TNO Automotive, Integrated Safety Department

Pre-Crash Testing in the VeHIL Facility

TNO | Knowledge for business

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TNO in a Nutshell

- TNO is the Netherlands' Organization for Applied Research

- Over 75 years of experience

- Independent R&D organization

- 5,000 employees world-wide

- HQ in Delft, the Netherlands

- Annual turnover approx. 550 M€

Contents

- **Advanced Driver Assistance (ADA)**

- **ADA Development Tools**
  - PreScan Simulation Environment
  - VeHIL
  - Pre-crash Test Set-up

- **Conclusions**

Introduction

- **Advanced Driver Assistance**
  - Monitor the environment of the vehicle
  - Support the driver by warning or autonomous intervention

77 GHz Long Range Radar/ Lidar	Infrared (Night Vision)	Video	24 GHz Short Range Radar	Ultrasonic
Long 1 to 120 m	Extended Medium 0.2 to 80m*/200m**	Medium 0 to 80 m	Short 0.2 to 20 m	Ultra short 0.2 to 1.5 (2.5) m

- **Examples**
  - Adaptive Cruise Control (ACC)
  - Lane Keeping
  - Pre-Crash Systems
  - Blind Spot Monitoring
  - Collision Avoidance
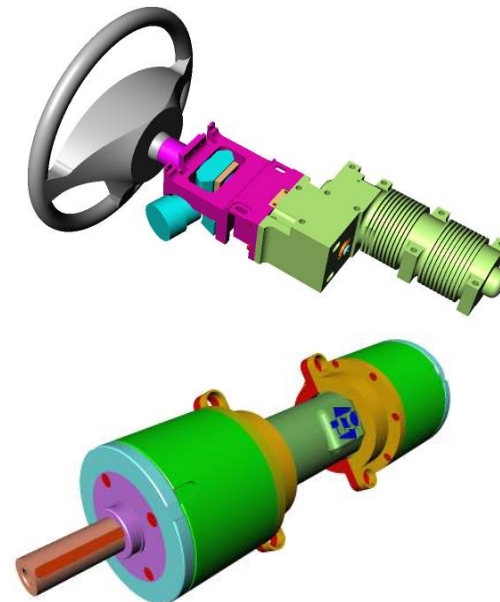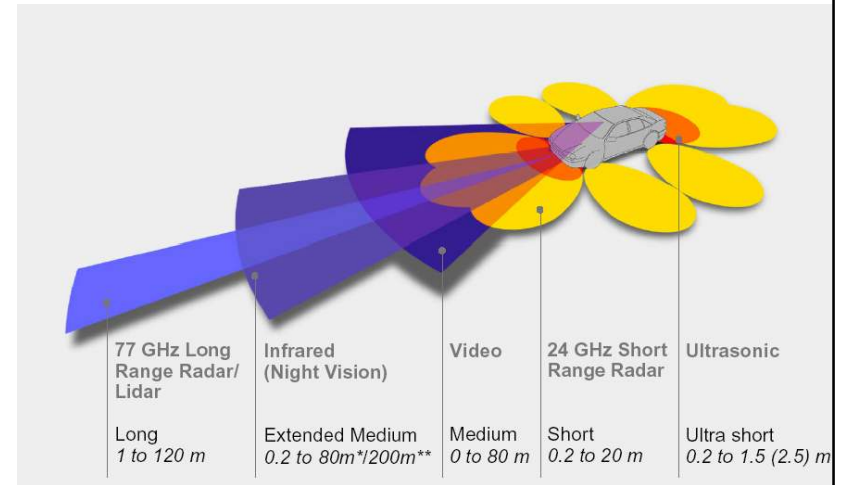
General Development Challenges

- **Efficiency (time and effort)**
  - Methods and tools

- **Performance**
  - According to specifications
  - Methods, tools, and knowledge

- **Knowledge Management**
  - Learn from the past
  - Share knowledge between disciplines
  - Common language
  - Methods, tools (e.g. animation)

ADA Development Tools at TNO

Simulation
- system specification
- control system design
- system analysis

validation

analysis support

Lab Experiments
- component & system hardware tests
- testing and tuning of control loops
- evaluation under controlled conditions

evaluation criteria

prognosis of expected vehicle behaviour & analysis

analysis support

test definition

PreScan

Full Scale Test Drives
- evaluation of system functionality
- evaluation of system reliability
- fine-tuning of control algorithms

VEHIL

CarLabs

PreScan

- **Simulation of ADA systems (and other intelligent vehicle systems) in user-defined scenarios**
  - Build scenarios
  - Model sensors, GPS, communication systems, …
  - Model vehicle dynamics
  - Add / develop control algorithms
  - Run experiments

PreScan: New Release 3.5

- **First commercial release (3.0), July 2007**
- **4 launching customers as of July 2006 (2 OEMs, 2 suppliers)**

Live Demo at the TNO Booth (no. 1634)

- TNO Booth: no. 1634 (Hall 1)
- Demonstration and more information

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# VeHIL: Vehicle Hardware-In-the-Loop

VeHIL Principle

- **Testing of Advanced Driver Assistance System**

- **In VeHIL, the motion of other road users with respect to the test vehicle is identical to real world scenario**

VeHIL Advantages

- **HIL set-up for intelligent vehicles on system level**

- **VeHIL — Vehicle Hardware-In-the-Loop**
  - repeatable — fast iteration in algorithm optimisation
  - effective — focussing on the problem at hand
  - safe — safe testing especially for collision systems
  - efficient — high test throughput
  - accurate — very high quality ground truth data

Case: sensor mapping (design & verification)
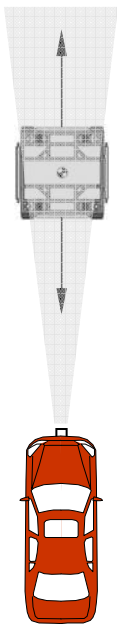
Test Track Automation

Pre-Crash Collision Mitigation

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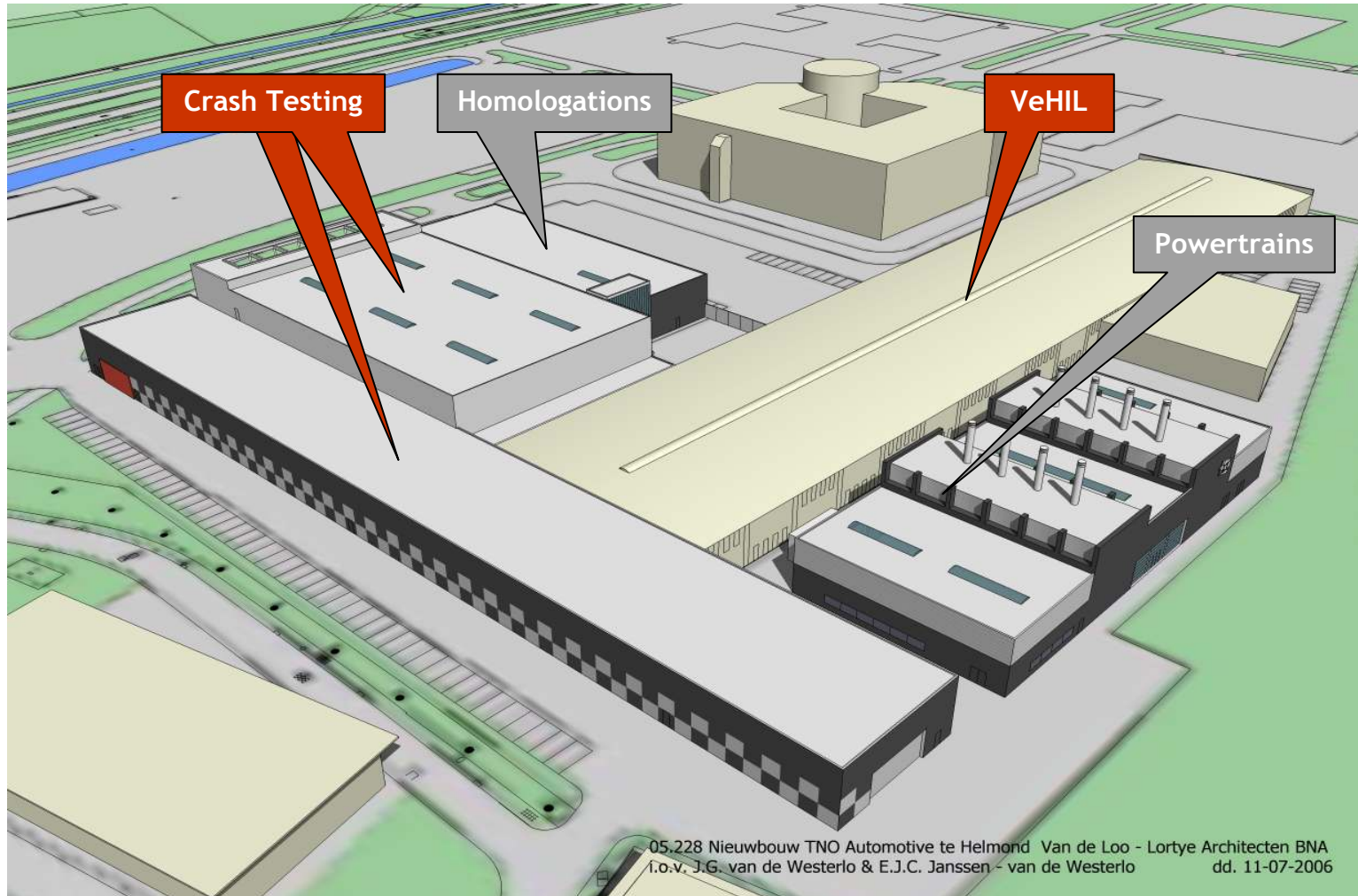
- **Conclusions**

Near-zero Time-To-Collision (TTC) Testing
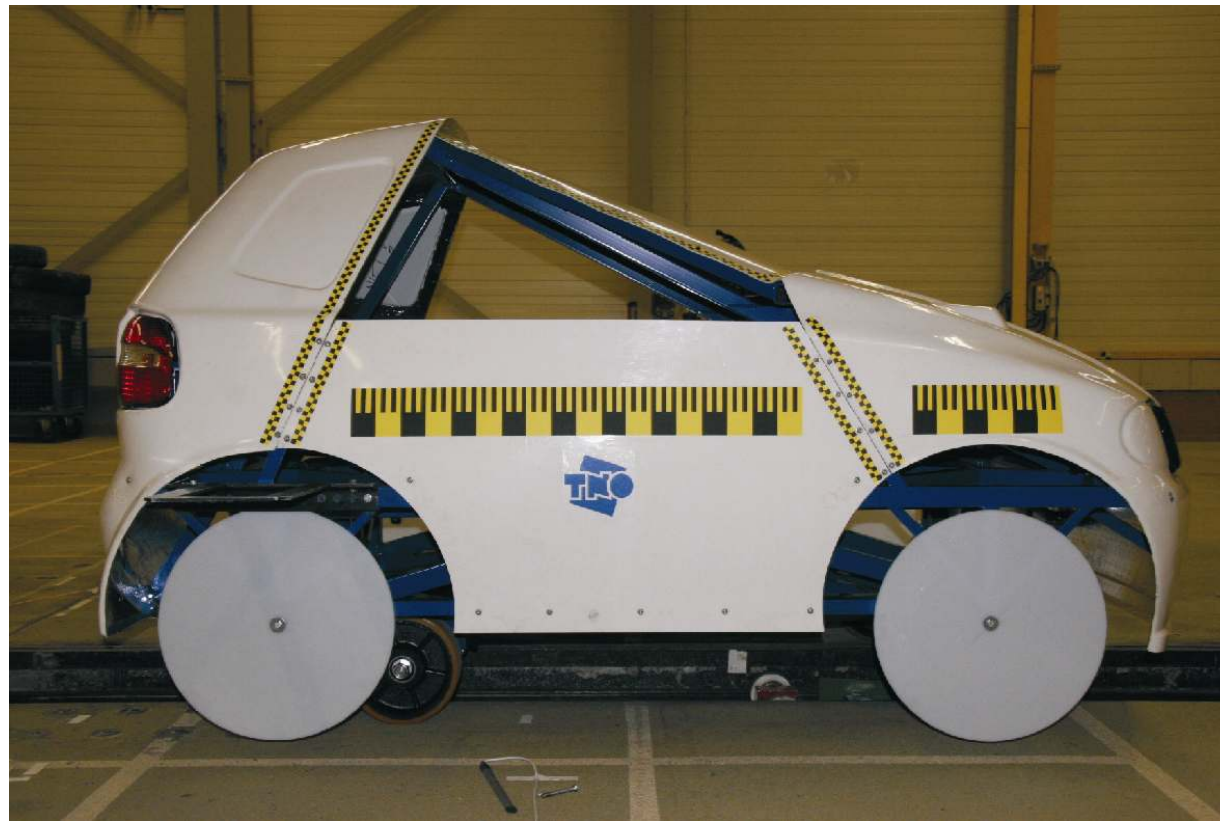
- **Application of crash lab, minimum TTC 50 ms**

Source APROSYS SP6: DaimlerChrysler, Fraunhofer, Siemens VDO, TNO

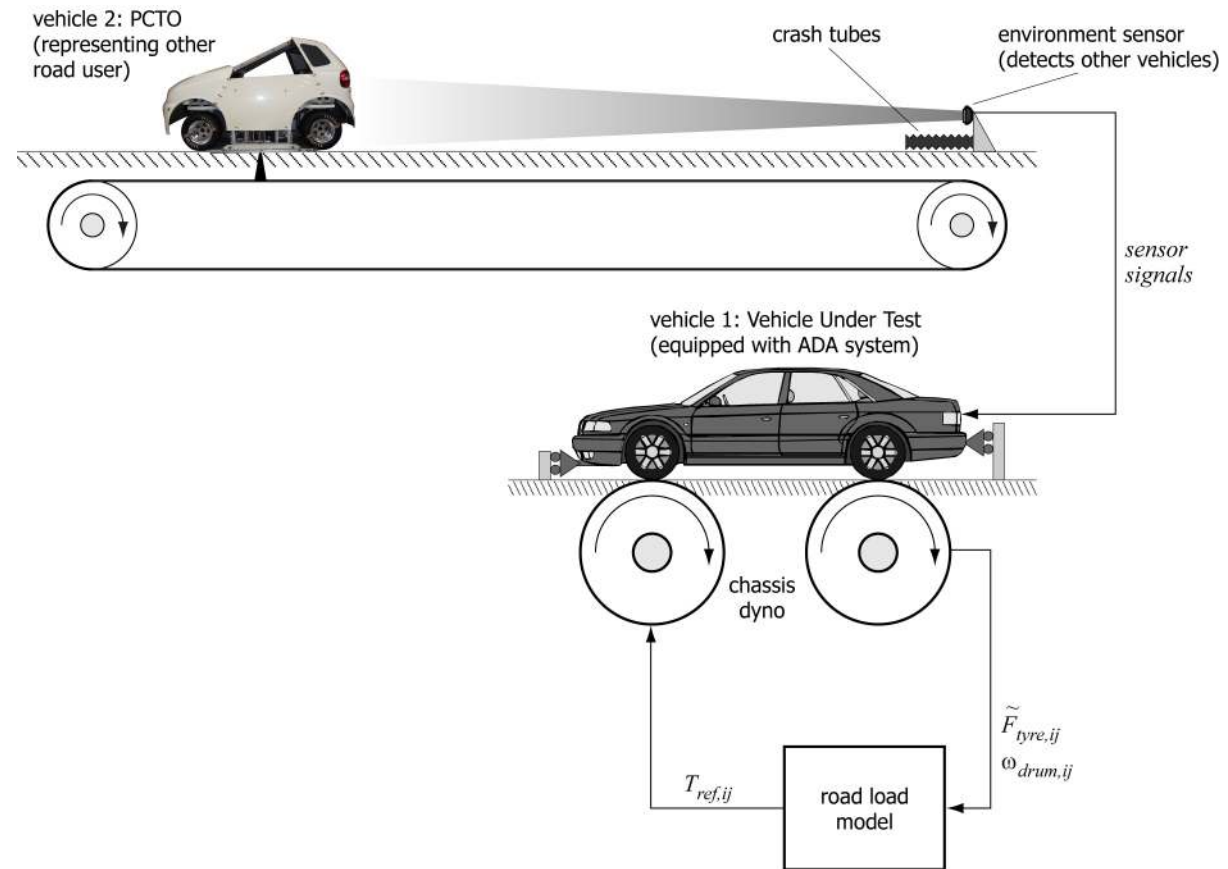# Combination of Crash Lab and VeHIL

Crash Testing

Homologations

VeHIL

Powertrains

05.228 Nieuwbouw TNO Automotive te Helmond Van de Loo - Lortye Architecten BNA
i.o.v. J.G. van de Westerlo & E.J.C. Janssen - van de Westerlo   dd. 11-07-2006

VeHIL/Pre-crash Testing

- **Target similarity VeHIL ↔ VeHIL/Pre-crash**

Possible Addition 1

- **Vehicle on Roller Bench**

vehicle 2: PCTO (representing other road user)

crash tubes

environment sensor (detects other vehicles)

sensor signals

vehicle 1: Vehicle Under Test (equipped with ADA system)

chassis dyno

$\tilde{F}_{tyre,ij}$

$\omega_{drum,ij}$

$T_{ref,ij}$

road load model

Possible Addition 2

- **Variable Object Speed**

vehicle 2: PCTO
(representing other
road user)

crash tubes

environment sensor
(detects other vehicles)

sensor
signals

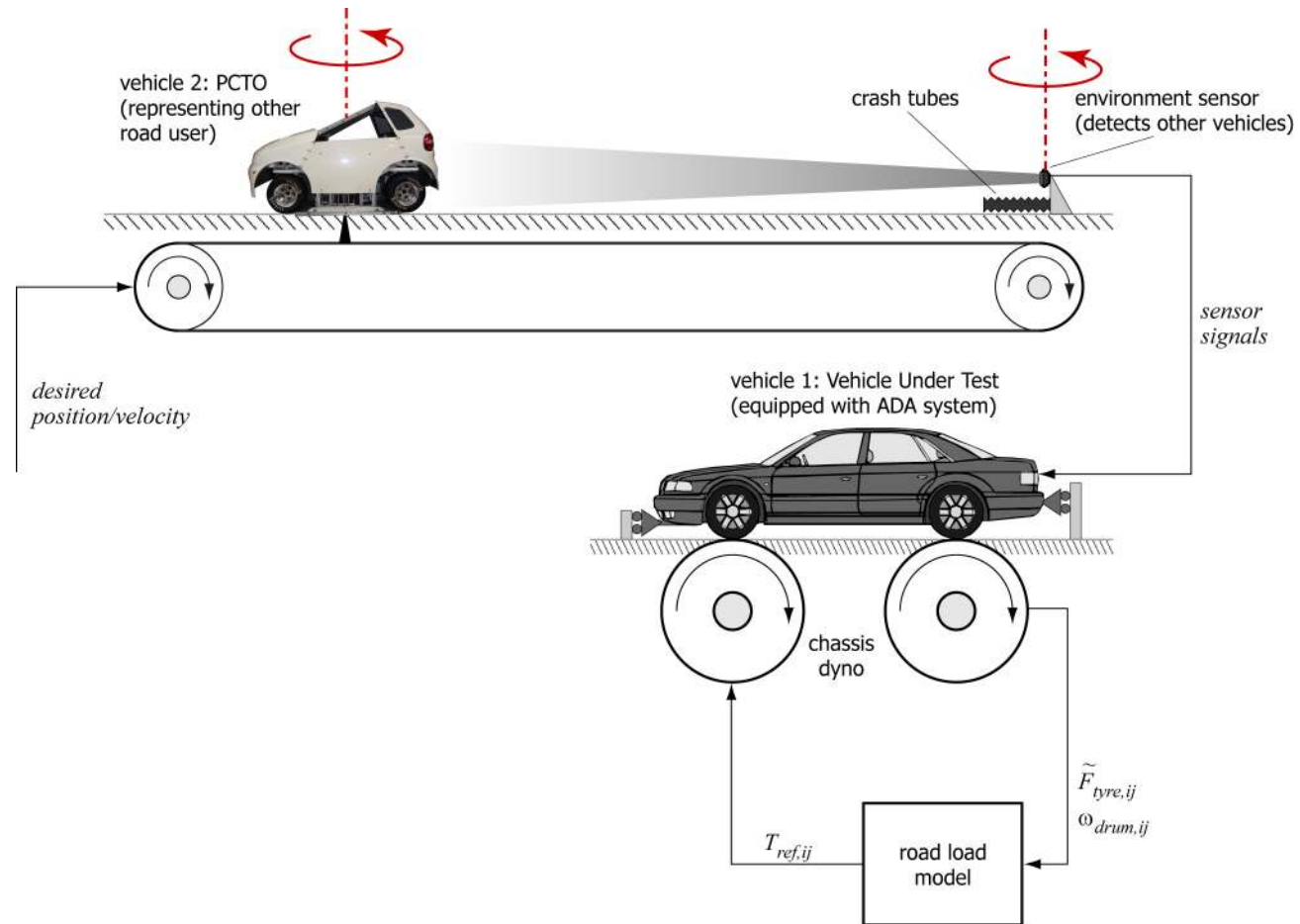*desired
position/velocity*
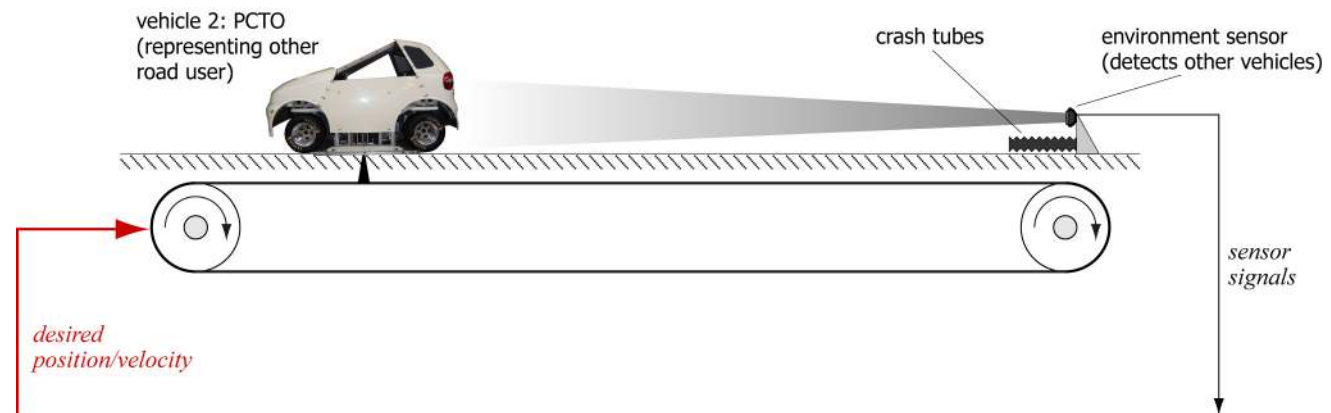
Possible Addition 3

- **Closed-loop simulation using a traffic model**
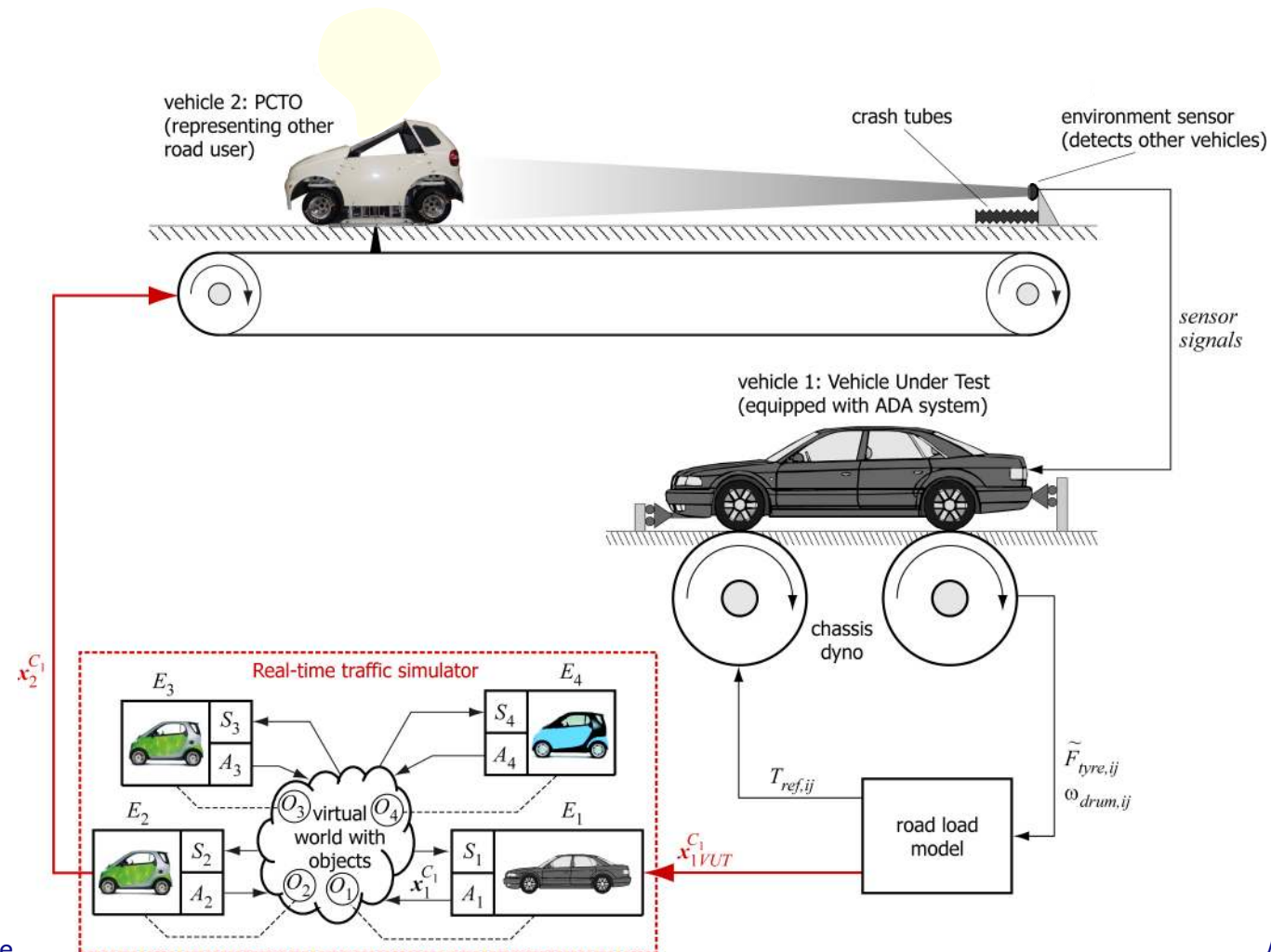
Possible Addition 4

- **Traffic scenario extension**
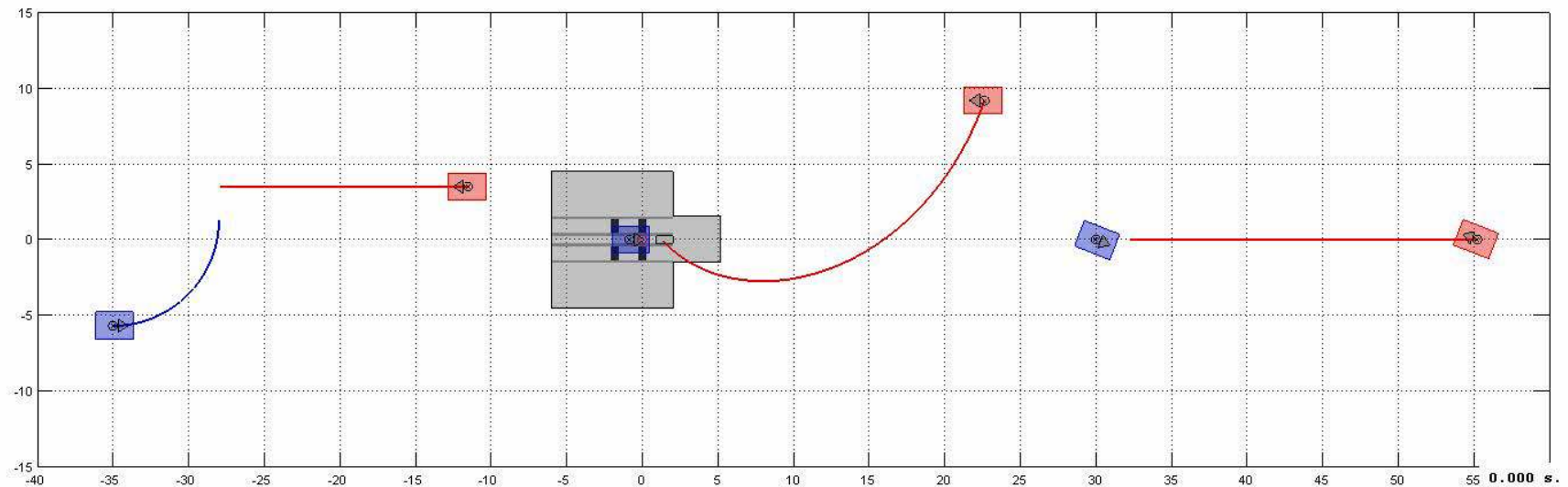 - non-straight scenario's, e.g. left/right turn, take-over, ...
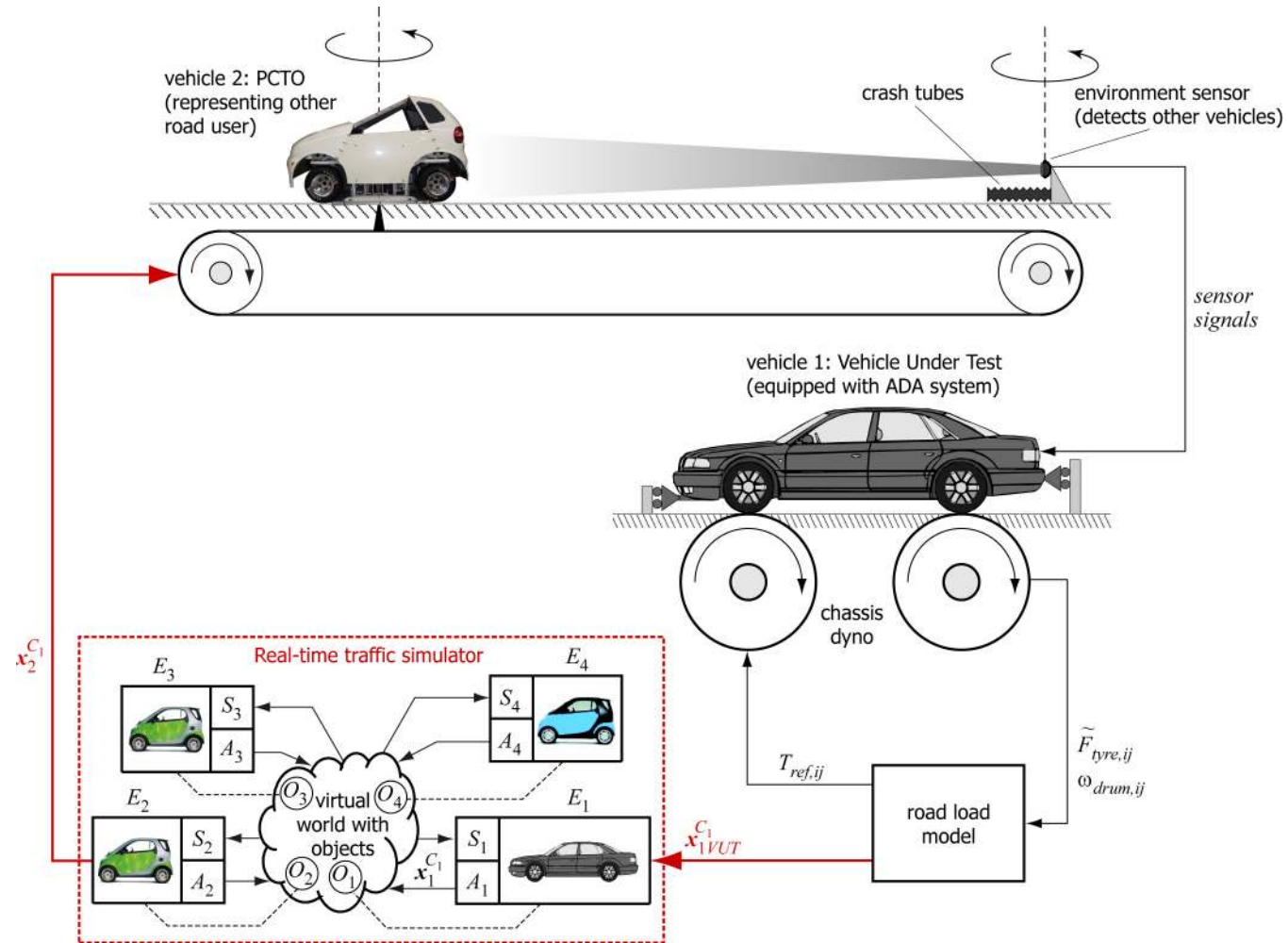
Addition 4 Example: Left Turn Host, Hit

Real world
(host & target)

VeHIL
(VUT & MB)

VeHIL/Pre-Crash
(VUT & PCTO)

Final Pre-Crash Test Set-up

Summary

- **TNO has unique tools and competences for Advanced Driver Assistance System development**
    - PreScan Simulation Environment
    - VeHIL
    - Test Track Automation Tools
    - Pre-Crash Test Set-up

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