SELF-DRIVING CARS

CHALLENGES IN DEPENDABILITY AND VERIFICATION

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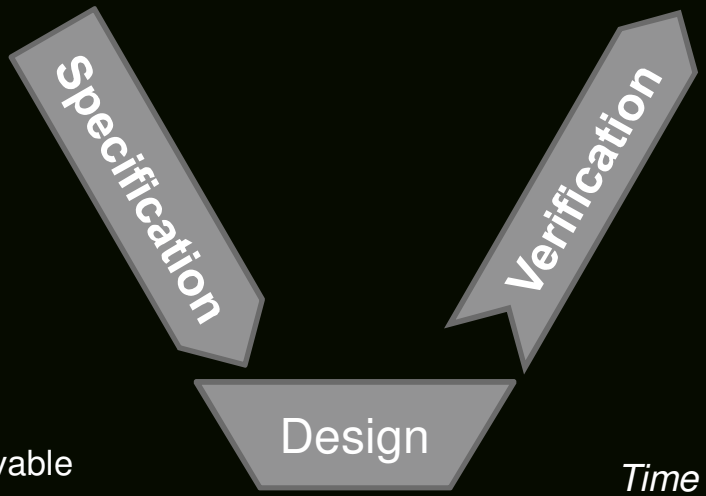
RESEARCH PROJECTS FUNDED BY SWEDISH PROGRAMME: "FFI-VEHICLE AND TRAFFIC SAFETY"



FUSE

FUnctional Safety and Evolvable architectures for autonomy

Partners: SP, Volvo Cars, KTH, Semcon, Qamcom, Comentor

http://www.fuse-project.se/
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TRUST-ME

Time efficient RobUSt verification of auTonomous vehicles - theory and Methods

Partners: Volvo Cars, Chalmers

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OUTLINE

I. Self-driving vehicles and the DRIVE ME Project
II. New challenges when going autonomous
III. Impact on system design
IV. Impact on system verification

NOW


San Francisco
ONLY
LANE
600 FEET
San Jose
San Francisco
3 RIGHT LANES
EXIT

VOLVO

MAIN BENEFITS WITH AUTONOMOUS DRIVING

- Safety
- Environment
- Traffic flow
- Lower and more efficient infrastructure investments
- Use of time

Drive Me

SELF-DRIVING CARS FOR SUSTAINABLE MOBILITY

Issuer: Jonas Nilsson; 96021; Security Class: Public

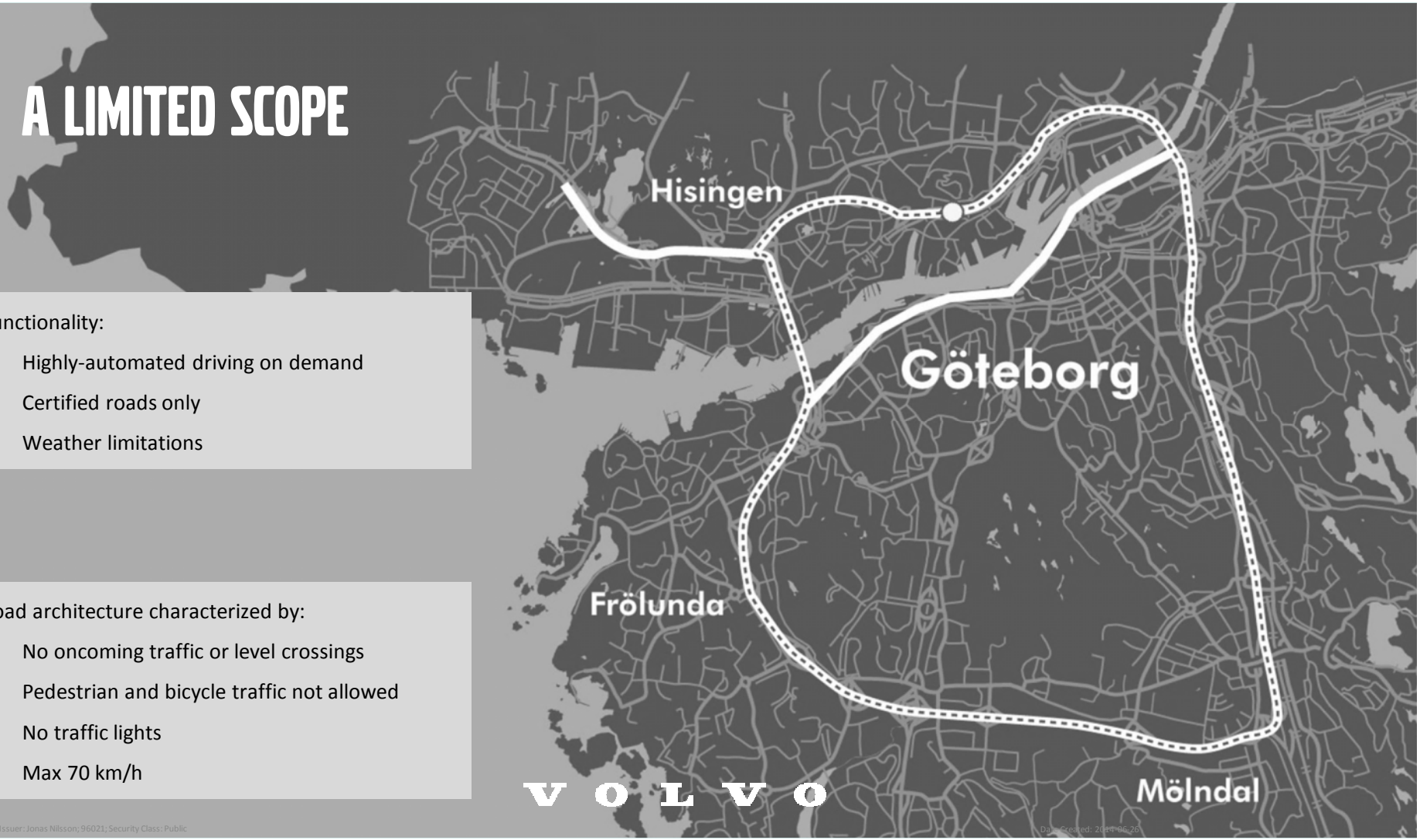
Date Created: 2014-06-26

COOPERATION FOR SUSTAINABLE MOBILITY

- A large-scale test of self-driving vehicles
- Project started Dec 2013
- 100 Volvo cars to selected leasing customers between 2017-2018
- Autonomous Driving (driver not supervising the drive) at selected roads
- Approx. 50 km around Gothenburg

- A world-unique project

A LIMITED SCOPE



Functionality:

- Highly-automated driving on demand
- Certified roads only
- Weather limitations

Road architecture characterized by:

- No oncoming traffic or level crossings
- Pedestrian and bicycle traffic not allowed
- No traffic lights
- Max 70 km/h

THE CHALLENGE

Driver out of the loop
(no engineer supervising as in most concept vehicles)

AD vehicles must be able to handle *all* situations
(and *prove* that it can!)

This puts unique requirements on the vehicle,
its sensor, actuators and electrical architecture.

CHALLENGES: FAIL-OPERATIONAL

Auto Pilot fully responsible, once activated

- Cannot rely on driver to take over
- Safe strategy needed for every possible scenario

CHALLENGES: DRIVER INTERACTION

Non-traditional ISO 26262 hazards:

- ***Mode confusion*** – Who is in control of the vehicle?
- ***Driver override*** – Is manual driver always safer?
- ***Reasonable foreseeable misuse*** – Driver or other traffic participants

CHALLENGES: OTHER ITEMS

Items outside vehicle

i. Certified road signal
ii. Online map updates

Items in vehicle

i. AD Mode: Faults that the driver will manage, e.g. flat tire
ii. Manual Mode: Added failure modes for existing items
iii. Arbitration with other functions (e.g. Collision Avoidance)

CHALLENGES: ENVIRONMENT SENSING

- Missed detections => e.g. No braking for obstacles
- False detections => e.g. Unmotivated braking
- Localisation error => e.g. Does not follow road

Situation dependent *– Performance varies heavily between e.g. objects, weather, lighting conditions.*

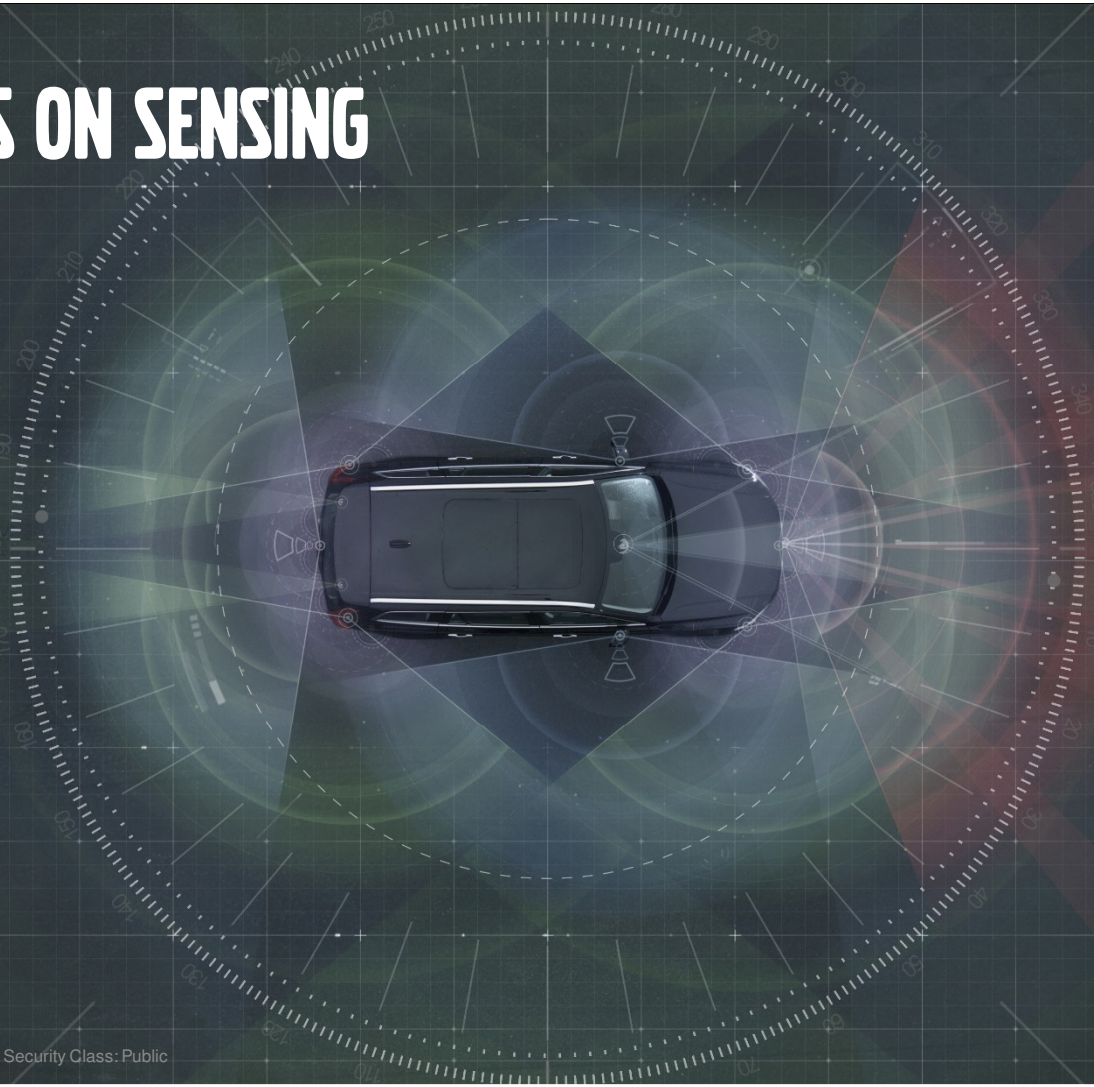
IMPACTS ON ARCHITECTURE

AD Vehicles require:

- ✓ Redundant sensing
- ✓ Redundant high-end control units
- ✓ Redundant brake system
- ✓ Redundant steering
- ✓ Redundant signaling paths
- ✓ Clustered power distribution
- ✓ Safety critical HMI

IMPACTS ON SENSING

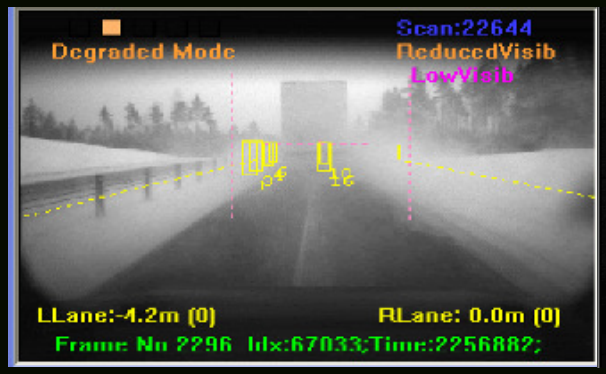
- IMU
- Camera
- Radar
- Laser
- Map data
- Cloud



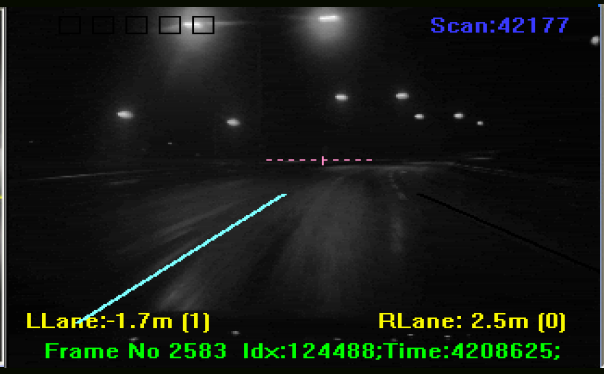
HOW SAFE IS ”SAFE ENOUGH”?

Infeasible to verify by driving billions of kilometers!

ENVIRONMENT SENSING VERIFICATION



Snow smoke



Wet road at night

Low sun

Just covering the reasonable cases is challenging!

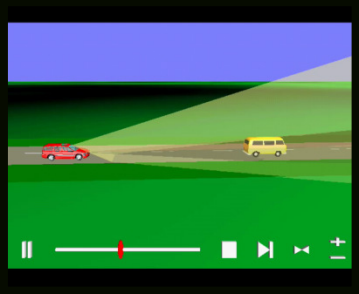
TRAFFIC ENVIRONMENT VARIATIONS

Huge number of traffic scenarios to evaluate!

VERIFICATION STATE-OF-THE-ART

Field Testing
(Real Traffic)

Directed Testing



Simulation

Test Track

VERIFICATION STATE-OF-THE-ART

Active Safety:

- Driver out of the loop only on rare occasions
  e.g. Automatic Emergency Braking (AEB)

Verification Strategy:

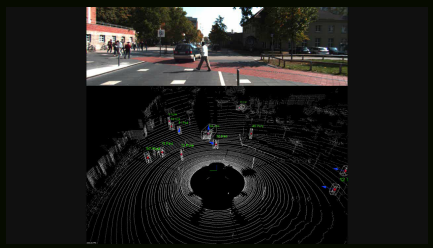
I. Test AEB interventions in ***Directed Testing***
II. Use ***Field Test*** to ensure that unnecessary AEB interventions are rare

*Only handles a **single** (rare) manuever!*

How can we handle all situations without driving a billion kilometers?

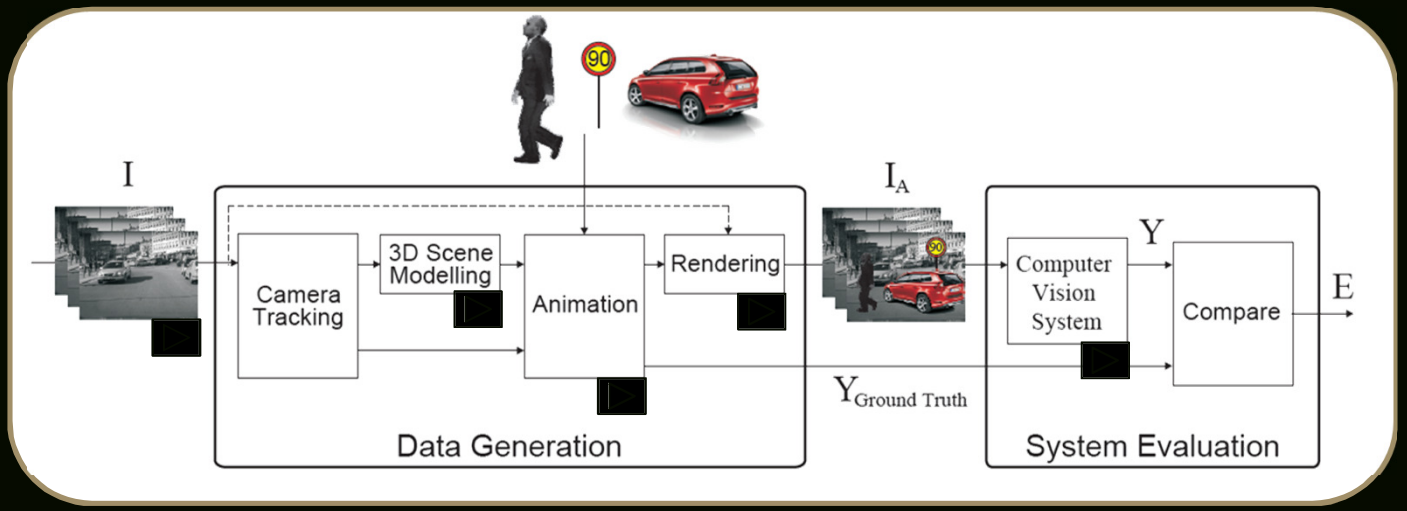
USING DATA MORE EFFICIENTLY

- Crucial to keep field test at feasible size
- Identify the most critical situations and direct testing



IMPROVED DIRECTED TESTING

Augmented Vision: Photo-realistic virtual objects inserted into real movies



J. Nilsson, A. C. E. Ödblom, J. Fredriksson, A. Zafar, and F. Ahmed, "Performance Evaluation Method for Mobile Computer Vision Systems using Augmented Reality," in *IEEE Virtual Reality Conference*, 2010, pp. 19–22.

J. Nilsson, J. Fredriksson, and A. C. E. Ödblom, "Bundle Adjustment using Single-Track Vehicle Model," in *2013 IEEE International Conference on Robotics and Automation*, 2013, pp. 2888–2893.

IMPROVED DIRECTED TESTING

SUMMARY

- ✓ Main drivers for Self-Driving Cars:
  - Use of Time
  - Safety
- ✓ Driver out of the loop is a big change...
- ✓ Fail-operational implies (a lot of) redundancy
- ✓ Verification by merely driving is unfeasible!


THANK YOU FOR YOUR ATTENTION!