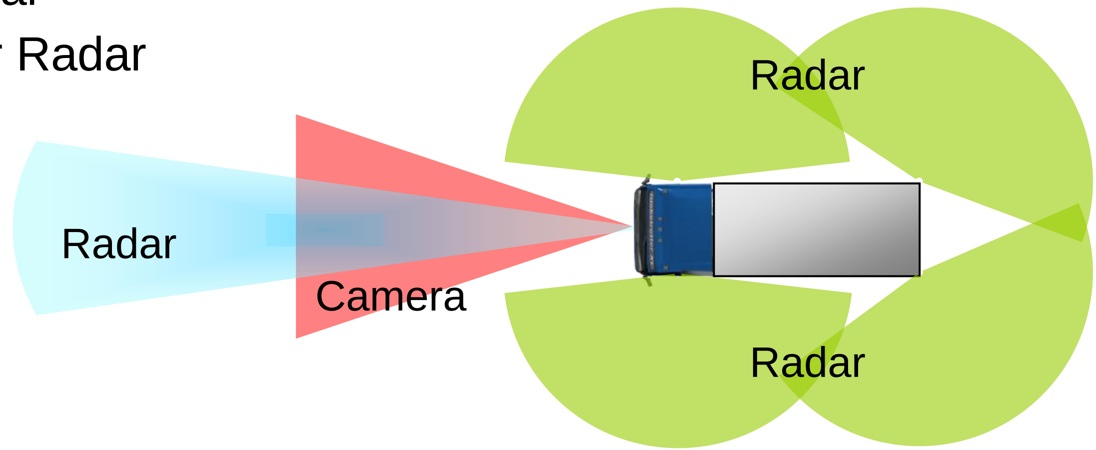


# Research SDF Applications – Examples

**Collision Avoidance (InteractIVe FP7 EU)**

- 2010-2013
- Avoiding collisions via automated steering and braking

- Fusing
  - Camera
  - 1 x Fwd Radar
  - 4 x Side/rear Radar
  - Map
  - V2V

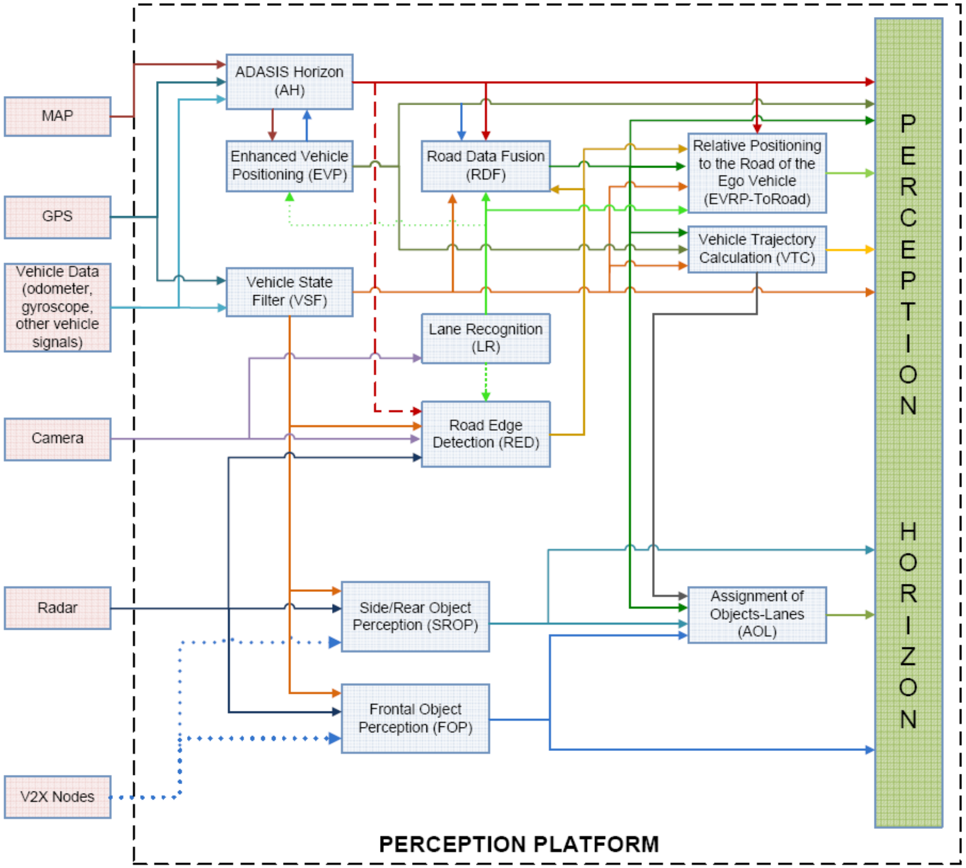


# Research SDF Applications – Examples

**Collision Avoidance (InteractIVe FP7 EU)**

- Object track fusion (front radar + side/rear radar)
- Lane fusion (camera + map)
- Road edge fusion (camera + radar + map)

- Implemented in ADTF (C++) with Windows XP



# Research SDF Applications – Examples

**Platooning (SARTRE FP7 EU)**

- 2009-2012
- Vehicle platooning for fuel efficiency, safety, and comfort
- Multiple vehicles with different sensors

- Following truck fuses:
  - Stereo vision
  - Radar
  - V2V
- Track-to-track object fusion

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# Lessons Learned and the Future

- Standardising fusion development platforms
  - Selecting a development platform that works in research projects <u>and</u> for product development

- Generic fusion (plug and play)
  - Exchange sensors with minimal fusion changes
  - Architecture which supports PnP
  - Common interfaces

- Integrated perception
  - Perception of entire vehicle environment

# Lessons Learned and the Future

- Better utilisation of V2X
    - Provides more information than traditional sensors
    - But still not exploited fully in fusion systems

- Legislation for AEBS and LDW for HGV – 2013/2015

# Conclusions

- Fusion is an important aspect of automotive ADAS!
  - The demands from ADAS systems towards perception are high
  - We can only achieve this through a fusion of different sensors

- Perception is today the limiting factor in providing ADAS functions
  - Better fusion will improve perception

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Accident avoidance by active intervention for Intelligent Vehicles


# Thank you.

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