Sensor model development for virtual testing of ADAS and AV

Mike Dempsey

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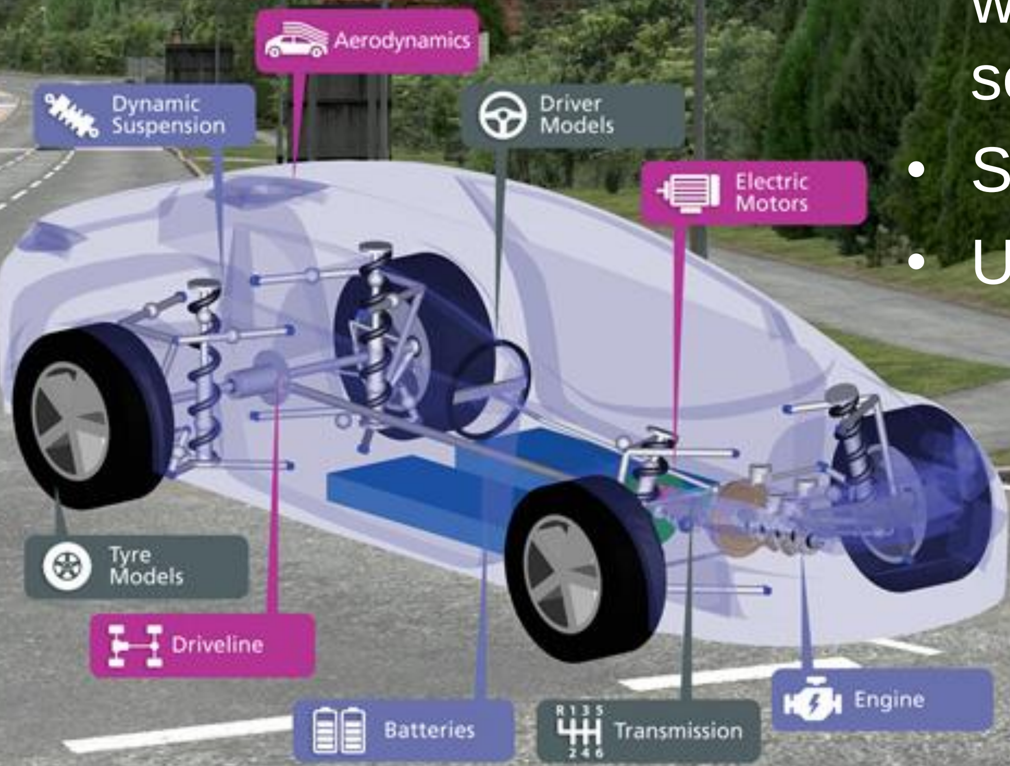
- Solutions for virtual testing combining real world locations with high fidelity vehicle and sensor models
- Software, Consulting, Training
- UK, USA, South Africa



Developing ADAS and Autonomous Vehicles

Simulation

- Huge number of scenarios can be considered
- Full control of virtual environment: traffic, pedestrians, weather, etc.

Proving Grounds

- Recreate critical scenarios
- Limited control of the environment
- Robot controlled targets
- Pedestrian targets
- No control of weather and light

Field Tests

- Investigation of real driving situations
- No control of the environment

Need a continuum between simulation and real world tests

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Building the simulation solution

Simulation

- Huge number of scenarios can be considered
- Full control of virtual environment: traffic, pedestrians, weather, etc.

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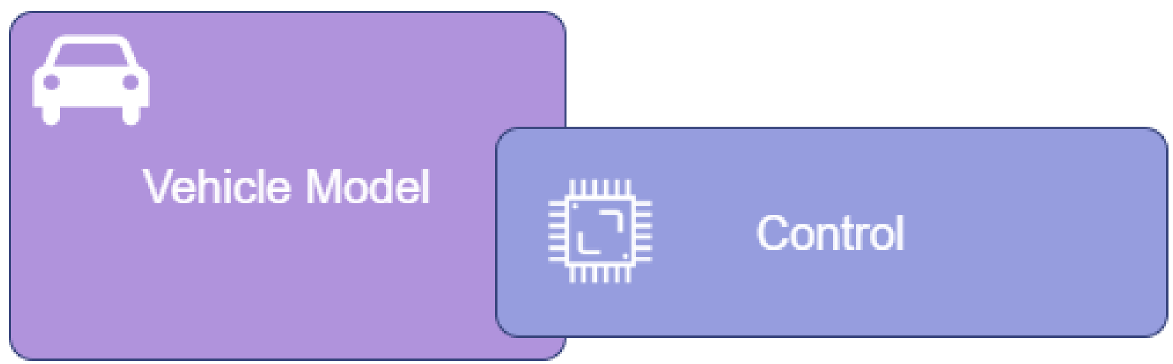
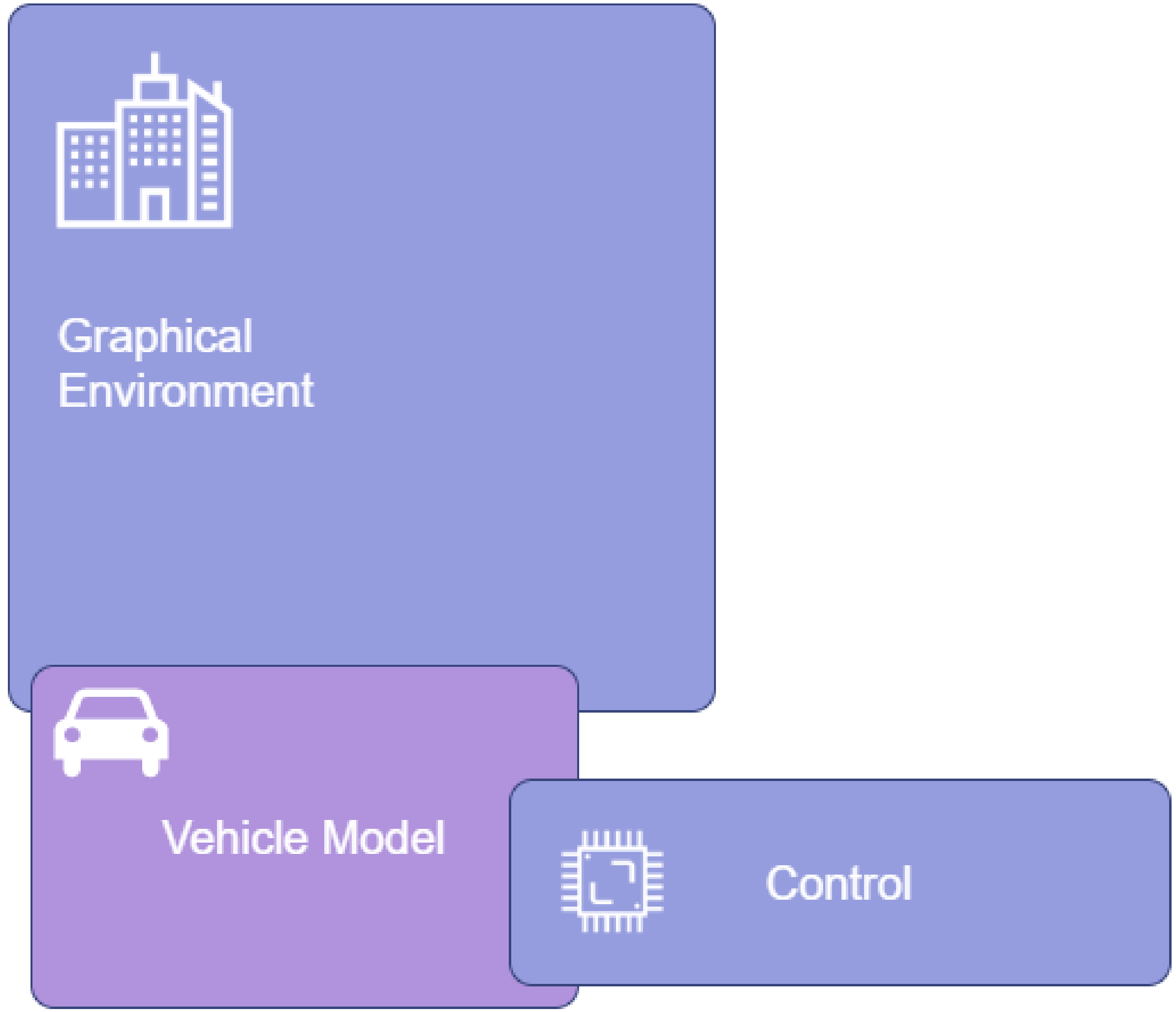
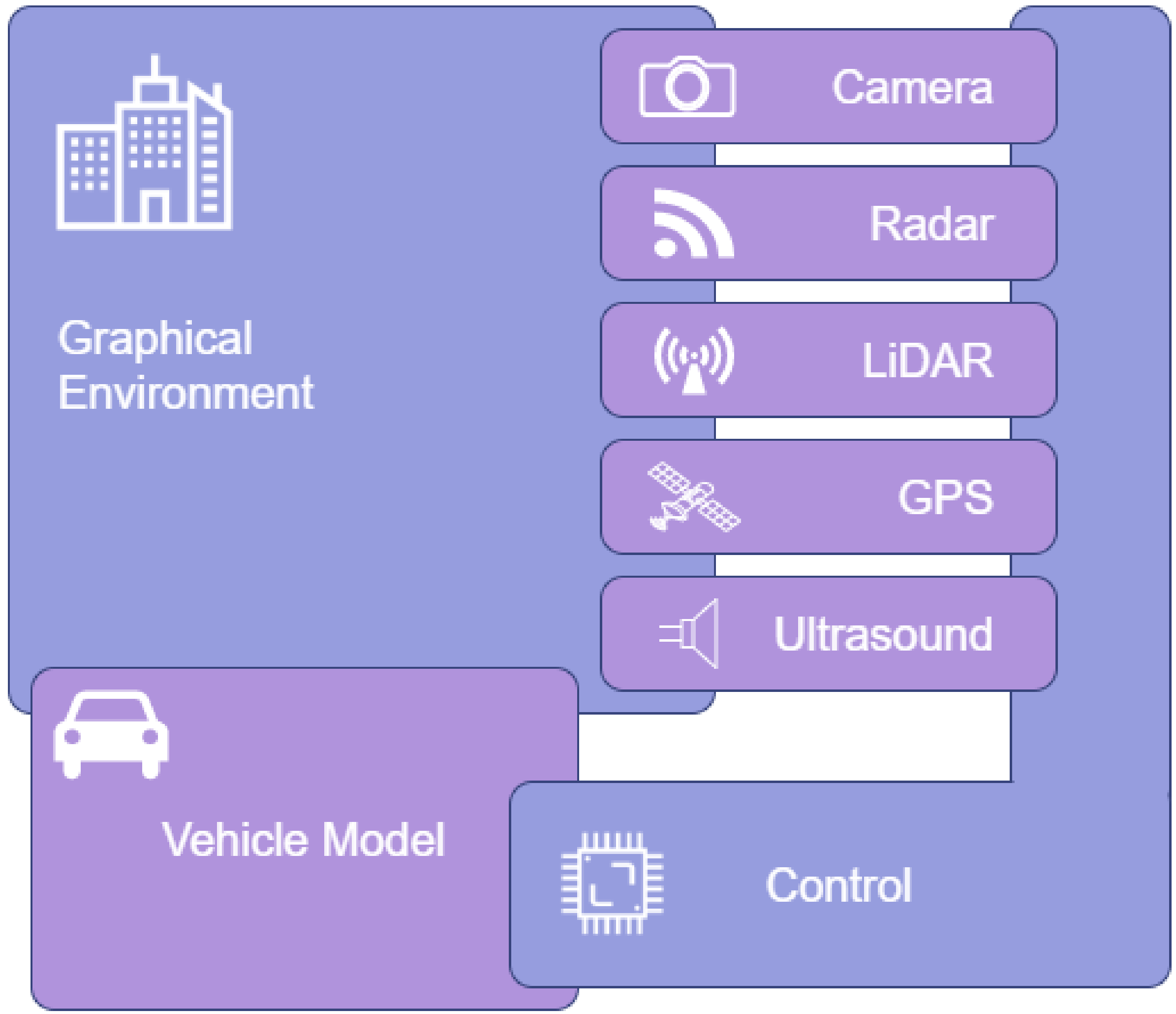
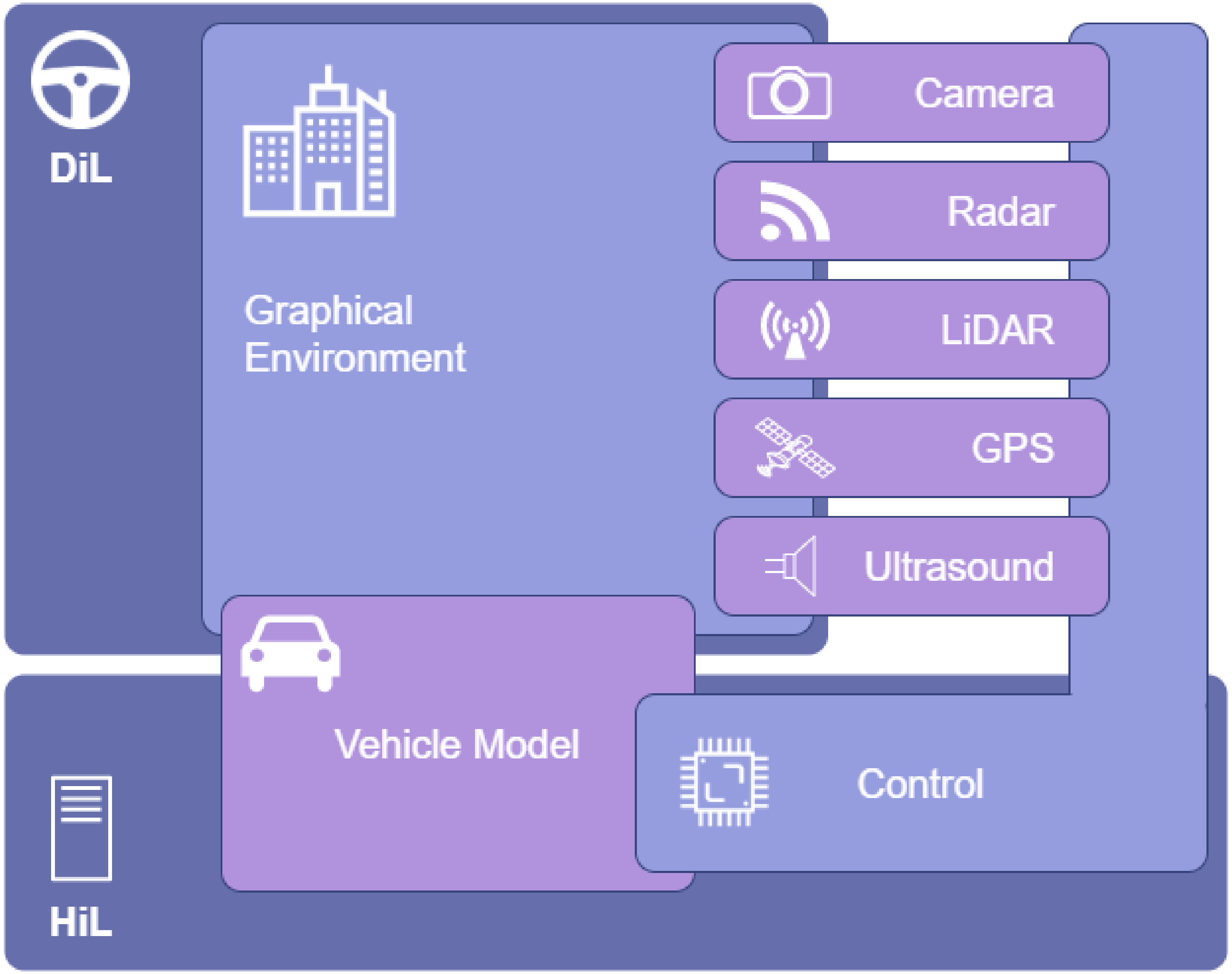

Vehicle Model
Control


Graphical
Environment
Vehicle Model
Control


Camera
Radar
LiDAR
GPS
Ultrasound
Graphical
Environment
Vehicle Model
Control



DiL
Graphical
Environment
Camera
Radar
LiDAR
GPS
Ultrasound
Vehicle Model
Control
HiL
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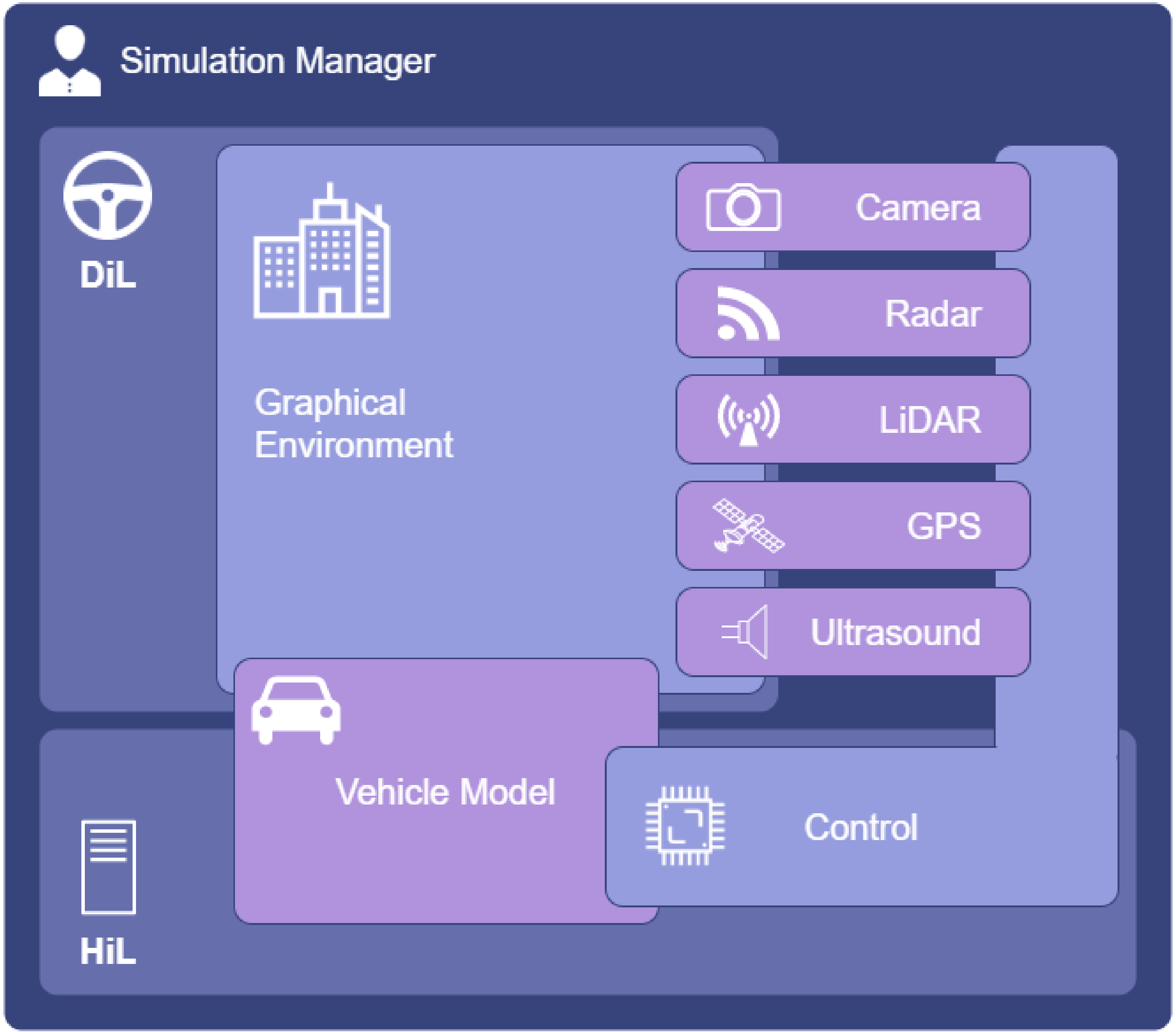
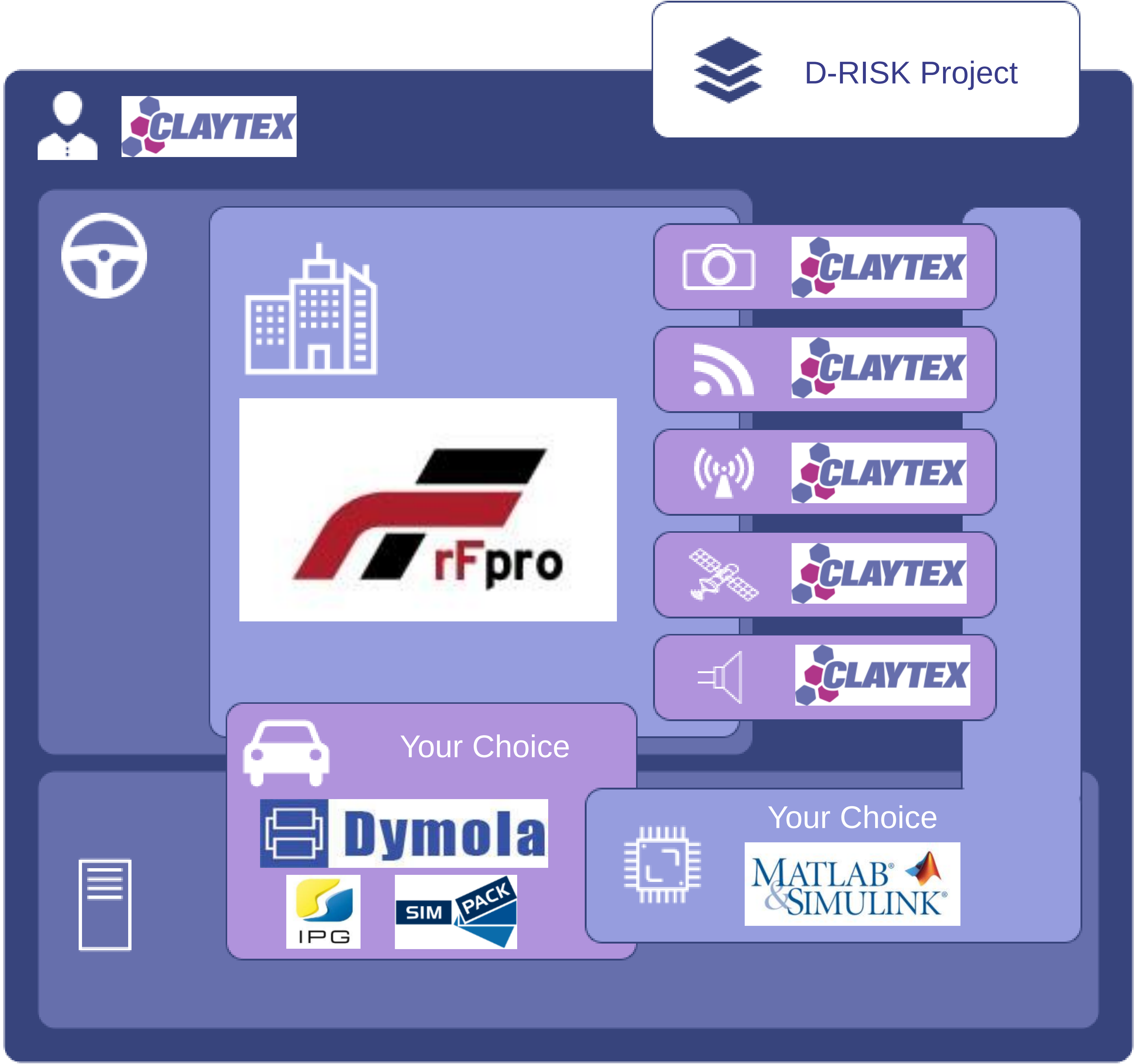


Simulation Manager
DiL
Graphical Environment
Camera
Radar
LiDAR
GPS
Ultrasound
Vehicle Model
Control
HiL


Scenario Database
Simulation Manager
DiL
Graphical Environment
Camera
Radar
LiDAR
GPS
Ultrasound
Vehicle Model
Control
HiL


D-RISK Project
CLAYTEX
CLAYTEX
CLAYTEX
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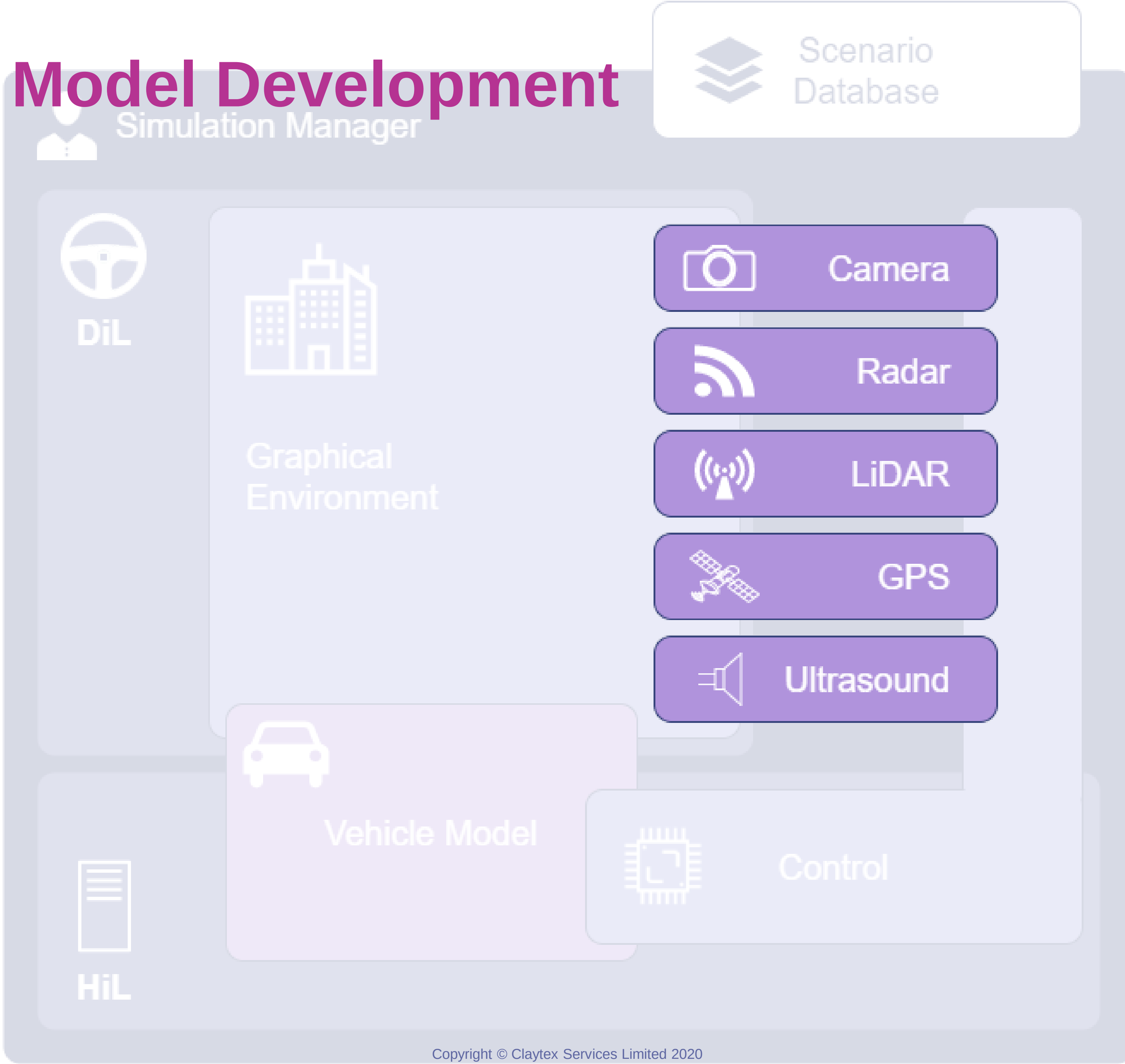
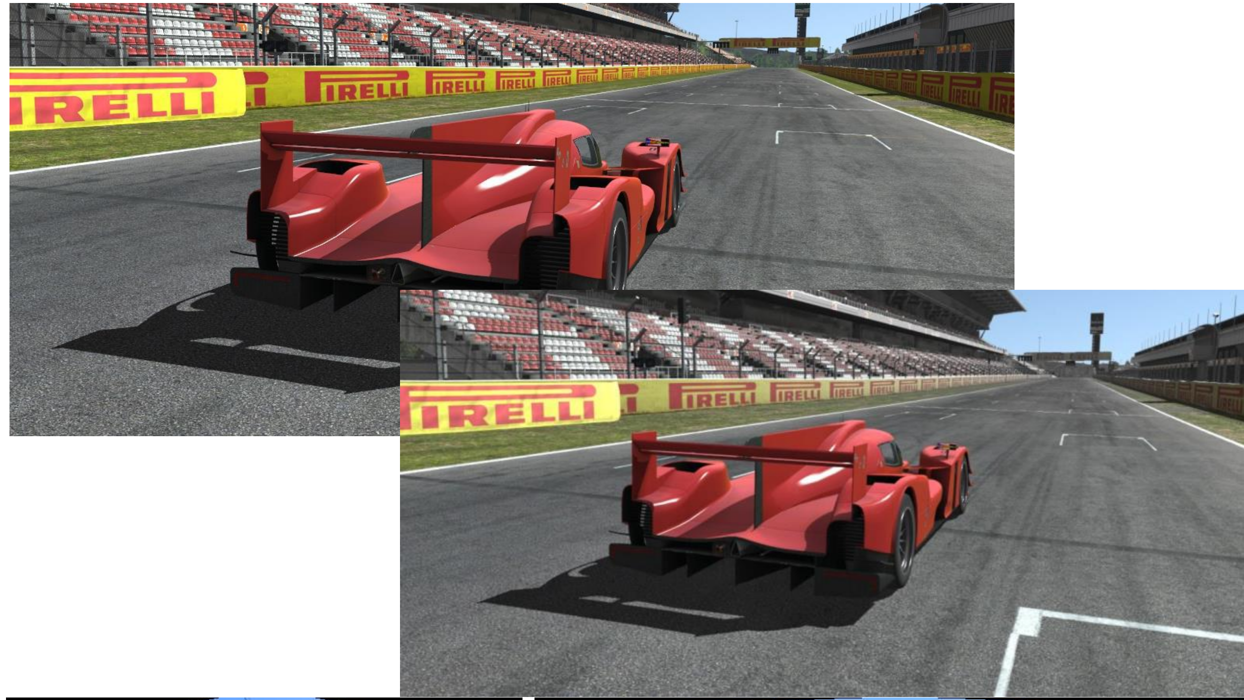
CLAYTEX
CLAYTEX
rFpro
Your Choice
Dymola
IPG
SIM PACK
Your Choice
MATLAB & SIMULINK

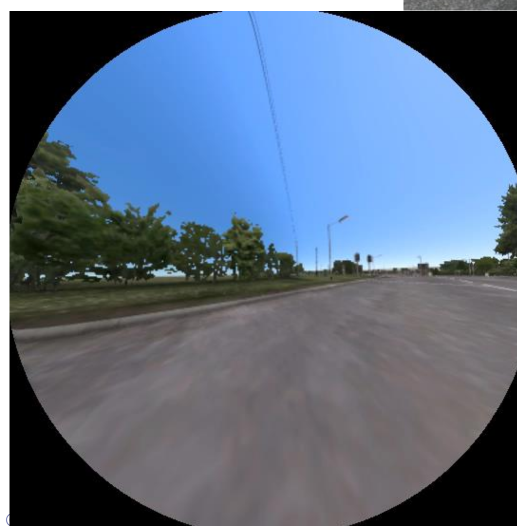
Sensor Model Development



Camera Models

- Physics based rendering
  - Light sources with physical parameters defining intensity and decay
  - Material properties using physical parameters for reflectivity, smoothness
- Lens Distortion Models
- Fisheye cameras
- Chromatic Aberations
- Depth desaturation
- Masks to apply dirt to the lens
- Colour and Monochrome cameras
- Multiple exposure
- Customise to match <u>your</u> camera and <u>your</u> lens





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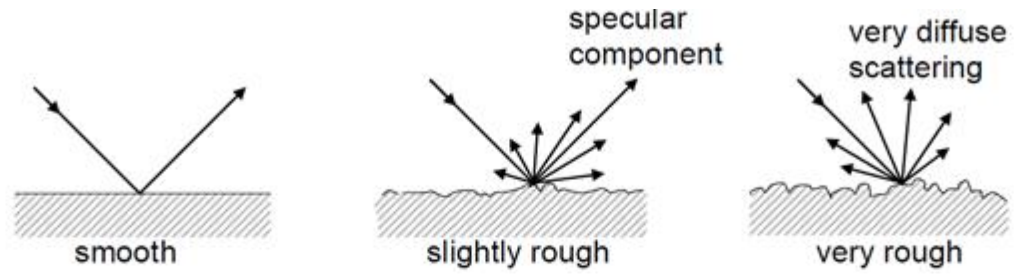
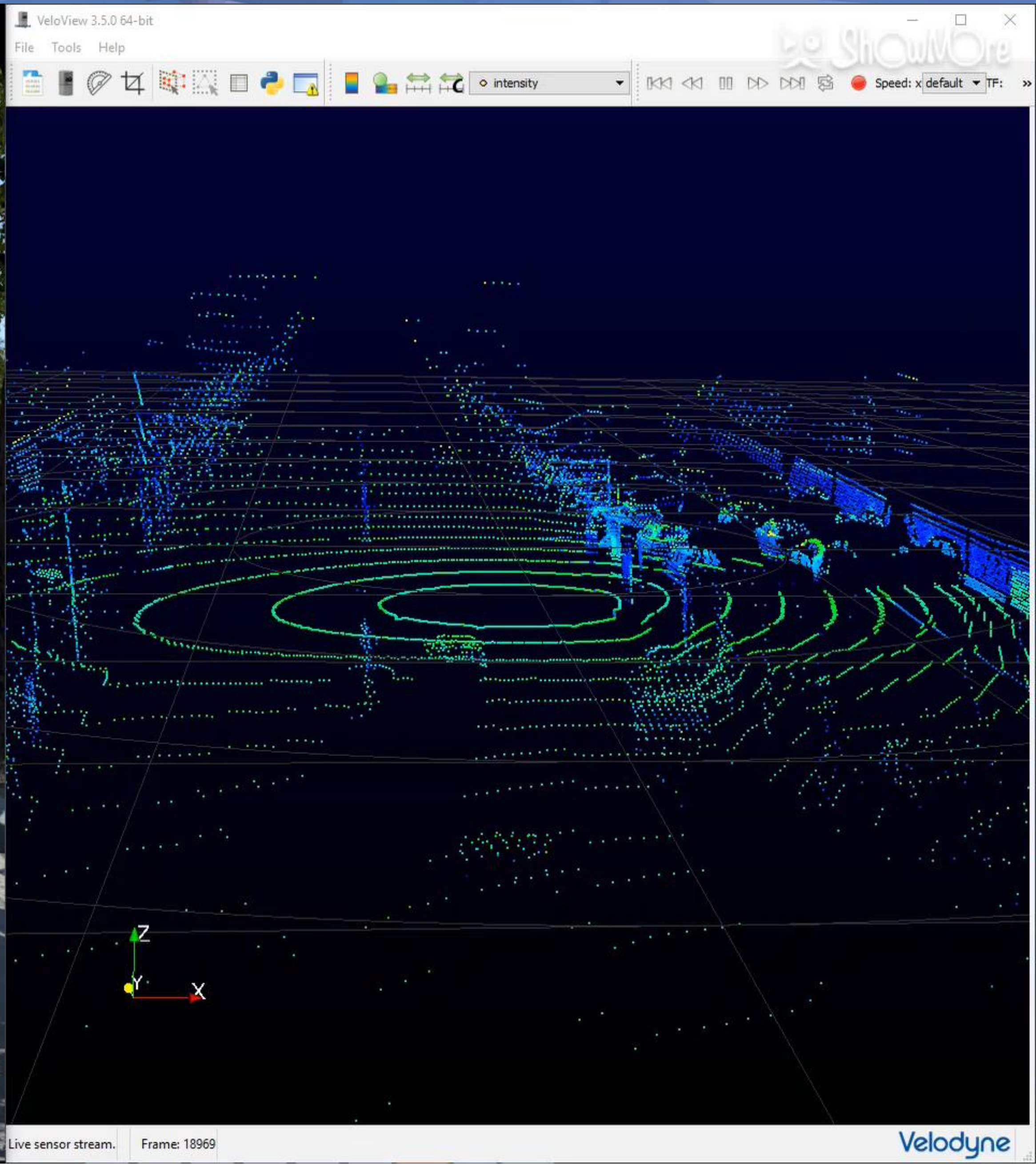
LiDAR Models

- Requires physics based rendering
  - Material properties need to be correct for the wavelength of light used by the sensor
- Generic LiDAR models
  - Define scan pattern, fixed array or 360 scanning
  - Ideal sensor
- Device specific models
  - Velodyne Puck, Ouster OS1, etc.
  - Message format exactly the same as the real device
  - Can include noise and weather models



Model of Velodyne Ultra Puck

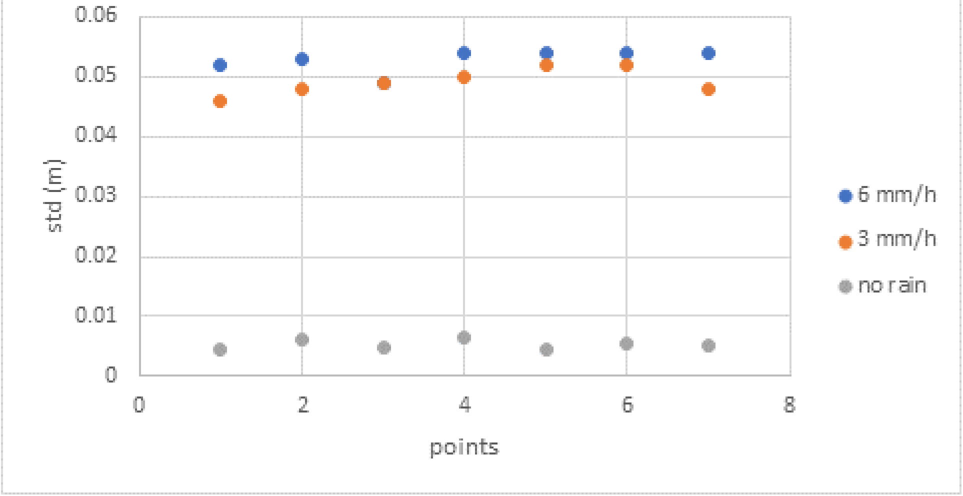


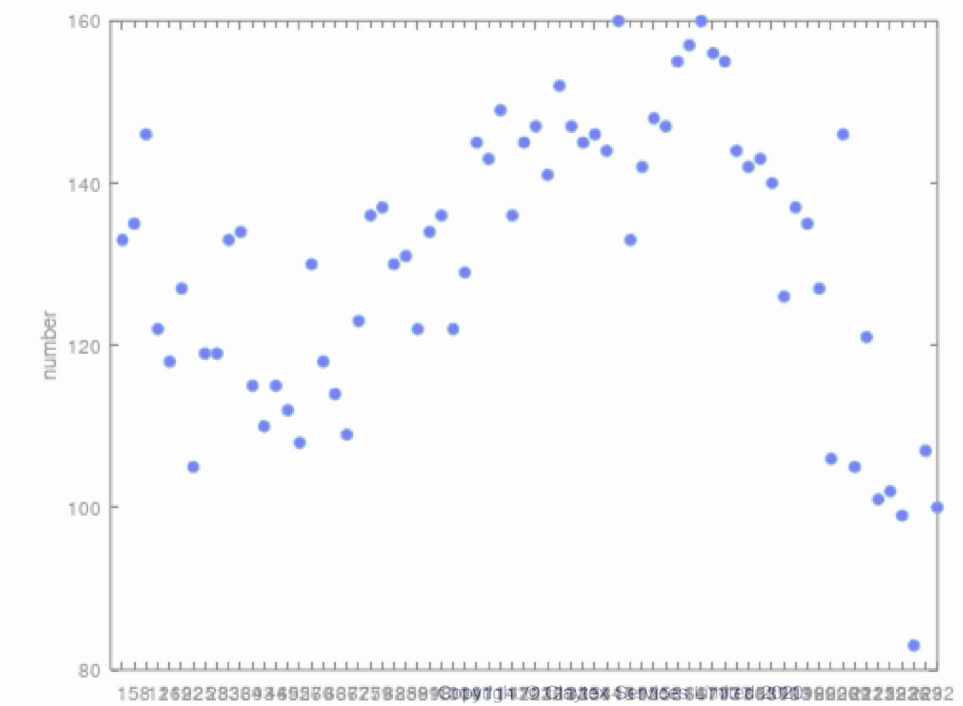
LiDAR model weather effects

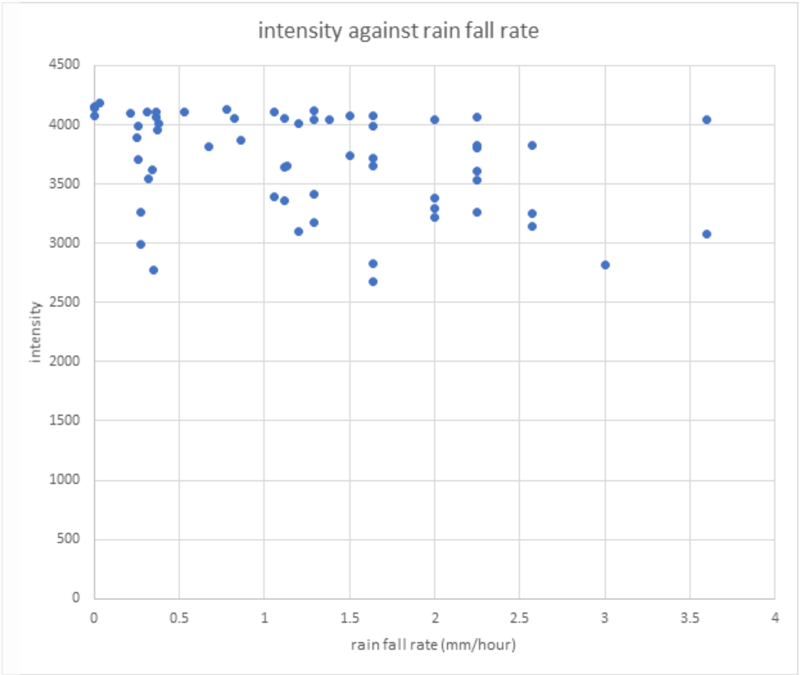
- Field testing of sensors with standardised targets
  - In all weather conditions

LiDAR model weather effects

- Field testing of sensors with standardised targets
  - In all weather conditions
- Three effects to be defined
  - Range accuracy
  - Change in intensity of return
  - Number of returns
- Not always as simple as a function of rainfall rate







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Radar

- Line of sight approach provides a perfect radar sensor
- Generic model
  - Field of view
  - Resolution
  - Max range/velocity
- Device specific models
  - Generate same output message as real device

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Multi-path radar model

- Multi-path is essential for radar
  - Developing a ray tracing model
- Infineon radar development platform to validate our models predicting range-doppler data
  - Provides access to the low-level output data from the radar chip
  - Therefore we can validate against this data
- Radar sensors process this low-level data to generate their target lists
  - Proprietary algorithms from each sensor developer
  - We will provide some common algorithms to mimic what the sensor outputs
  - An api will allow your own, or the sensor developers, algorithm to be integrated

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- Experimental Setup

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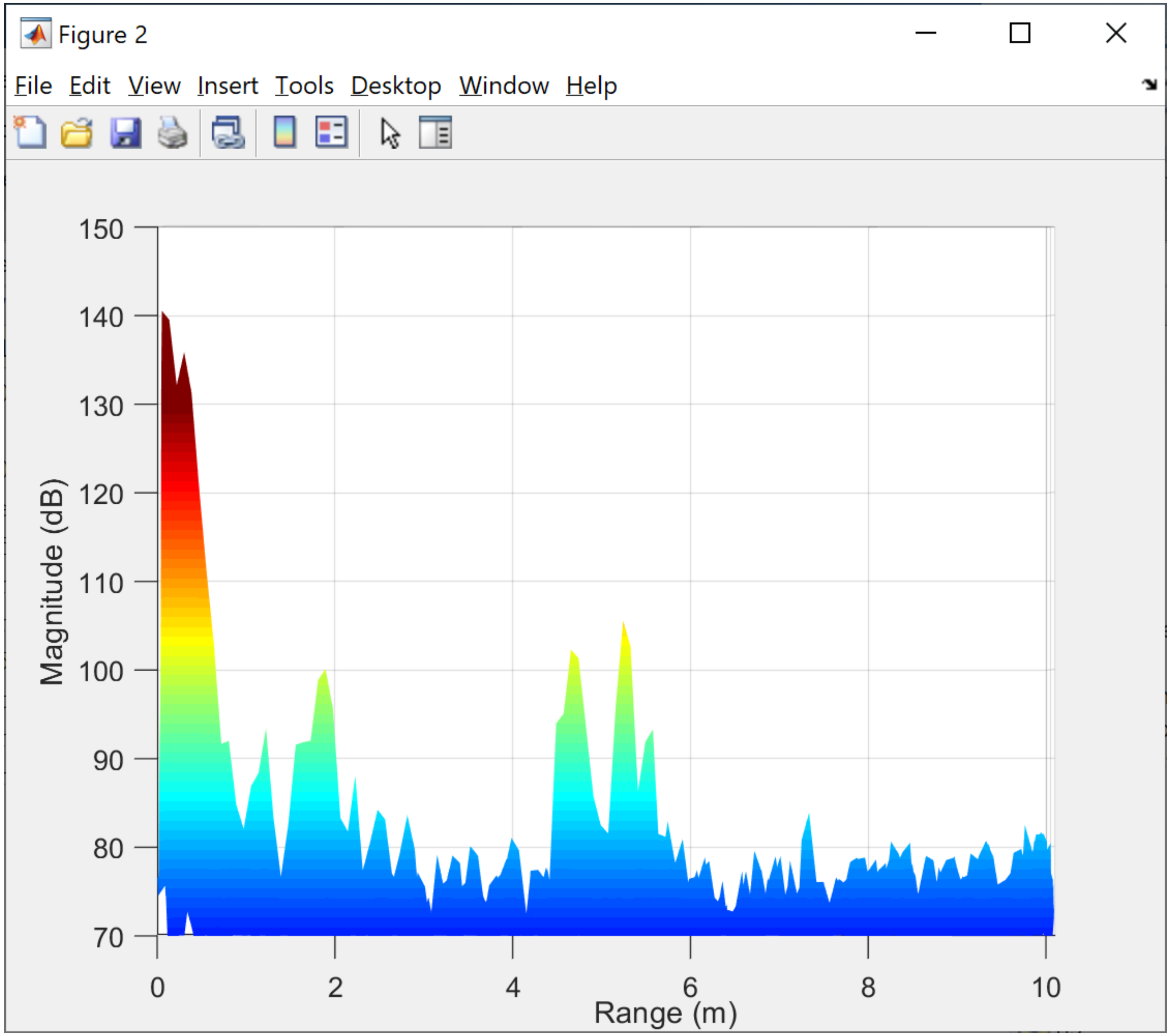
Validation results

- Measurement data
  - No measurement possible below 1m (with current parameterisation of sensor)
  - Peak at 1.8m due to the gazebo legs
  - Two peaks at 4.8m and 5.3m are due to the metallic sphere



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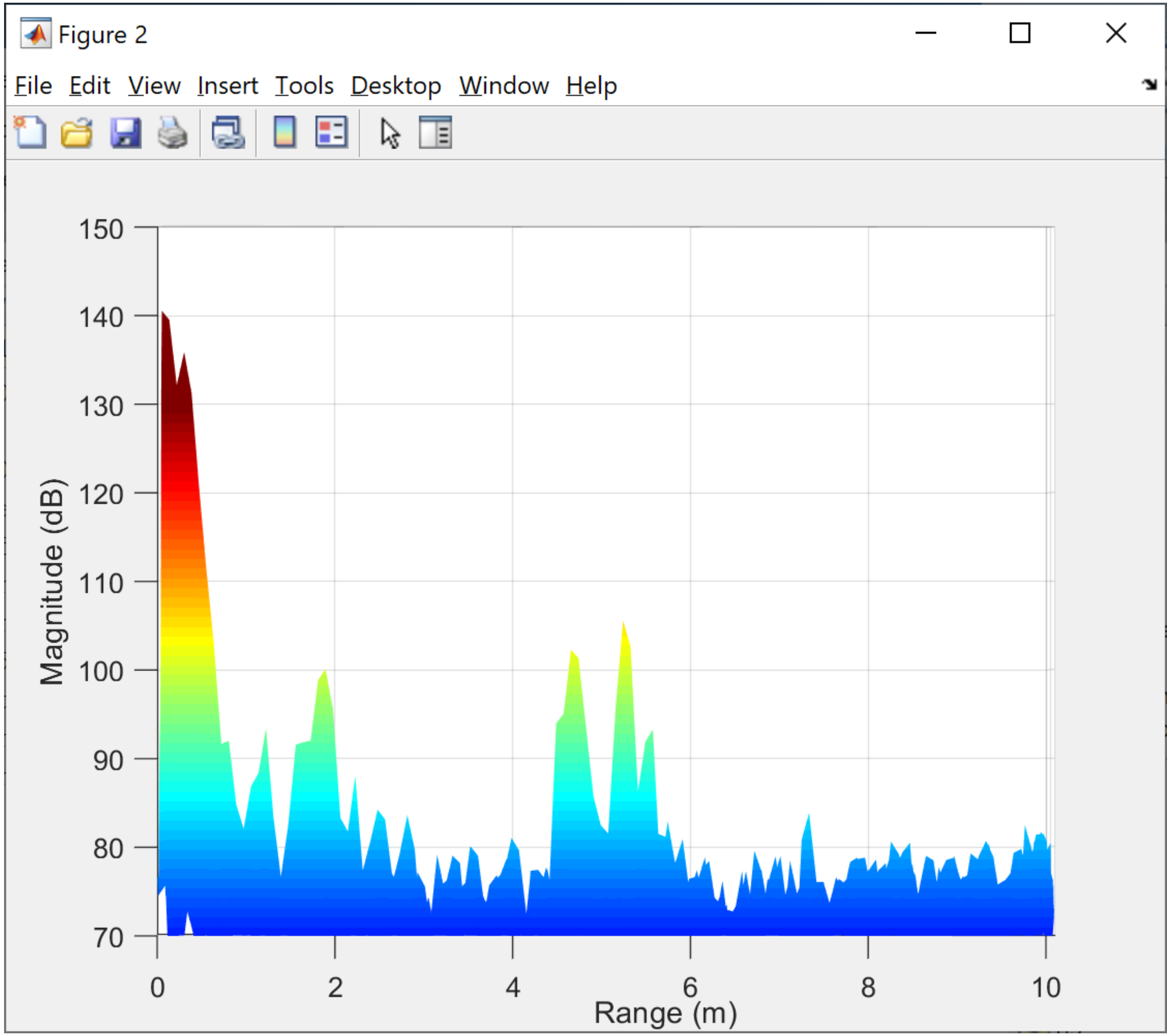
Early simulation results

- Simulation data
  - Scene only includes the metallic sphere
  - Two peaks at 4.8m and 5.3m overlay
  - Currently using different vertical scales
    - dB for measurement data
    - Received power in Watts for sim



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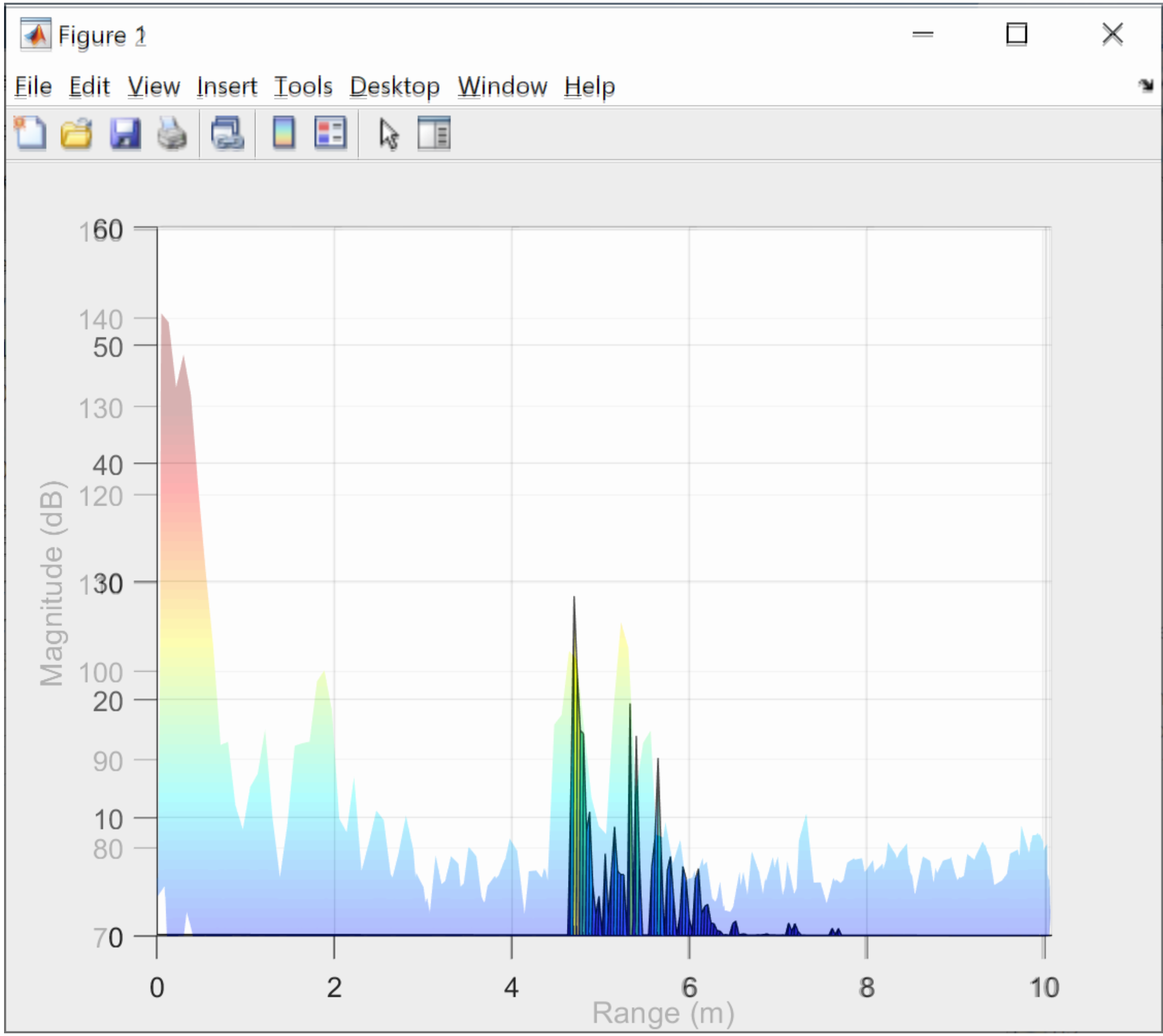

GPS, Ultrasound and more

- GPS
  - Simple version can test for line of sight to known location of satellite
  - Detailed model requires ray tracing to account for reflections of GPS signals through the built environment
    - Working on integration of leading GPS simulator
- Ultrasound
  - Most current sensors simply return the distance to the closest object which is easy to replicate
  - Next generation 3D ultrasound sensors may require ray tracing to handle the reflection of sound waves
- Infrared/Thermal imaging
  - This requires another render mode for the simulator with a different set of parameters for every object in the scene

Simulation for ADAS and AV development

- Simulation of L2+ ADAS and AV's needs complex, comprehensive solutions
- Best in class solutions are built by combining tools from multiple vendors
  - rFpro for the graphical environment and real world location models
  - Dymola for full vehicle system models
  - Sensor models from Claytex
- Our solutions are also flexible with interfaces to many different tools and platforms
  - Open API for vehicle model, control systems
- Scenario definition for AV is being tackled through the D-RISK project

Thank you

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