AIM – Application Platform for Intelligent Mobility

Dr. Henning Mosebach, DLR Braunschweig

Experience with AIM and other Living Labs
Prof. Bernhard Josko, OFFIS Oldenburg
Research focuses

- Aeronautics
- Space
- Transport
- Energy
- Defense and Security

Institute of Transportation Systems
Braunschweig
DLR Institute of Transportation Systems (TS)

Residence: Braunschweig, Berlin
Since: 2001
Director: Prof. Dr.-Ing. Karsten Lemmer
Employees: Presently 160 employees from various scientific disciplines

Fields of research: Automotive
Railway Systems
Traffic Management
Intermodality, public transport

Range of tasks: Basic research
Creating concepts and strategies
Prototype development
Since 2002 DLR is active in the development of intelligent transportation systems.

TS is in the field of ITS with scope on:
- Analysis of drivers behavior and workload
- Interaction strategies between human and relevant objects
- Developing and operating test vehicles and simulators for ADAS development

Highly automated driving in a connected environment is one of the main scopes of the institute's research.
Key elements of cooperative and automated driving

- Highly automated and connected driving will be one key element of future driving.
- Future vehicles will be "connected vehicles" by evolution.
- Higher degrees on automation require connected driving.
- Local dynamic maps (LDM) will promote the development of local services.
- C-ITS test sites are required to support the development, test and validation of cooperative and highly automated in-vehicle functionality.
Smart and cooperative mobility - Two-way-approach

„Smart Cities“

- Growing number of connected traffic participants
- Multimodal communication channels
- Cloud based service platforms

„Smart Vehicles“

- Basic vehicle equipment supports automation of driving maneuvers
- Realtime connection of vehicles

Source: Continental AG

Source: Acatec
Vision of institute: “An entire city serves as a platform for application-focused science, research, and development in the field of intelligent mobility services.”

AIM-Modules:

- ITS G5 communication units
- Cooperative research vehicles
- Traffic detection environment
- Connected simulation environment
- Virtual representations of AIM
- Backend service platform

City of Braunschweig (“City of research”): 250,000 habitants, 30,000 students
AIM Modules

- ITS G5 communication units
- Cooperative research vehicles
- Traffic detection environment
- Connected simulation environment
- Virtual representations of AIM
- Backend service platforms
ITS G5 communication units
IRS – topology on AIM testsite Braunschweig

- 35 ITS roadside stations at traffic light poles
- Direct link to traffic light controllers
- Uplinks to SW-management
- WLAN Clusters combine RSUs for realtime processing and local data aggregation
- Development and test of cooperative systems
ITS G5 communication units
Intelligent Roadside Station (IRS)

- Application Unit (AU) and Communication Unit (CCU) as described by CAR 2 CAR

- Transmission of traffic light signal state and intersection topology (SPaT, MAP)

- Reception of vehicle data (CAM, DENM)

- Local dynamic map (LDM) for realtime services

Current AIM communication protocols
- SPaT: SAE J2735 region-D definition
- MAP: SAE J2735 region-D definition
- CAM: v1.3.2 (EN 302 637-2, 2014-09)
- DENM: v1.2.2 (EN 302 637-3, 2014-09)
- GeoNetworking: v1.2.1 (EN 302 636-4-1, 2014-05)
- GeoNetworking BTP: v1.2.1 (EN 302 636-5-1, 2013-10)
ITS G5 communication units
Selected IRS on testsite AIM Braunschweig
ITS G5 communication units
Car2X – Central software provisioning system

- Online IRS Management
  - Status of each IRS on central GUI
  - Specified metadata also available

- Monitoring
  - Diagnosis and reporting by script
  - Preconfigured logging of specific data

- Software provisioning
  - Central deployment of IRS-Software
    (AU, CCU und local configuration)

- Testmanagement
  - Central management for the configuration of tests

GUI of software provisioning system
ITS G5 communication units

GLOSA – Green Light Optimal Speed Advisory

- IRS sends out intersection map (MAP)
- IRS sends out traffic light state (SPaT)
- Vehicle receives messages and calculates the optimized speed sector
- Visualization of speed sector
- Option: Direct execution of speed demand on powertrain („GLOSA-ACC“)
ITS G5 communication units

GLOSA – Green Light Optimal Speed Advisory
ITS G5 communication units

UR:BAN use case intersection pilot

Source: www.urban-online.org
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Cooperative research vehicles

DLR Research vehicles

2002: ViewCar (EU CVIS)

2006: FASCar I (EU HAVEit)

2009: FASCar II (EU adaptIVe)

2015: FASCarE

Degree on automation and cooperation

- Powertrain control by software
  - Gas and brake control
  - Steering control
- Data acquisition and control platform
- HMI units
- Positioning and communication module

- Driver analysis
- Scenario analysis
Cooperative research vehicles
Development of urban ADAS

- Vehicle serving as development platform for ADAS
- Allows longitudinal and lateral control of the powertrain
- Data fusion platform for environment perception
- High automation level maneuvers
- Fully electric vehicle
- ADAS: Automated lane change, valet parking, GLOSA, merging situations etc…
Cooperative research vehicles
Vehicle architecture

- CAN network for sensors and vehicle data
- Fast control algorithms on dSPACE Autobox and CAN-communication
- Applications on Linux-PCs and ethernet-communication
Cooperative research vehicles
Development of urban ADAS
AIM Modules

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Traffic detection environment
Research intersection

- Sensor-based realtime identification of objects
- Designed for situation analysis and classification of events
- Supporting local LDM-services and development of ADAS
- Classification and tracking of objects
- Online processing of object data into trajectories
- Current project: EU XCycle
  (www.xcycle-H2020.eu)
Traffic detection environment
Research intersection
Traffic detection environment

Research intersection
Traffic detection environment
Research intersection

Stereo-Camera-System
IR-Flashlight
Traffic detection environment
Research intersection
Traffic detection environment
Research intersection
Traffic detection environment
Research intersection example results

- Extended data acquisition time (e.g. weeks)
- Filtering for specific objects or scenarios
- Analysis against specified measures
- Examples: Post Enchroachment Time (PET) for a certain area e.g. in relation to traffic light parameters
Traffic detection environment
Mobile smart sensor units

- Portable smart units
- Extension with communication platform
- Serves as technology platform for campaigns
- Examples:
  - Microtraffic regulation at construction sites
  - LDM-applications
Traffic detection environment

Mobile smart sensor units

Detection of pedestrians and cyclists  Detection of vehicles
Traffic detection environment
Mobile smart sensor units
AIM Modules

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Connected simulation environment
3 seat simulation laboratory (MOSaIC)

- Lab environment for analyzing cooperative driver behavior
- Development of ADAS and user acceptance studies
- Based on VIRES virtual testdrive [www.vires.com](http://www.vires.com)
- Integration of third party components possible
Connected simulation environment
3 seat simulation laboratory (MOSaIC)

3 identical fixed-base simulators equipped with

- 160° front sight and left mirror
- Digital dashboard for HMI
- Active steering wheel for driver feedback
- Active brake pedal
- Active gas pedal
- Secondary display with touchscreen for specific distraction
- Driver monitoring and assessment
Connected simulation environment
3 seat simulation laboratory (MOSalC)
AIM Modules

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Virtual representation of AIM
Map and traffic simulation

- Acquisition of georefered data based on standard maps and probe vehicles
- Open Drive and Navigation Data Standard 2.4
- Transformation of map into DLR driving simulators
- SUMO Traffic flow simulation
- Traffic data platform with traffic state

Map standards: OpenDRIVE and/or NDS 2.4
AIM Modules

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- Backend service platform
- Operational layer
  - Realtime communication
- Tactic layer
  - Coordinating microscopic traffic
- Backend layer
  - Global services
- Analysis layer
  - Research and Optimization
Backend service platform
AIM topology
Backend service platform
AIM Backend components

- Netapp Server
  - Backup and node-server
  - Approx. 200 TB Storage volume

- Oracle Exadata Server
  - Relational database system
  - Database enterprise edition 12c

- Middleware server
  - Service platform
  - Several virtual machines
  - IKT-service platform

All components are operated by DLR
Backend service platform
Service platform IKT-P

- “Information and Communication Technology Platform”
- Open and scalable service platform for e-mobility and according services
- Basic traffic data available of selected regions
- E-Marketplace for mobility services
Backend service platform
Connection of services - inter roaming protocol
Backend service platform
Service platform IKT-P

- Finalized in 2015
- Under construction

- Public transport
- Traffic data and maps
- CRM
- Carsharing
- Billing
- Service Registry
- Business Support Services

Basic services

- IKTP

 IKTP - bundesweit + regional

Service platform IKT - bundesweit + regional

- Charging
- Parking

Regional

- Metropolregion
- Hamburg
- Berlin
- Wolfsburg
- Hannover
- Düsseldorf
- Freiburg
- Erlangen
- Leipzig
- Dresden
- Köln
- Nürnberg

Finalized in 2015
Under construction

DLR
AIM use case: automated Valet Parking (Jan. 2013)

Combining automated driving, I2Car Communication and Web Services

- Free parking space communicated via Car2x

- Vehicle calculates trajectory to parking space

- Smartphone sends request to backend service
AIM Valet Parking January 2013
The AIM vision: Partially automated urban traffic in 2030

- **Mixed traffic** (driverless, highly automated and manual driven vehicles)
- **Multimodal traffic system**
- **Extension** of AIM platform to Highway scenarios
- Service orientated business models **Mobility-as-a-Service**
- **Key-elements are:** Connection, human-machine Interaction, smart cities, IT-Security
- The use of living labs and their services will be an opener european funded projects and networks

Source: Acatec, Germany

Safe & Dependable Urban Mobility
Contact…

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Analyzing traffic scenarios
Research intersection

Stereo-Camera-System
IR-Flash
Mono-Cameras
IR-Flash
Radar sensor
DLR Braunschweig: Development of ADAS since 2002

Empirical research

Field operational tests

Detailed studies in research vehicles, simulators
- ViewCar®
- VR-Lab
- Cities
- Models

Finalization of prototypes
- FASCAR® (I+II)
- Test Beds / AIM

Development of functional prototypes and their evaluation in simulators
- Driver model
- SMPLab
- HMI-Lab
- dyn. driving sim.
- Mod. MockUp
- Vehicle models
DLR Braunschweig: Development of ADAS since 2002

Empirical Research
- Detailed studies in research vehicles, simulations, AIM and by using models
  - ViewCar®, VR-Lab, Test Beds / AIM, Models

Knowledge Management
- Finalization of prototypes and evaluation in AIM
  - FASCar® (I+II), Test Beds / AIM

Development of prototypes and their evaluation in simulators
- MoSAIC (Modular and Scalable Application-Platform for ITS Components)
  - VR-Lab, SMPLab, HMI-Lab, dyn. driving sim., Mod. MockUp, Models
Vision of DLR institute TS: “An entire city serves as a platform for application-focused science, research, and development in the field of intelligent mobility services.”

The AIM-modules supports:

- Connecting traffic lights and vehicles
- Cooperative and automated driving
- Analyzing traffic situations
- Simulation of cooperative scenarios
- Representing AIM testsite by maps
- Development of services

City of Braunschweig ("City of research"): ~250,000 habitants, 30000 students
Current state: ITS G5 projects and applications

- CVIS
- SAFESPOT
- COOPERS
- PRE DRIVE
- DRIVE C2X
- ITS Testbeds
- simTD
- ITS corridor Wien / Rotterdam
- ETSI Basic set of applications
- Many more...

Need for C-ITS Testsites
Beispiel: Transfer eines kooperativen Car2X-Knotens nach Düsseldorf

- BMWi-Projekt UR:BAN ([www.urban-online.org](http://www.urban-online.org))
- Entwicklung der Einzeltechnologien der „smarten Kreuzung in Braunschweig“
- Applikationsentwicklung der stationären und mobilen „CoApps“
- Technologietransfer zum Oberbilker Markt Düsseldorf
- Validierung in Düsseldorf
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