Simulation of the influence of road traffic on the operation of an electric city bus

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Introduction

- Cooperation between IPG and Karlsruhe Institute of Technology (KIT)
  - Chair of railway system technology (part of FAST → Institute of vehicle system technology) + Institute for Transport Studies (IfV)

- Project is a master thesis, announced and initiated by FAST (KIT) in the context of the BMVI-project “PRIMOVE Mannheim”

- Key aspect: Co-Simulation of IPG’s TruckMaker with a microscopic traffic simulation software in order to optimize the complete system of an electric city bus operation
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Lighthouse project “PRIMOVE Mannheim”

- Bus line 63 today operated with two buses (diesel-powered)
- Replacement with two electric city buses in Q4/2014
- e-Mercedes Vito also uses charging infrastructure
- Project duration at KIT: 2013 up to the end of 2015
- Financing by BMVI
- Project partner
Overall system and energy flows
Characteristic of the bus line

- Length of bus line: 9 km
- Journey time: 33 min
- 21 bus stops
- Charging stations
  - 4 across the line
  - 2 at end stops
  - 1 in the depot
- Due to charging across the line:
  - Smaller battery
  - Less weight
  - Lower costs
- HGV/Bus: 1.5 – 2.5 kWh/km
Vehicle vs. traffic simulation software

**IPG TruckMaker**
- Open integration and test platform
- Robust and productive test case implementation for MIL, SIL and HIL applications
- Individualized and realistic vehicle models can be implemented
- Traffic module is customizable

**PTV Vissim**
- Microscopic traffic simulation software
- Modelling of traffic networks with infrastructure and road users
- Realistic modelling of driving behavior
  - Following Model
  - Lane Changing
- Modelling of vehicle dynamics is limited

Co-Simulation of both programs
Development environment of the project

**Input**
- Roadside data
- Schedule
- Driver profile
- Traffic data
- Vehicle data

**Operation & infrastructure**
- Environmental model

**Vehicle**
- Vehicle model

**Operation & infrastructure**
- Environmental model

**Output**
- Visualization
- Instruments
- Analyses of key figures

Software tools:
- TruckMaker
- Dymola
- Matlab Simulink
- Google Earth
- PTV VISSIM

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Intersection modelling with Vissim
Bird’s-eye view of test area in Mannheim
Setup of the interface (1/2)

- Design of the interface is essential
- Choice of the right tools
  - Interface coded in C++
  - Application of a COM Interface in Vissim
  - Server/Client architecture in TruckMaker
  - Determine Master and Slave
- Focus on performance and functionality
  - Size of traffic system
  - Number of traffic objects
  - Performance of both programs

**Vissim:**
- COM interface

**TruckMaker:**
- Server/Client architecture

Interface implemented in C++ Code
Setup of the interface (2/2)

- Several basic parameters are used to realize the interface
  - Position data of vehicles and road (Cartesian system)
  - Vehicle speed and acceleration
  - Simulation time

- Requirements for position data:
  - Both coordinate data has to be equal
  - Global cartesian system vs. road cartesian system in TruckMaker
  - Position of the vehicle in the traffic system
  - Divergence of vehicle data point
Challenges of the project

- Synchronization of both simulations
  - Vissim: maximum cycle rate $\frac{1}{20}$th of a second
  - TruckMaker: cycle rate of 1000 Hz

- Precision of transferred data (e.g. data points of traffic system)

- Interaction of exchanged traffic objects

- Harmonize two different driver models

- Different approaches of interface design
Use cases of the Co-Simulation (1/2)

- Realistic testing of different settings around the vehicle
  - Vehicle model/parameters
  - Sensor testing with IPG Movie

- When simulating new powertrains and their components, the influence of traffic is significant
  - Recuperation
  - Behavior of other drivers
  - Car-to-X communication

- Optimization of operation procedures in case of public transport scenarios
Use cases of the Co-Simulation (2/2)

- Follow scenario

- Stop-and-go scenario at a traffic light
Surplus value for operators (1/2)

- Complex traffic situations can be tested

- Easy and quick implementation of complex traffic scenarios
  - Traffic jam
  - Stop-and-go traffic
  - Urban traffic

- Variation of different traffic parameters
  - Traffic density
  - Traffic volume
  - Realistic driver model
Surplus value for operators (2/2)

- Quick variation of the same traffic scenarios (stochastic composition of traffic)

- Opportunity to use real traffic data

- Reproducibility of traffic scenarios

- User-friendliness of the new software tool → One click solution
Résumé

- Co-Simulation of IPG TruckMaker and PTV Vissim offers new ways of testing → especially regarding the system configuration for electric vehicles
- Operators are able to use the capabilities of both programs
- Reducing the gap between real world and simulation world
THANK YOU FOR YOUR ATTENTION!