Radar Simulation with CarMaker 9

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Agenda

- Introduction of ICON RADAR™
- Necessity of simulation
- History of Radar Simulation with CarMaker
- IPG & Magna Collaboration
- Pipeline & Development Process
- Use Cases

Automated Driving Systems

Radar

ICON RADAR™ provides both horizontal and vertical detection with the ability to discriminate adjacent targets with the longest object detection range >300m

Smarter
Safer
Autonomy
New Mobility
First to Market Opportunity

Competitive advantage/differentiators

- Excellent range resolution and isolation (very small targets next to large targets). Object separation as low as 10cm
- Mid-range radar provides consecutively tracked detection >160m
- True 2D-MIMO processing enables unmatched angular and super resolution
- Ultra-high resolution at 77GHz & 79GHz point cloud imaging similar to LiDAR with 3D detections and velocity measurements

Features

- Full and high-speed ACC, VRU-AEB, Stop and Go, Highway Pilot, Traffic Jam Assist
- Autonomous Lane Change, Lane Change Assist, Blind Spot Detection, Cross Traffic Intersection Detection, low speed such as Autonomous Valet
- Options for data fusion include:
  - CAN-FD object, tracks, classification, freespace
  - 1-2 GigE outputs for data logging & fusion

SOP

Ideation | Discovery | Concept | Development | Serial Preparation | in Production

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Necessity of Simulation

Virtual validation is more than just an element of the requirements. It raises the development process to a new level.

Simulation for Requirements

- Processing all real validation tests in the virtual context
- Testing from single features to complete systems

Simulation in development process

- Providing simulated data for developers from concept phase to SOP
- Comparing results of software components with ground truth data from the simulation in the early development stages
- Reducing the amount of measurements with test cars

Simulation in CarMaker

Radar simulation in Carmaker continuously improved over time – from basic object simulation to complex amplitudes of virtual receivers

Before CarMaker 7 (< April 2018)

- Radar Sensor providing objects
- Probabilistic sensor model considering
  - Occlusion effects
  - Antenna gain model
  - Propagation losses
  - RCS of targets
  - Noise

CarMaker 7 & 8 (since April 2018)

- Introduction of Radar Raw Signal Interface Sensor (Radar RSI)
- Providing detection points instead of objects based on a raytracing
- Considered effects by the raytracing
  - Material dependent reflection
  - Multipath propagation
  - Doppler shift

CarMaker 9 (April 2020)

- Geometrical and optical raytracing
- Antenna parameters for transmitter and receiver
- Discretization of the analog signal
- Processing and Filtering
- Possible Outputs:
  - Detections (only 1D)
  - Complex Amplitudes of all virtual receivers (VRx mode)

Radar RSI in CarMaker 9

With CarMaker 9, two different output modes were introduced, and the raytracing was extended by the optical component

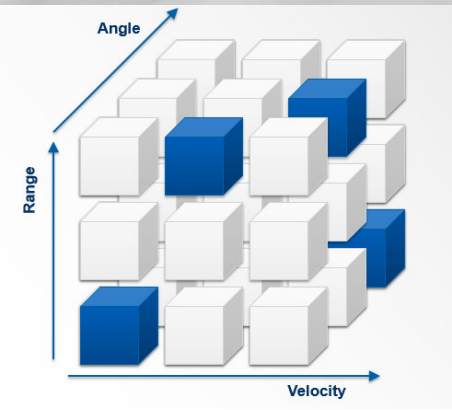
IPG and Magna collaborated to improve the radar simulation

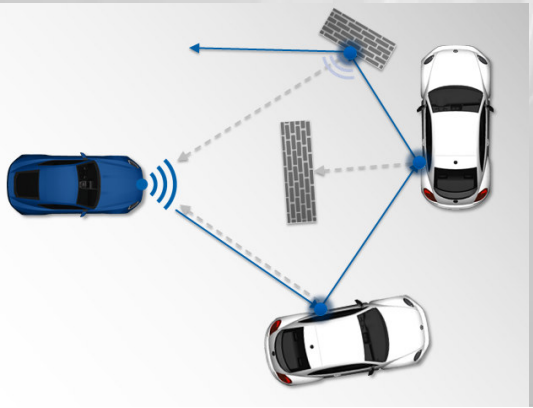
Detection mode

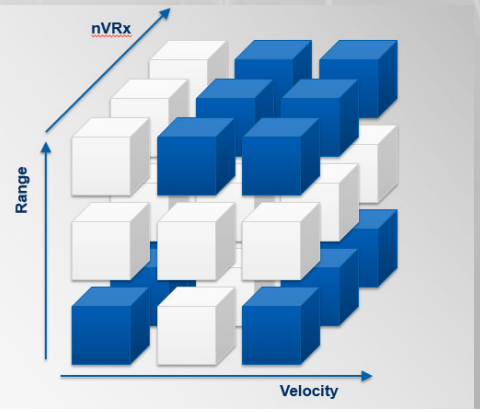
- Range-Doppler-Map as origin
- Range-Doppler filtering with additional peak finder
- Angular filtering and peak finder
- Detection output with
  - Cartesian or spherical coordinates
  - Velocity
  - Power

VRx mode

- Range-Doppler-Map as origin
- Range-Doppler filtering with additional peak finder
- Custom beamforming
- Activation output with
  - Range
  - Velocity
  - Complex amplitudes of all virtual receivers







Measurement Campaign

IPG & Magna performed a measurement campaign to validate the output of the Radar RSI with real radar data

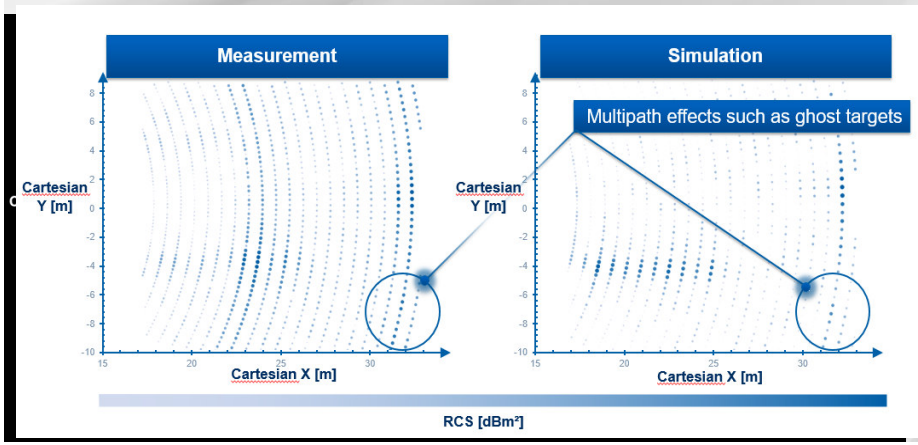
Test cases

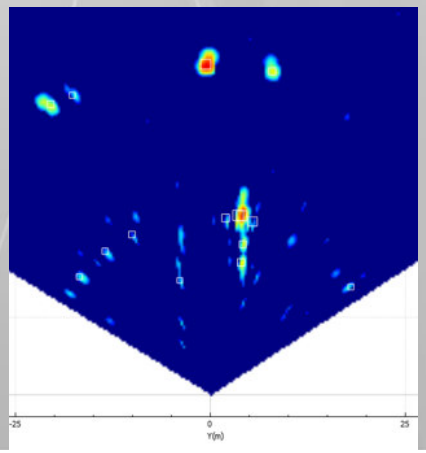
Focus on:

- Power level
- Scattering
- Interference effects, ...
- Complexity varied from single corner reflectors or traffic objects to more complex scenarios to measure object merging and multipath propagation
- more than 700 measurements

Validation of simulation data

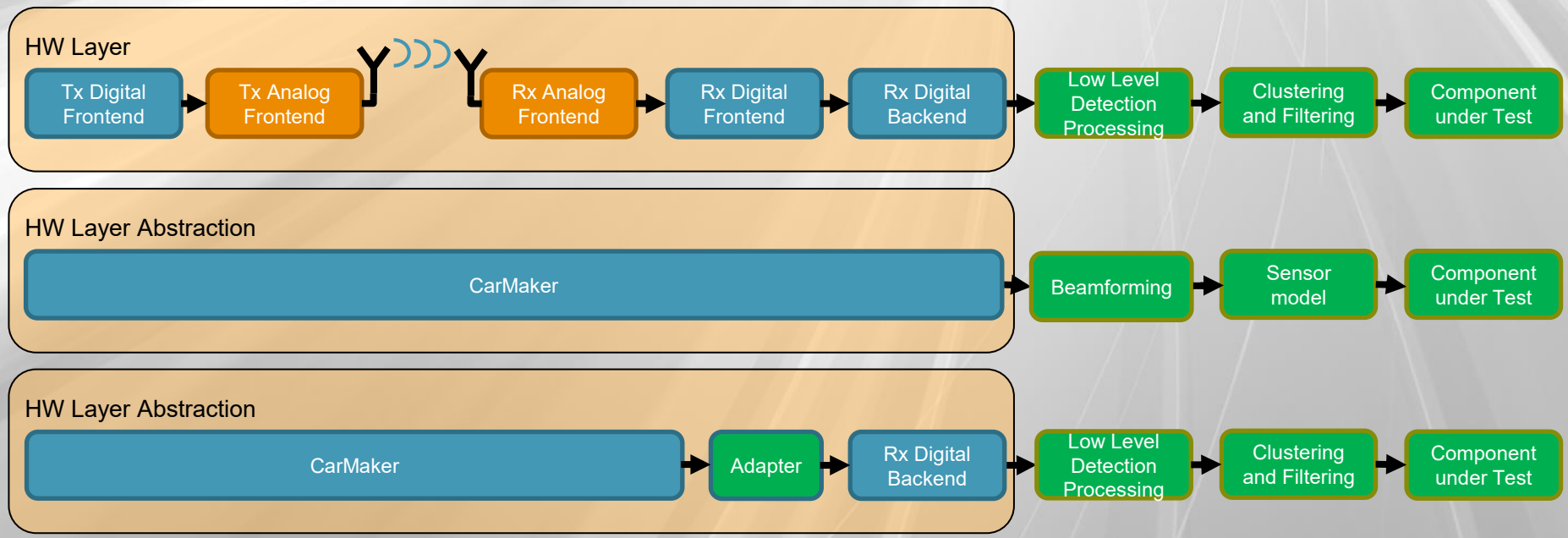
- Test cases from measurement campaign were rebuild in CarMaker and validated by IPG
- Example from pictures: Effects like ghost targets can be seen in the simulation





Pipeline Overview

There are two different approaches for simulating our radar



Using CarMaker – Development process

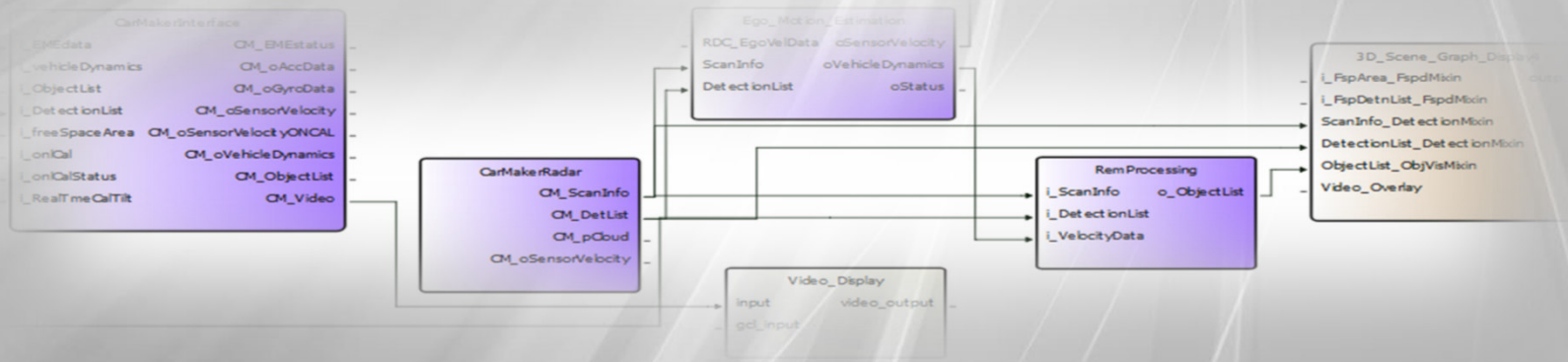
Our Software Components are validated during the development process with real and simulated data

ADTF connection

- Running software components in ADTF (Automotive Data and Time-Triggered Framework)
- Instead of receiving data from the radar test cars or HiL benches, the simulated data from CarMaker is used

Jenkins integration

- Continuous integration based on Jenkins automation server
- Simulated data from CarMaker is used for validation after changes
- Developers get test results in the next morning



Use Case
Ego Motion Estimation

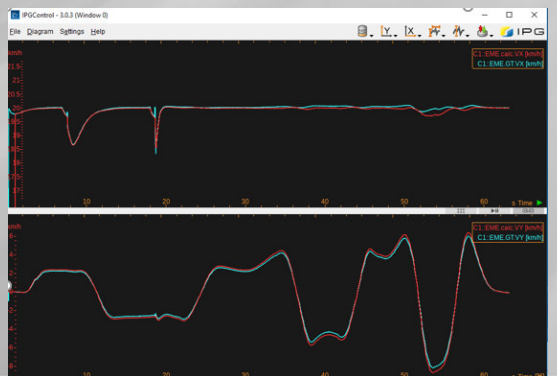
The software component “Ego Motion Estimation” allows to calculate the velocity of the ego vehicle based on the radar detections

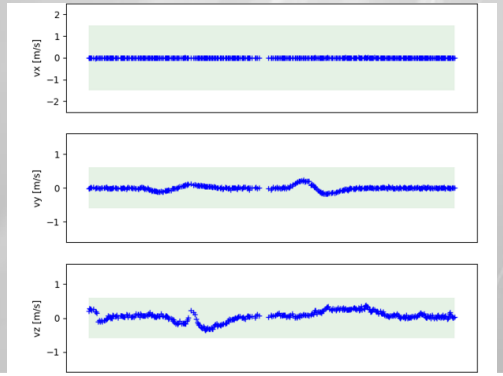
Benefit of virtual validation

- Creating corner cases that are difficult to test in a real system
- Re-evaluating large amount of test cases can be completely automated
- Simulated data supports during the whole development cycle

Evaluation

- Output of component
  - x, y and z velocity of the ego car
- Comparing output to Inertial Sensor data from CarMaker
- Checking if difference is smaller than thresholds defined in the requirements





Use Case
Object Tracking

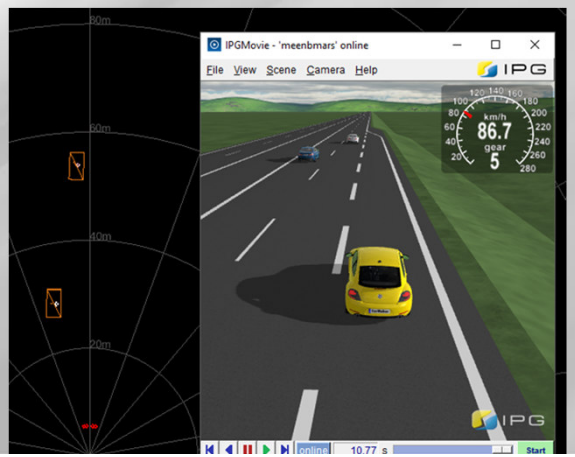
The software component “Object Tracking” allows to detect traffic objects in the detections and tracks them by predicting their positions and velocities

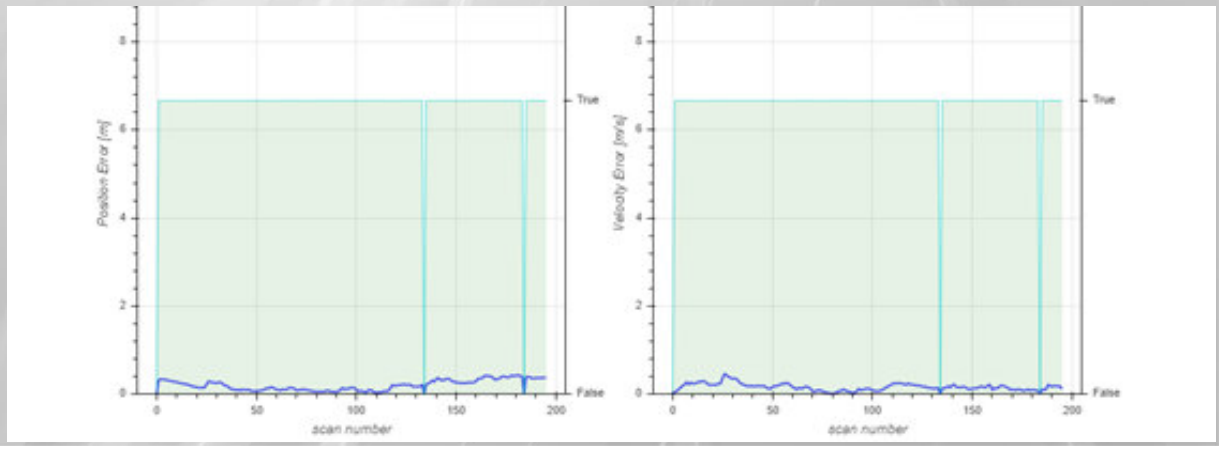
Benefit of virtual validation

- Creating corner cases that are difficult to test in a real system
- Re-evaluating huge amount of test cases can be completely automated
- Simulated data supports during the whole development cycle
- Independent of complex reference sensors in test cars

Evaluation

- Output are traffic objects containing
  - Position
  - Velocity
  - Size, and more...
- Comparing output to Object Sensor data from CarMaker





Use Case
Free Space Estimation

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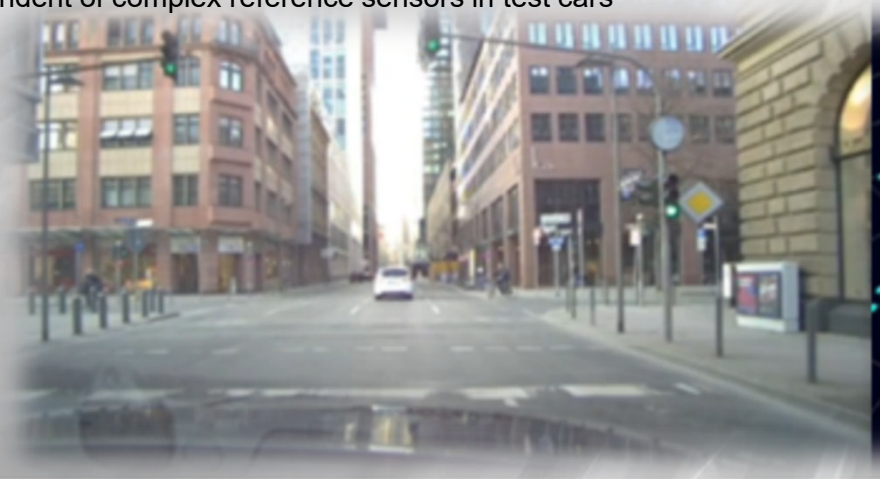
The software component “Free Space Estimation” calculates the unblocked area around the ego car based on an occupancy grid map

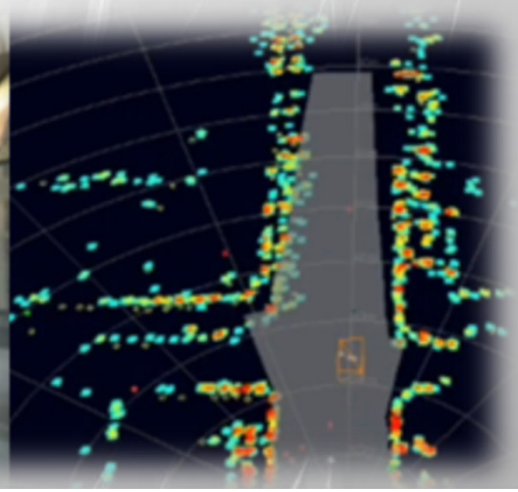
Benefit of virtual validation

- Creating corner cases that are difficult to test in a real system
- Re-evaluating huge amount of test cases can be completely automated
- Simulated data supports during the whole development cycle
- Independent of complex reference sensors in test cars

Evaluation

- Output of the component:
  - Vectors describing the free space area around the ego car
- Comparing output to the Free Space Sensor in CarMaker



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