Iterative Design Process For The Development A l Testing Of Cooperative Applications

Tobias Lorenz

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Short Introduction – DLR and Institute TS

German Aerospace Center

Areas of Research

- Aeronautics
- Space
- Transport
- Energy

DLR in numbers

- Budget:
  - 2006 1.168 M Euro
  - 2007 1.224 M Euro

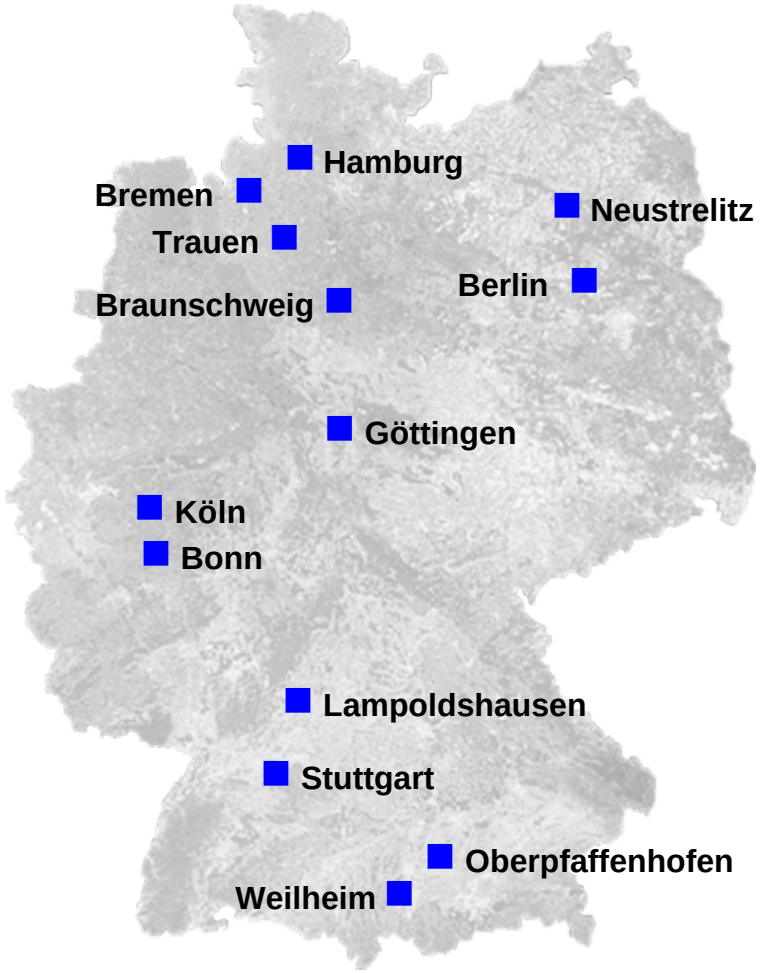




Locations and Employees

5.600 employees work at
28 research institutes and facilities
at ■ 13 locations.

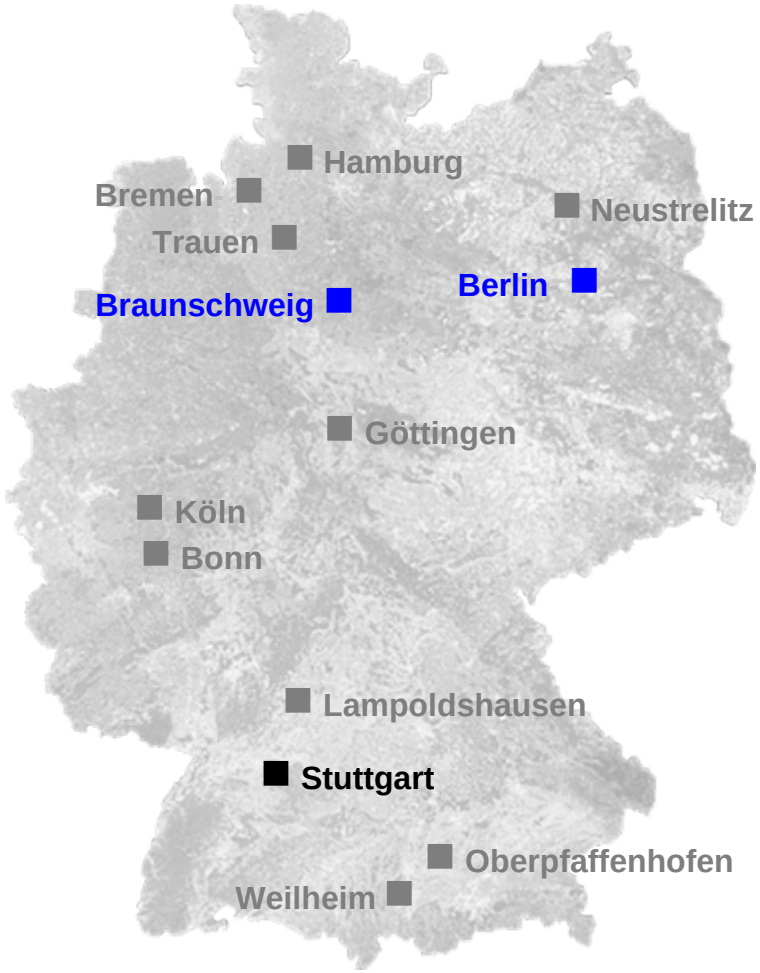
Offices in Brussels,
Paris and Washington.



Transportation
Participating institutes

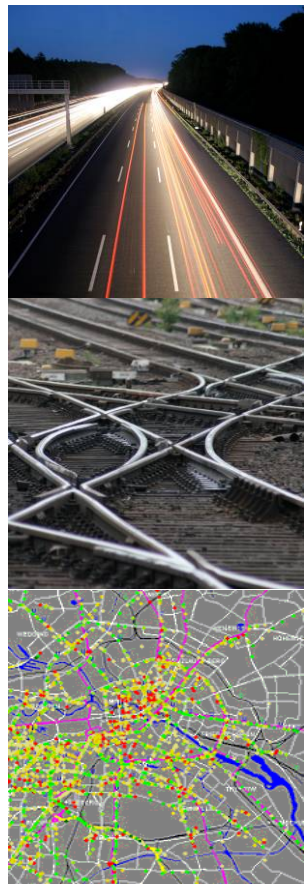
- Institute of Transport Research
- Project Transport Studies
- **Institute of Transportation Systems**
- Institute of Vehicle Concepts

… and 21 more institutes from aeronautics, space and energy



Institute of Transportation Systems

Residence:	Braunschweig and Berlin
Since:	March 2001
Director:	Prof. Dr.-Ing. Karsten Lemmer
Employees:	Presently 100 employees from various scientific disciplines



Range of tasks

- Basic research
- Creating concepts and strategies
- Prototype development

Fields of Research

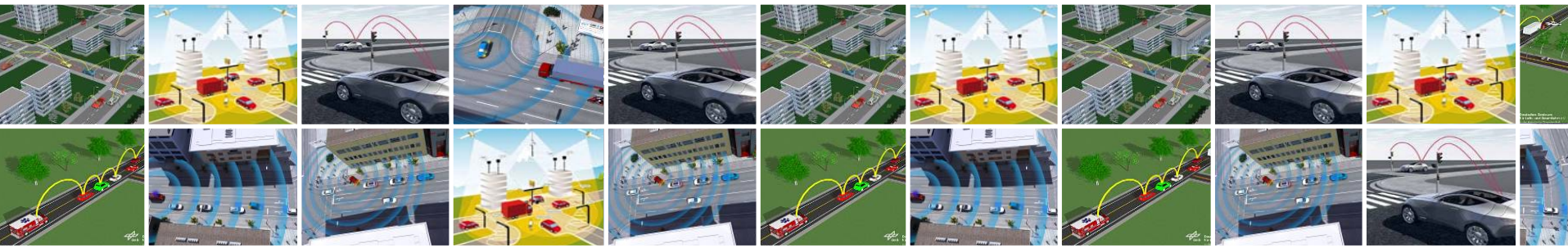
- Automotive
- Railway Systems
- Traffic Management

Iterative Design Process
Overview

Iterative Design Process

Introduction and Motivation

- The determination of requirements for cooperative assistance and automation based on Car-to-X technologies emphasize research questions on different levels – e.g.
  - Reliability / availability
  - Interoperability of assistance and automation systems / security
  - Different penetration rates and their influence on the function of the system, traffic safety/-efficiency, driver behavior and acceptance



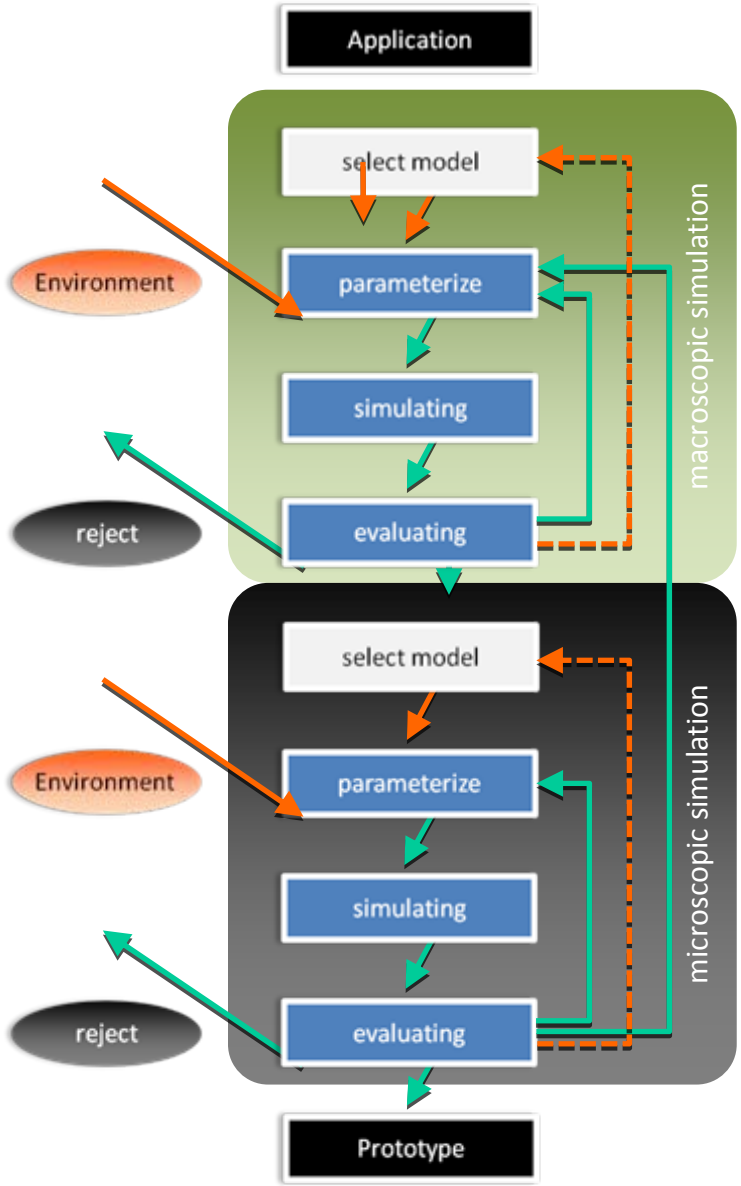
Iterative Design Process
Introduction and Motivation

- Increasing importance of conducting simulation tests during the development and evaluation process because
  - Basically field operational tests (FOTs) are applicable **but**
    - Large number of equipped vehicles
    - Huge testing areas especially urban areas required
    - Immense costs
    - Influence of different penetration rates

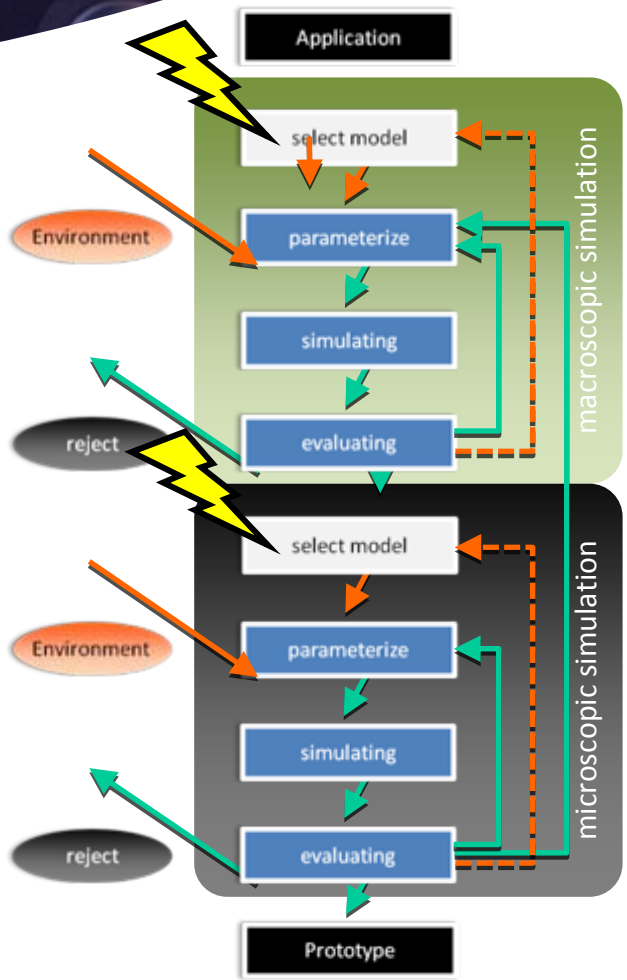
- To run these simulation tests systematically by using the right simulators an iterative design process including guidelines and code of practice is indispensible

Iterative Design Process
Overview

- Different steps within this process
  - Accident analysis provides an application idea
    - Study statistics on road accidents
    - Reasons for the accidents
  - Development and testing of the application within different scenario views
    - Model selection
    - Parameterization
    - Evaluation
- Prototype as final outcome

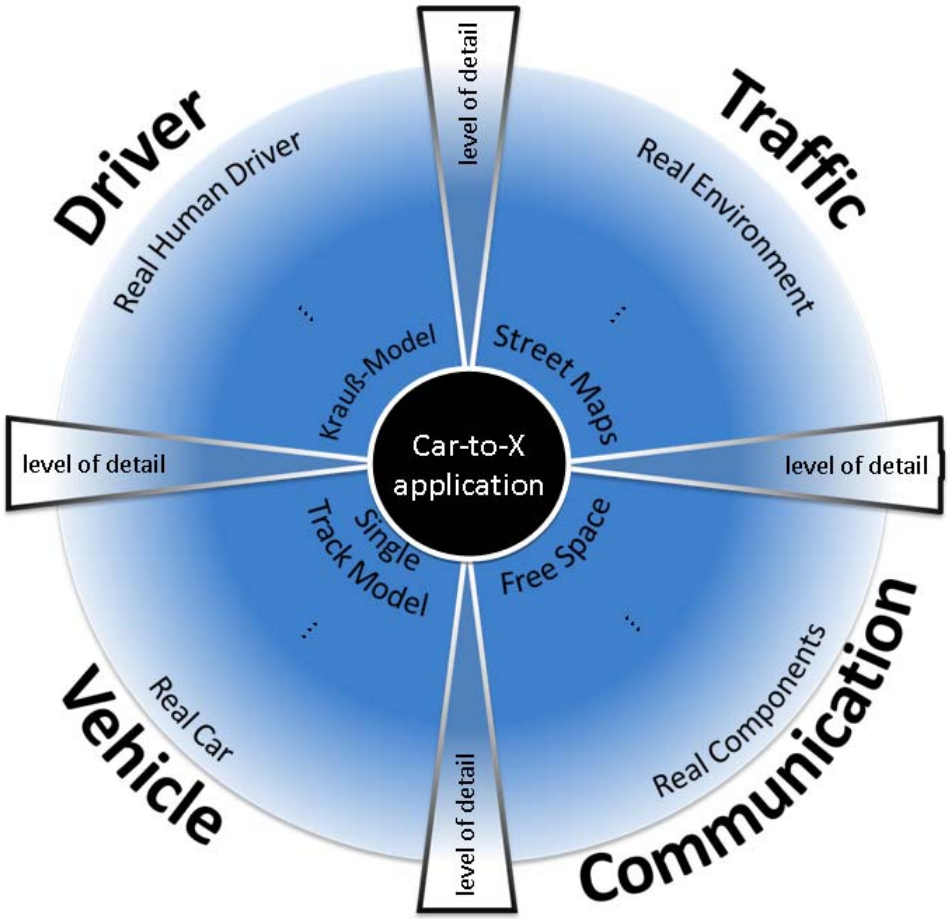


Iterative Design Process
Model Selection



Iterative Design Process

Model Selection I – Overview



Iterative Design Process
Model Selection II – Background

- Often Simulators/Models are used which are not applicable for the current research question because
  - Too many unknown parameters within the model
  - Environmental influences are not considered
- **Non-transferability of the results to the real world**

- Example
  - Often NS-2 is used with non-deterministic communication model but
    - Not applicable for the investigation of safety applications in urban environments
    - Buildings and other cars are not considered for the communication

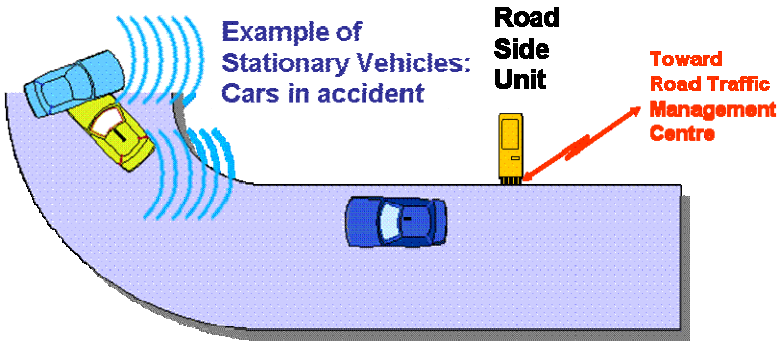
Iterative Design Process
Model Selection III – Key Parameters

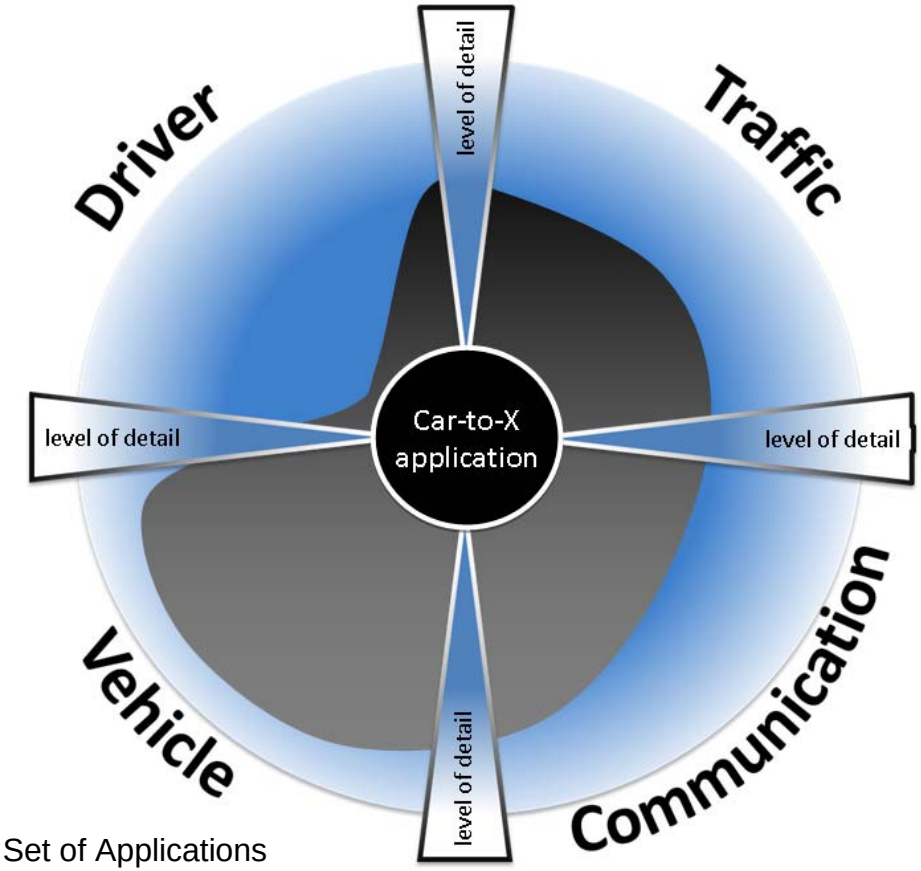
- Two main key parameters for model selection
  - **Scenario scale**
    - Macroscopic
      - Traffic flows in huge areas
        - Traffic Management
    - Microscopic
      - Certain parts of the traffic flow
        - Safety critical applications
        - Communication aspects (e.g. message propagation)
  - **The description of the Car-to-X application**
    - Requirements
    - Intended Effect
    - Performance Indicators
    - ...

Iterative Design Process

Model Selection IV – “Stationary Vehicle Warning“

- Example – “Stationary Vehicle Warning“ (ETSI BSA[1])
  - Informs the driver about a stationary vehicle
  - Safety application
    - Microscopic view only





[1] European Telecommunications Standards Institute Basic Set of Applications

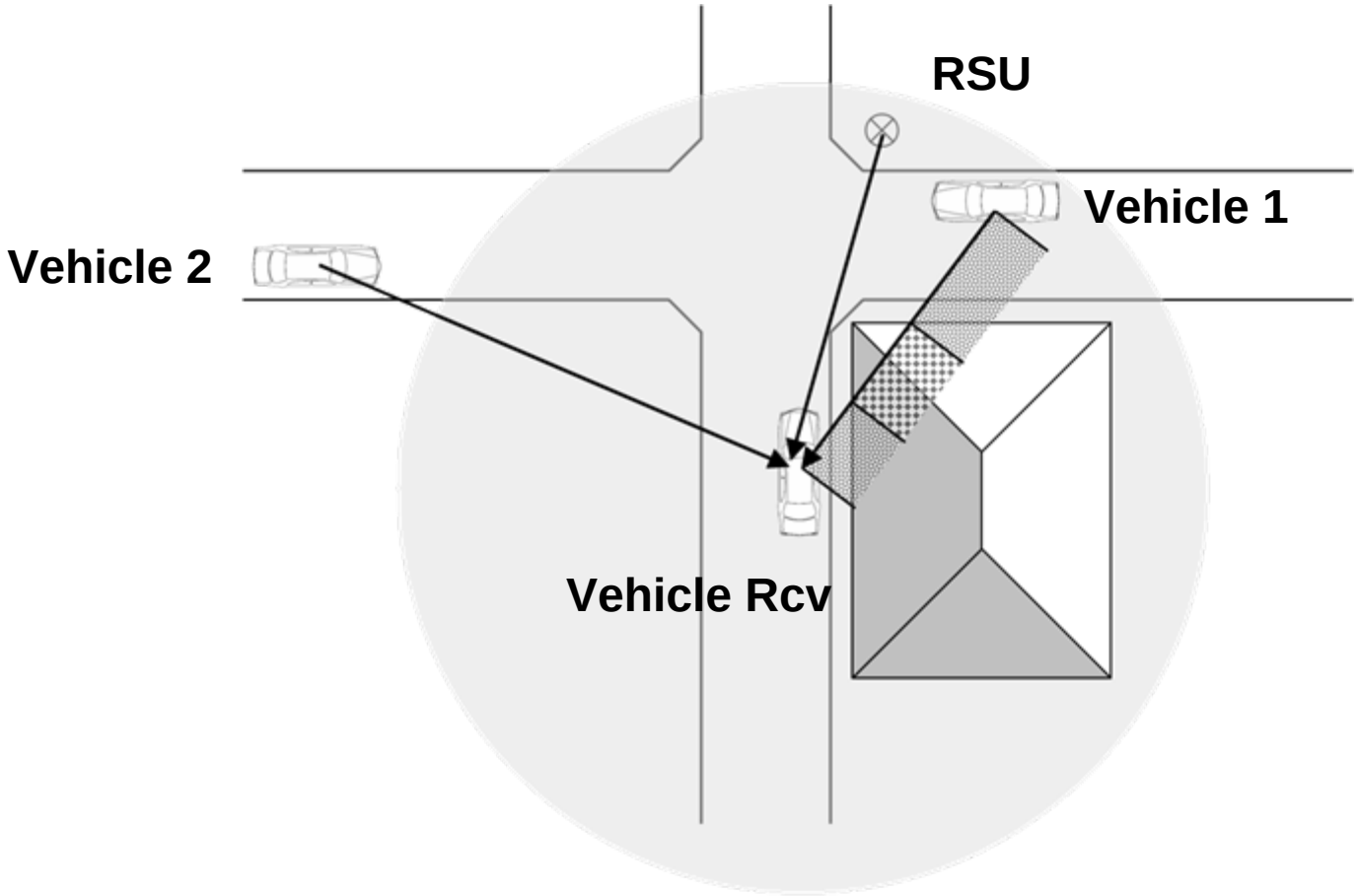
Iterative Design Process

Model Selection V – “Stationary Vehicle Warning“

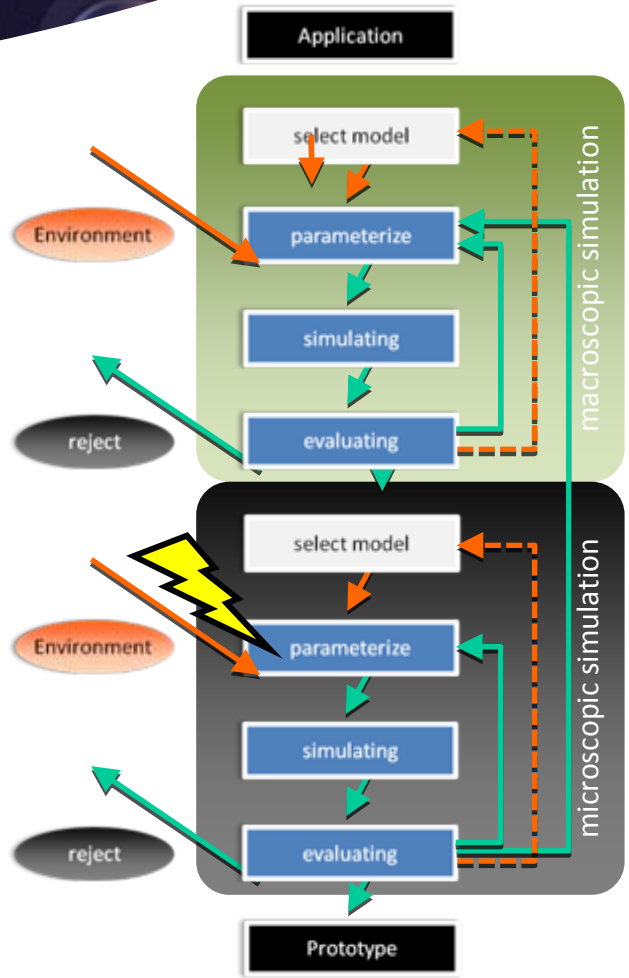
- **Communication Model**
  - **Environmental influences**
    - **Deterministic message propagation**
  - **No simulation of ISO/OSI layers like MAC/NET/TRA**
  - **Latency times, Sample frequency**
  - **Signal Damping**
    - **Communication range**
- Driver Model of surrounding traffic
  - e.g. Krauß model
- Vehicle Model of ego vehicle
  - Non-linear two track model
- Traffic
  - e.g. VISSIM, SUMO, ...

Iterative Design Process

Model Selection VI – Communication Simulator



Iterative Design Process
Model Parameterization



Iterative Design Process

Model Parameterization I – Overview

- Different models provide different influencing parameters
- Some of the parameters have to be varied and some are fixed within the simulation
  - Static parameters
  - Variable parameters
- Variable parameters are varied until the intended effect of the application can be verified
  - Traffic management
    - Macroscopic scenario view
      - e.g. identification of penetration rate and needed communication range to achieve the intended effect
    - Microscopic scenario view
      - Validation of the identified parameters by considering environmental influences, too

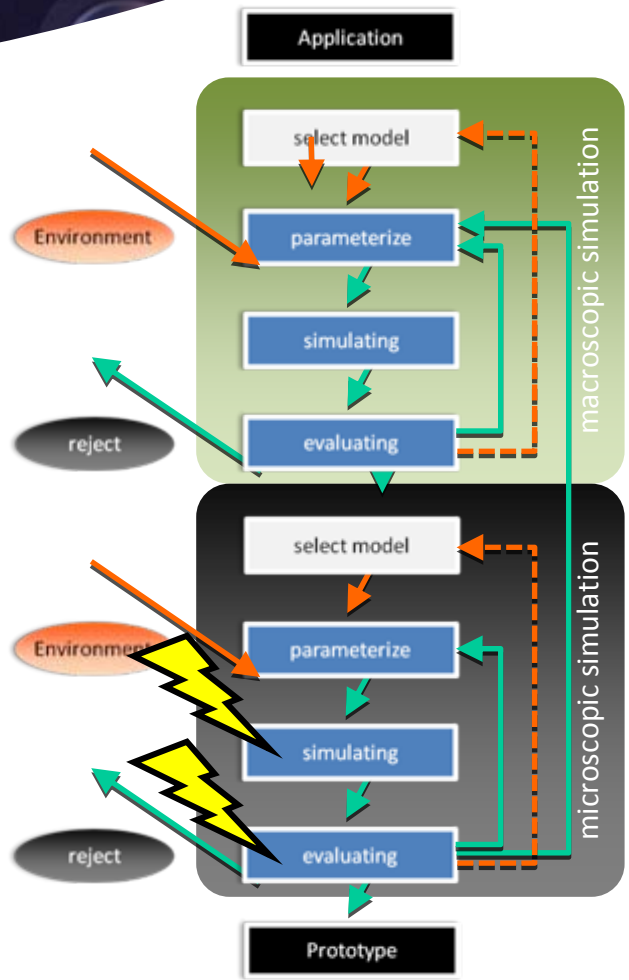
Iterative Design Process

Model Parameterization II – “Stationary Vehicle Warning“

- Stationary Vehicle Warning – Safety application
  - One aim could be the investigation of communication aspects and their influence on driver behavior
    - Intended effect
      - e.g. warn driver 300 m before traffic obstruction
    - Static parameters
      - Properties of environmental surroundings
      - Communication frequency 5.9 GHz
    - Variable Parameters
      - Transmitting power
      - Antenna position

Iterative Design Process

Simulation / Evaluation



Iterative Design Process

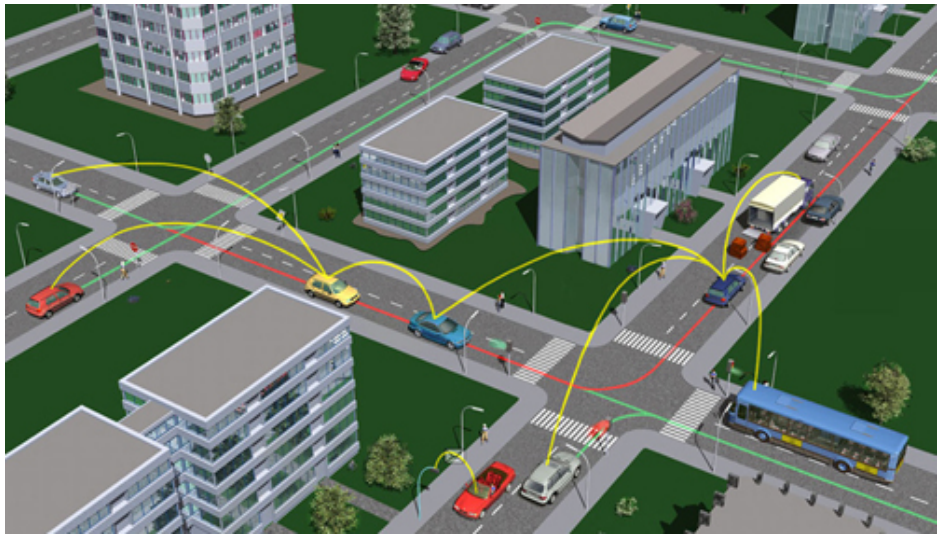
Simulation/Evaluation – “Stationary Vehicle Warning“

- For the simulation trials
  - The static parameters are fixed
  - The variable parameters will be varied
    - Iterative process
      - Fix all variable parameters but one
      - Vary the one left
      - If the intended effect is not verifiable change one or more of the fixed parameters and restart process
    - Example
      - Fix antenna position
      - Vary the transmitting power

Iterative Design Process
Conclusion

Iterative Design Process
Conclusion

- The iterative design process emphasize the importance of simulation in the area of Car-to-X systems
- Selection of the right simulator models is indispensible
  - For Car-to-X the focus is on communication simulation
- Choice of the right model parameters is important
- When running the iterative design process successfully for simulation it can be adapted to FOT
  - There the model selection process is omitted



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