Design Considerations for a Cyber-Physical Testing Language

Recent Self-Driving Cars (Selection)

Source: Carnegie Mellon University

Source: Stanford University

Source: TU Braunschweig

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Recent Self-Driving Cars (Selection)

Source: Volkswagen AG.

University of California, Berkeley

Source: http://www.technologyreview.com/photogallery/425849/the-latest-in-self-driving-cars/4/#photo

Source: http://viac.vislab.it/?page_id=155

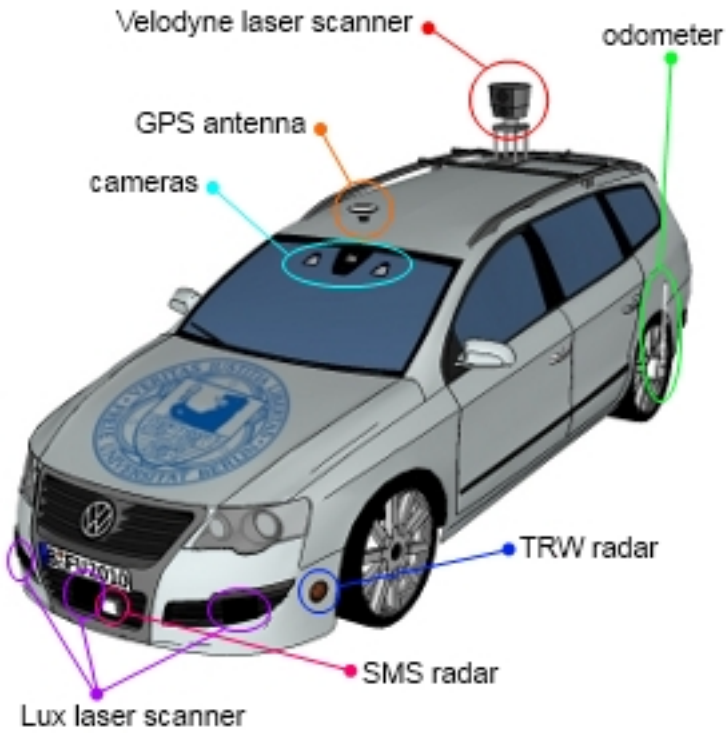
Today's Urban Challenges

- Reliable detection of
  - Obstacles < mid-size car
  - Pedestrians
  - Bicyclists
  - Motocyclists
  - Traffic signs
  - Traffic lights
- Safe operation
  - In parking garages
  - At rush hours
  - At night
  - At rough weather conditions
- Usability aspects
  - Long-term usage
  - Energy consumption & sustainability
  - Comfort

Source: http://www.bmwblog.com/2010/10/10/bmw-makes-self-drive-car-with-active-cruise-control/

Today's Technology for Self-Driving Cars

- Sensors:
  - Positioning
  - Vision sensors
  - Active sensors
  - V2X communication
- Powerful computation
- System architecture:
  - Localization & Perception
  - Interpretation
  - Acting
  - Monitoring & Evaluation



Source: http://autonomos.inf.fu-berlin.de

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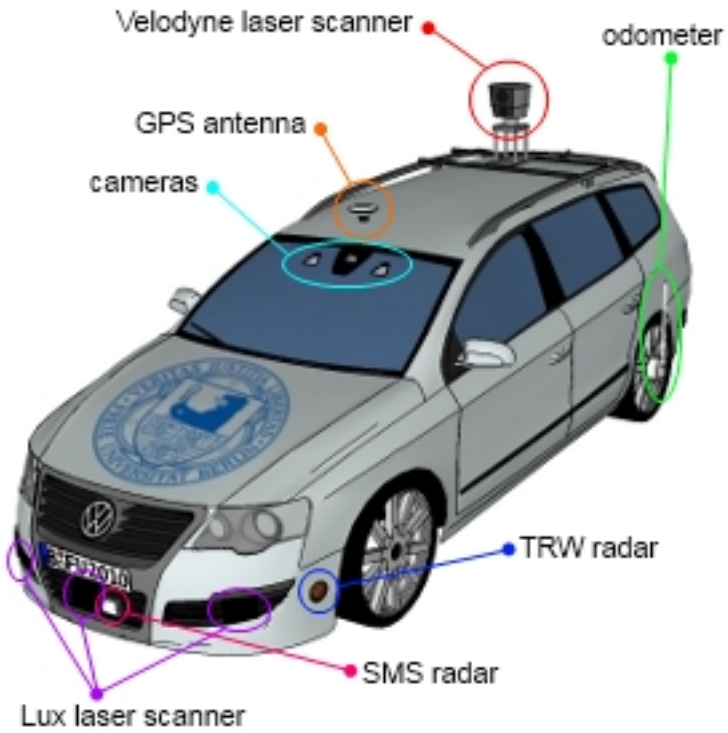
1. The magic is in the software!



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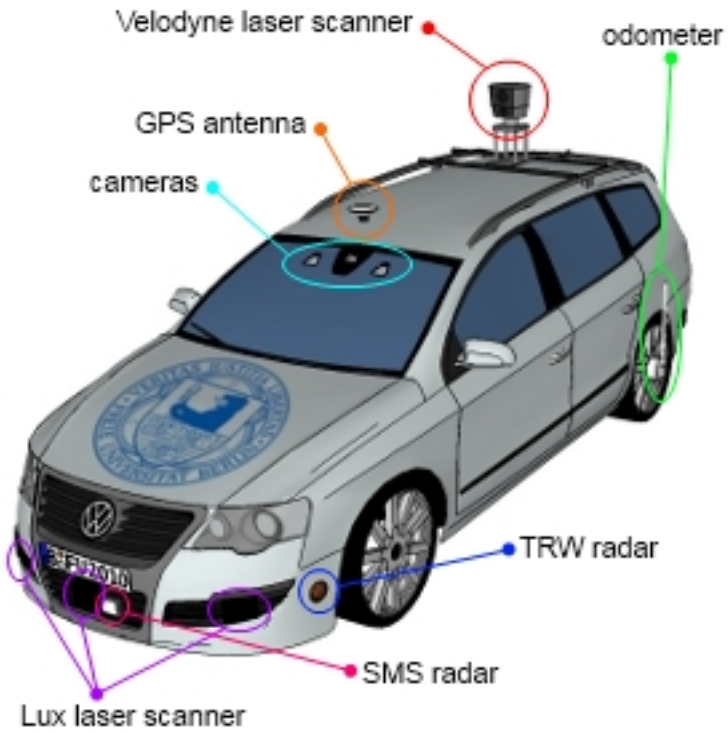
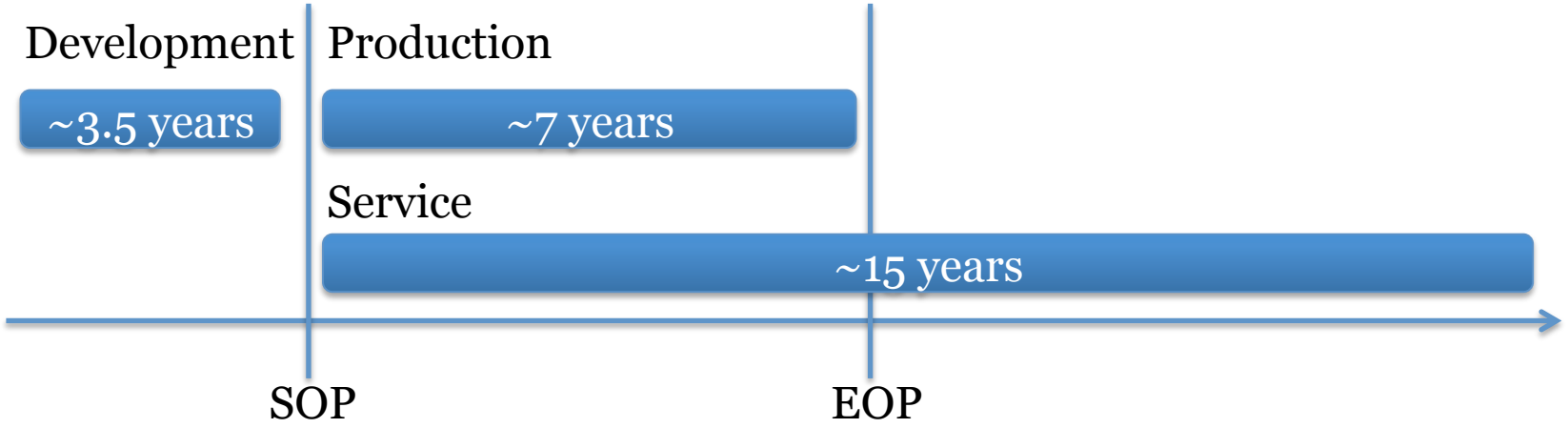


Source: http://autonomos.inf.fu-berlin.de

1. The magic is in the software!
2. But: „What methods can be applied to validation of complex systems that interact with the real world?" – Winner of DUC

Cyber-Physical Testing of Environment-based Vehicle Functions



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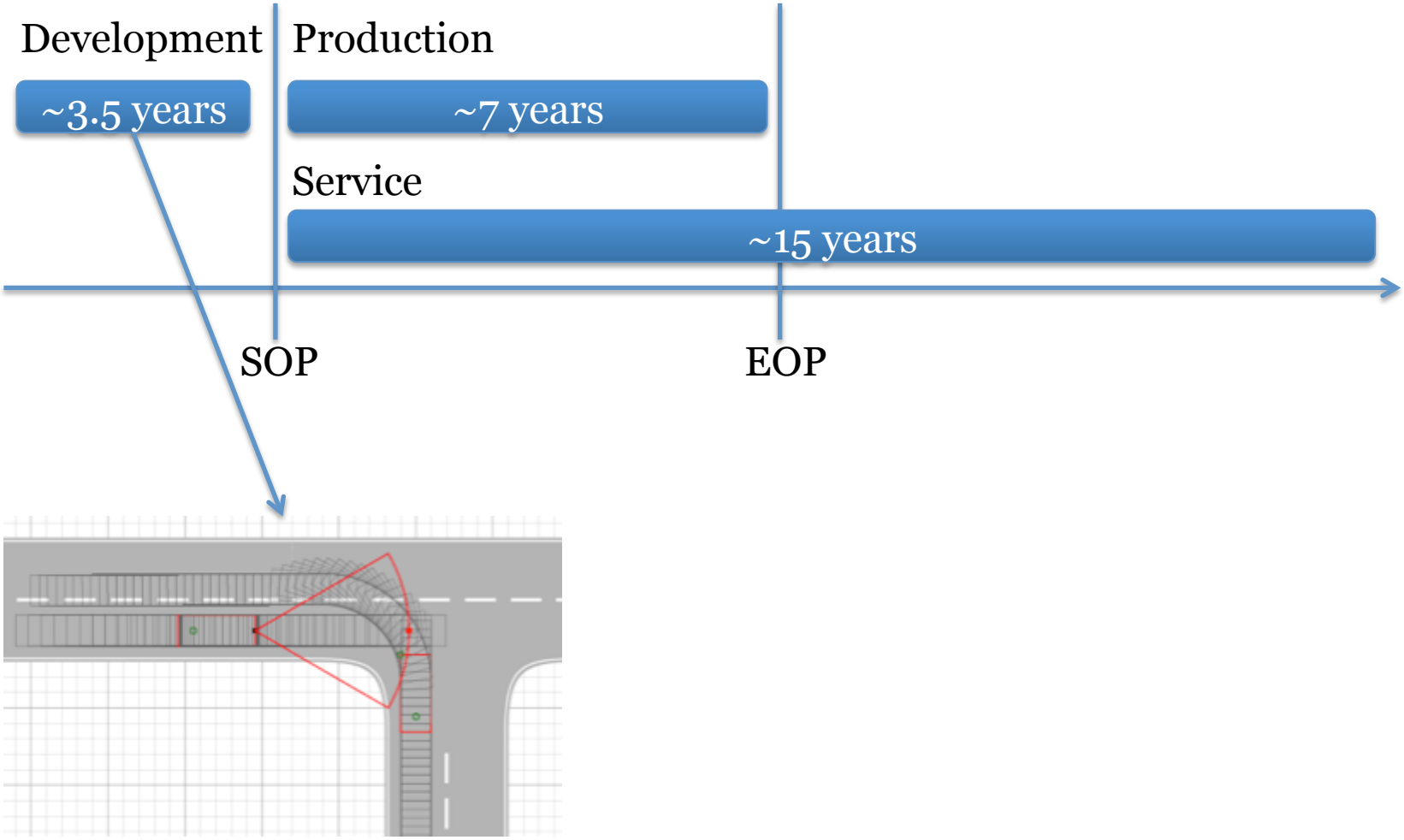

Source: IAV GmbH.

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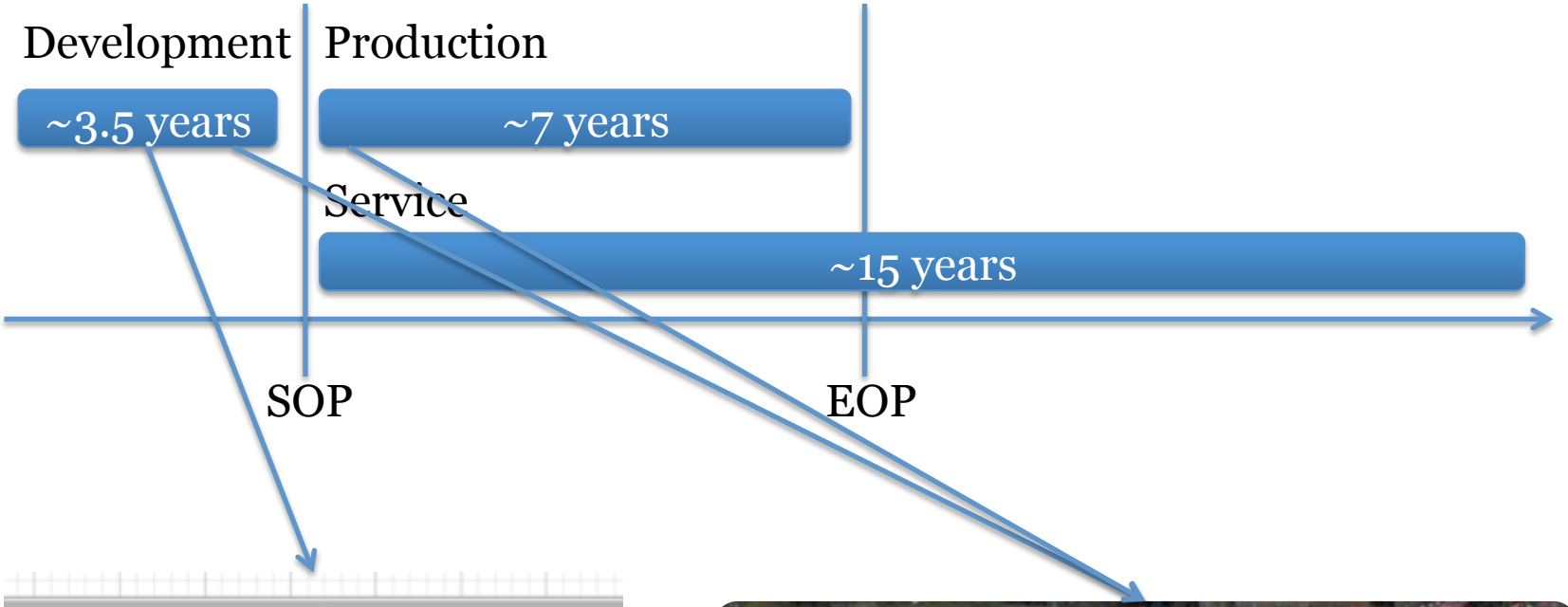

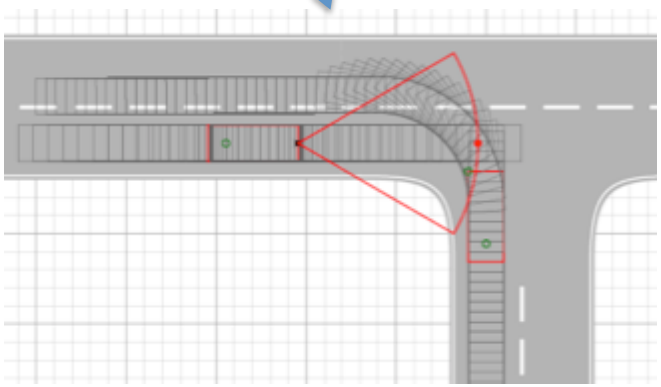

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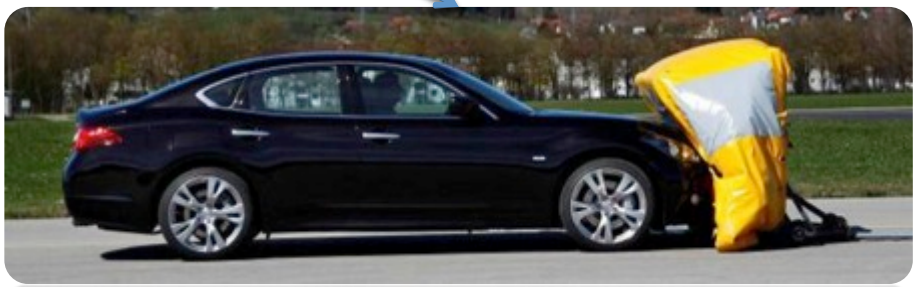

Testing an emergency braking assistant.
Source: ADAC e.V.

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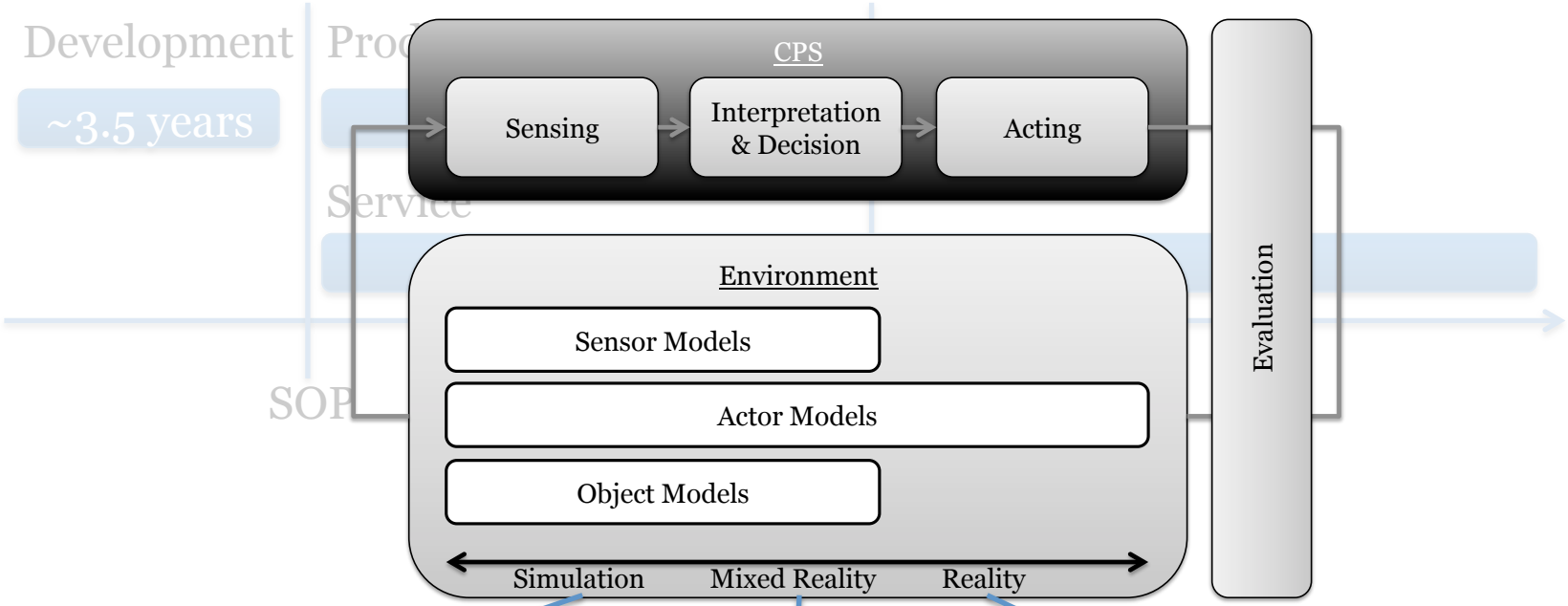

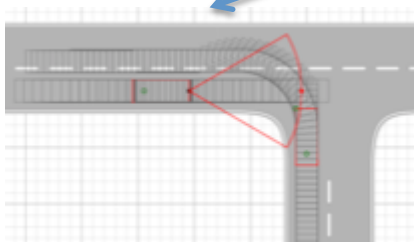

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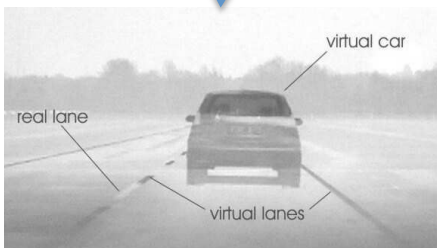
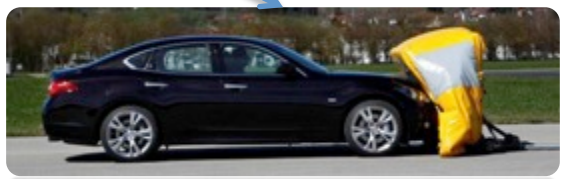


Source: Bock, Maurer, Färber, 2007.



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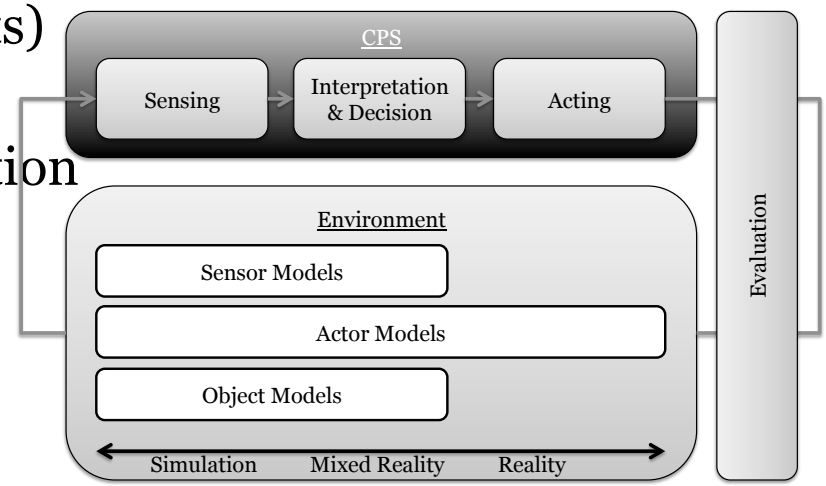
Cyber-Physical Testing of Environment-based Vehicle Functions

1. Consistent cyber-physical description for:
   - Scenarios
   - Stimuli behavior (dynamic elements)
   - SUT's expected behavior over time
   - Modeling experience-based evaluation
   - Comparable reporting



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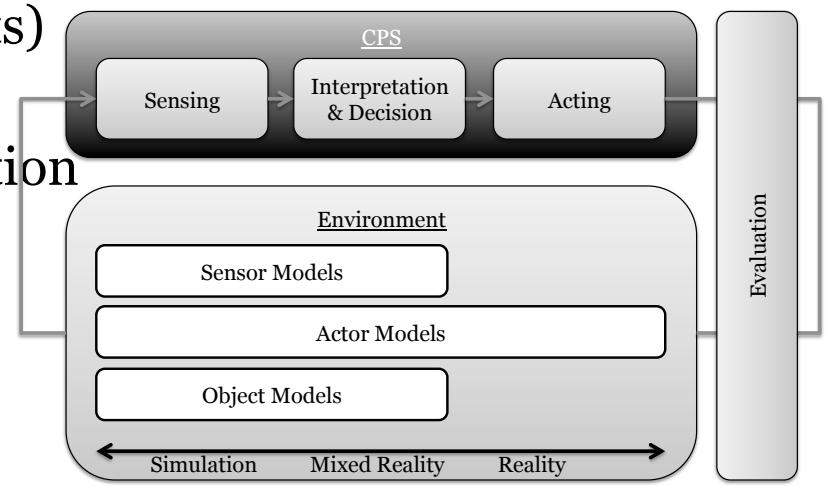

2. Transformations for instances:
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   - Augmented reality approaches on real proving grounds
   - Real test-runs

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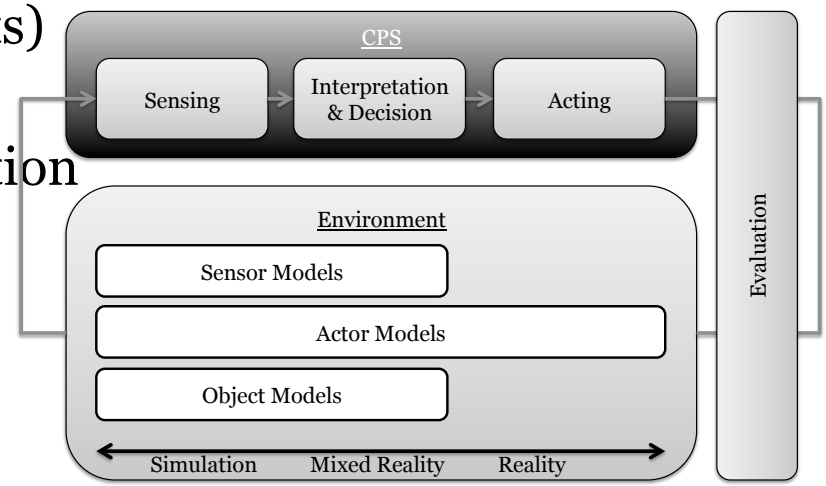

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3. Test-run data management and mining
   - Derivation of quality metrics
   - Prediction of SUT's maturity

Cyber-Physical Testing of Environment-based Vehicle Functions

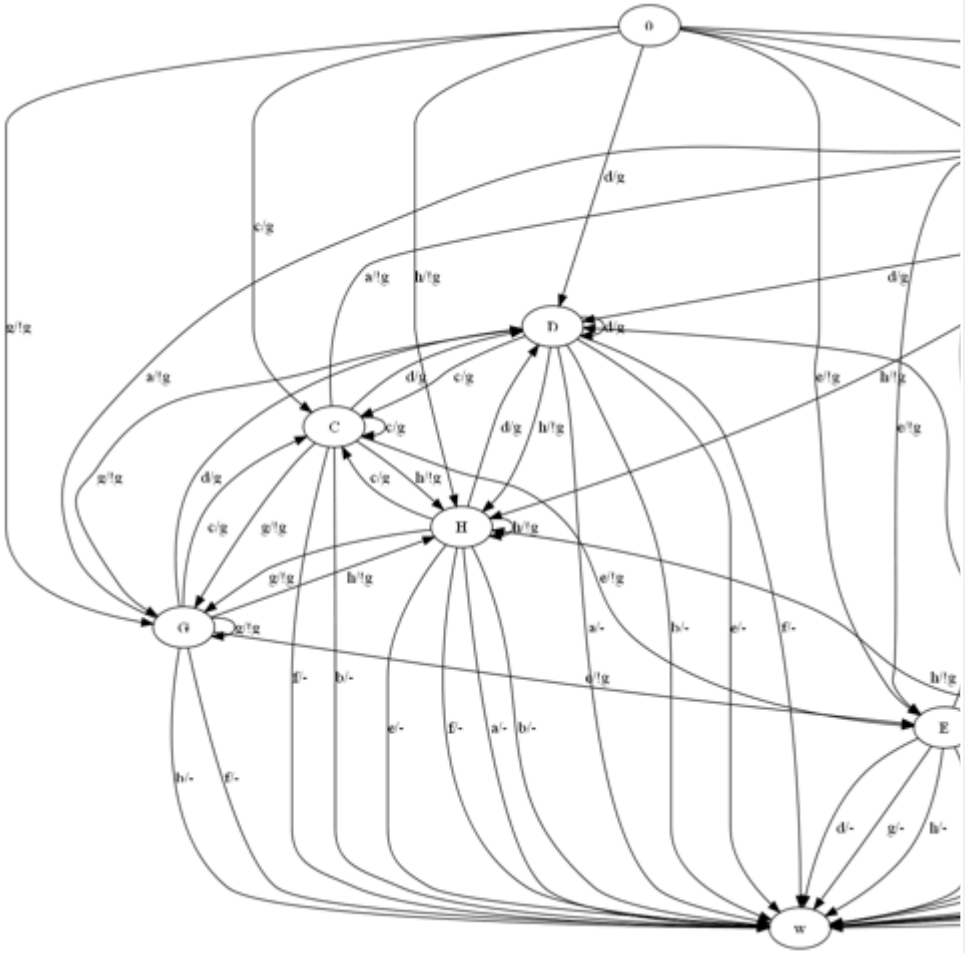
- Preliminary ideas for a cyber-physical testing language:

```
env.ground.origin = (57.707116;11.936903);
env.ground.area = { (-80;-80), (80;-80),
(-80;80), (80;80) }; # square-shaped area

env.obj = null; # no other real objects

obj.0 is Cylinder(1;1.8); # diameter;height
obj.0.name = "Pedestrian";
obj.0.origin = (5;40);
obj.0.heading = PI; # heading to the west
obj.0.color = LIGHTGRAY;
obj.0.action = ped0(cps);

Camera is GenericCamera;

Camera.position = (1;0;1);
Camera.heading = (1;5/180*pi;0);
Camera.resolution = (640;480);

Camera0 is VisibilityCamera refines Camera;
Camera0.range = 30;
Camera0.angle = 1/3*pi;
Camera0.fps = 15;
```

```
RealCamera0 is VendorCam refines Camera;
RealCamera0.fps = 10;

cps.origin = (0;0);
cps.heading = 0.5*PI; # heading to the north
cps.has = { Camera };
cps.action = drive();

agent.0 is SafetyDistance;
agent.0.distance = 0.5;
agent.0.observes = { cps };

agent.1 is MaxSpeed;
agent.1.max = 15; # m/s
agent.1.observes = { cps };

sim = { env, obj.*, cps(Camera0) };
real = { env, obj.*, cps(RealCamera0) };
```

Cyber-Physical Testing of Environment-based Vehicle Functions

- Generating test cases from a requirements specification:

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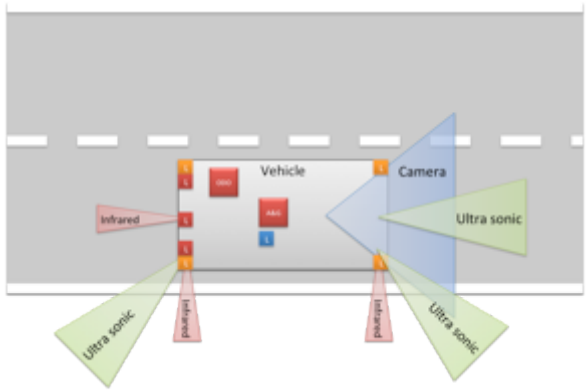
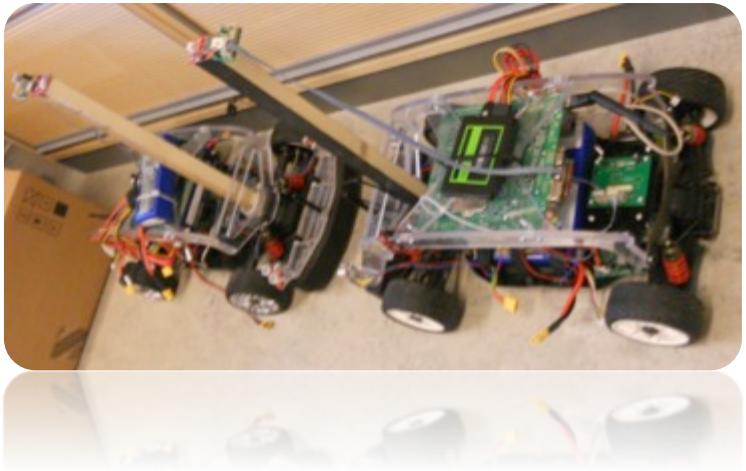
Conclusion & Outlook

- Simulative & real world evaluation of CPS needs to be considered together
- Foundation: Cyber-physical testing language to combine the evaluation in both worlds
- Autonomous miniature vehicle fleet as one exemplary experimental lab





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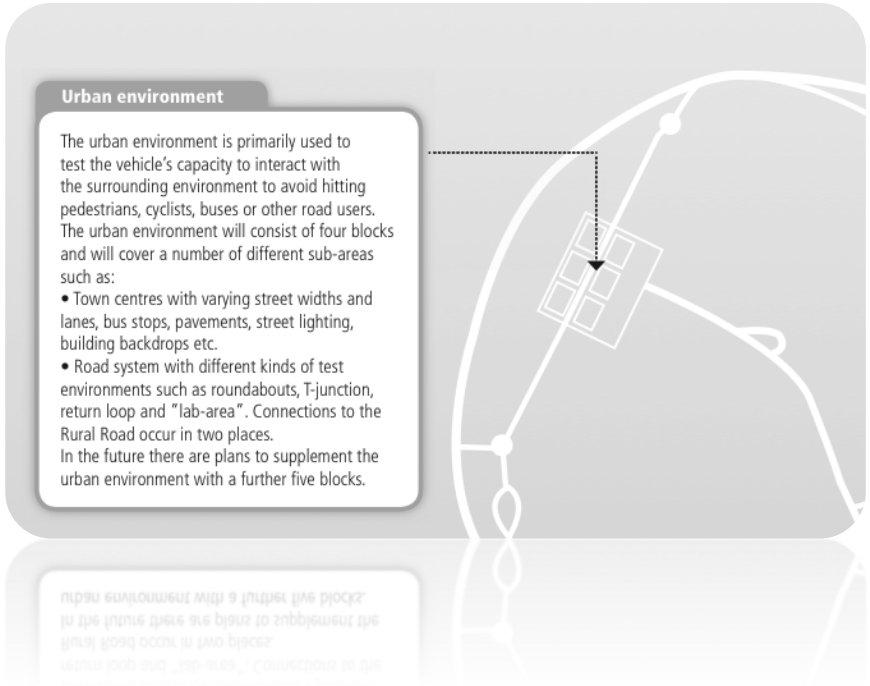
- Autonomous miniature vehicle fleet as one exemplary experimental lab
- ASTAzero from summer 2014:
  - Proving ground for active safety vehicle functions
  - Includes mock up urban environment

ASTAZERO
ACTIVE SAFETY TEST AREA



Tack så mycket.

christian.berger@chalmers.se