Institute for Transport Studies
FACULTY OF ENVIRONMENT

UNIVERSITY OF LEEDS

Model based design of Automated Vehicles

Richard Romano

Professor, Chair in Driving Simulation

Presented at the 15th MODPROD Workshop 3-4th February, Linköping, Sweden
www.modprod.org

Iowa Driving Simulator
Where I started

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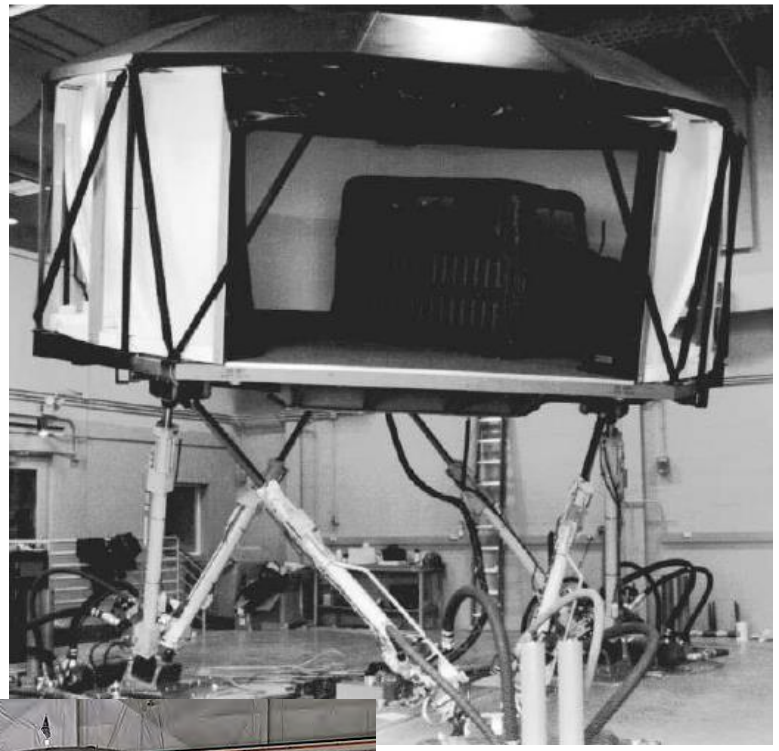
- Managed the development of the most advanced driving simulator in the world circa 1993
- Performed Automated Highways experiments for FHWA
- Supported the proposal development and served as a technical evaluator for NADS
- Left to start my own company



Iowa Driving Simulator/ICON

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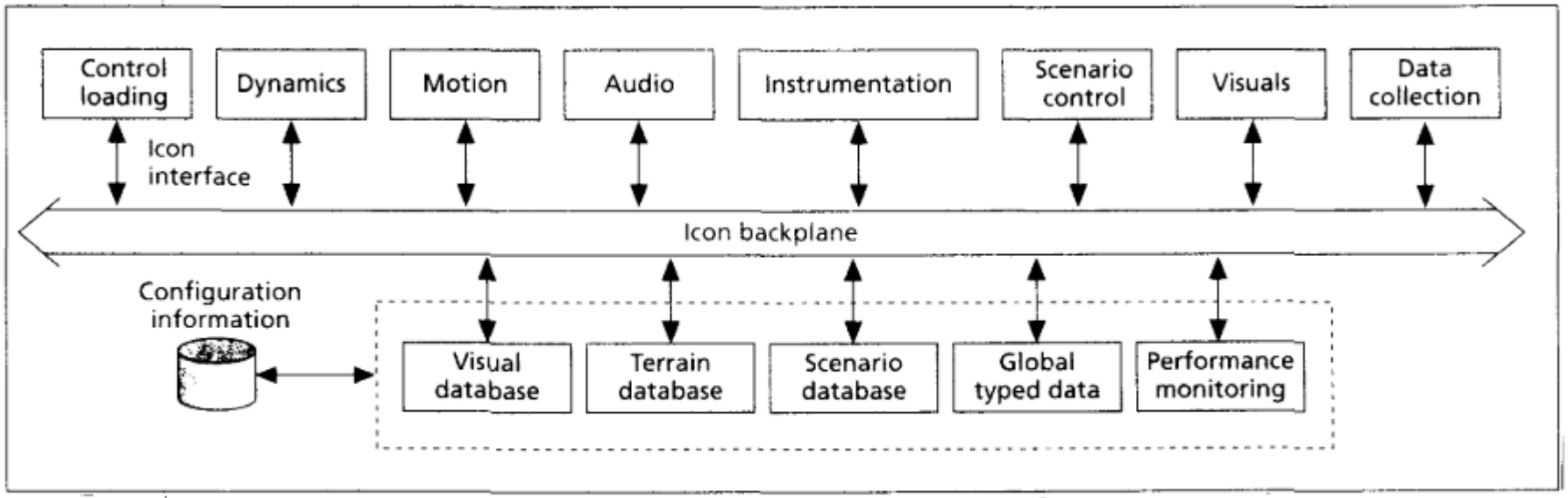

Figure 4. The software architecture of the IDS. The Icon (Iowa Driving Simulator Control) program controls the software backplane.

Iowa Driving Simulator/ICON

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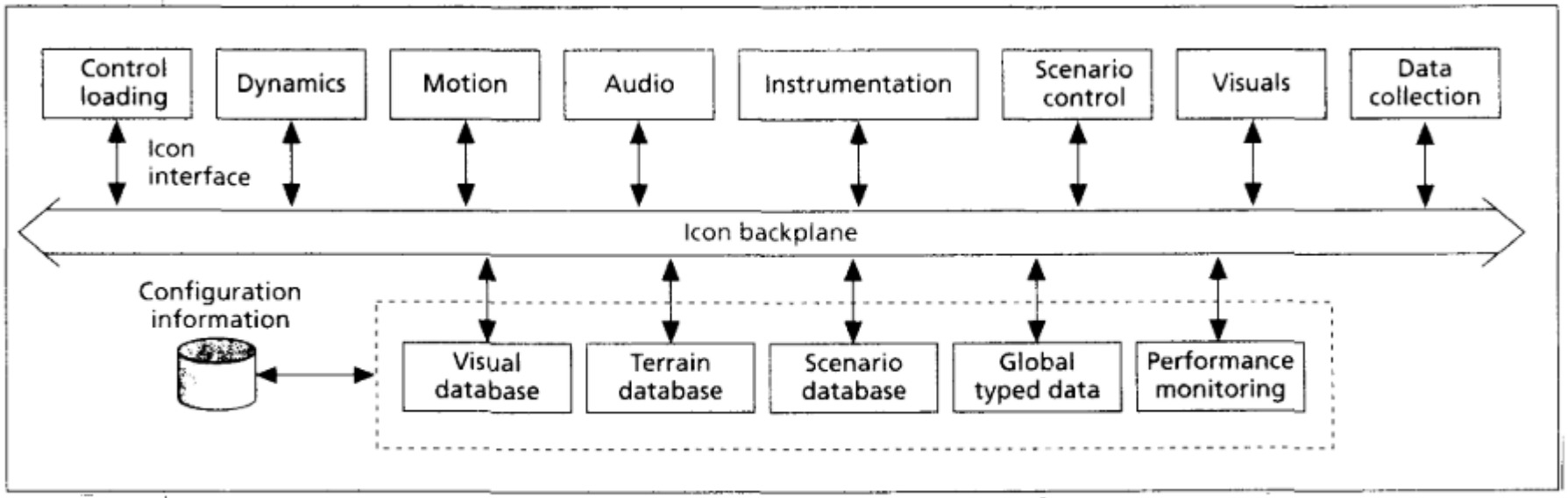

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Publish Subscribe Network

Iowa Driving Simulator/ICON

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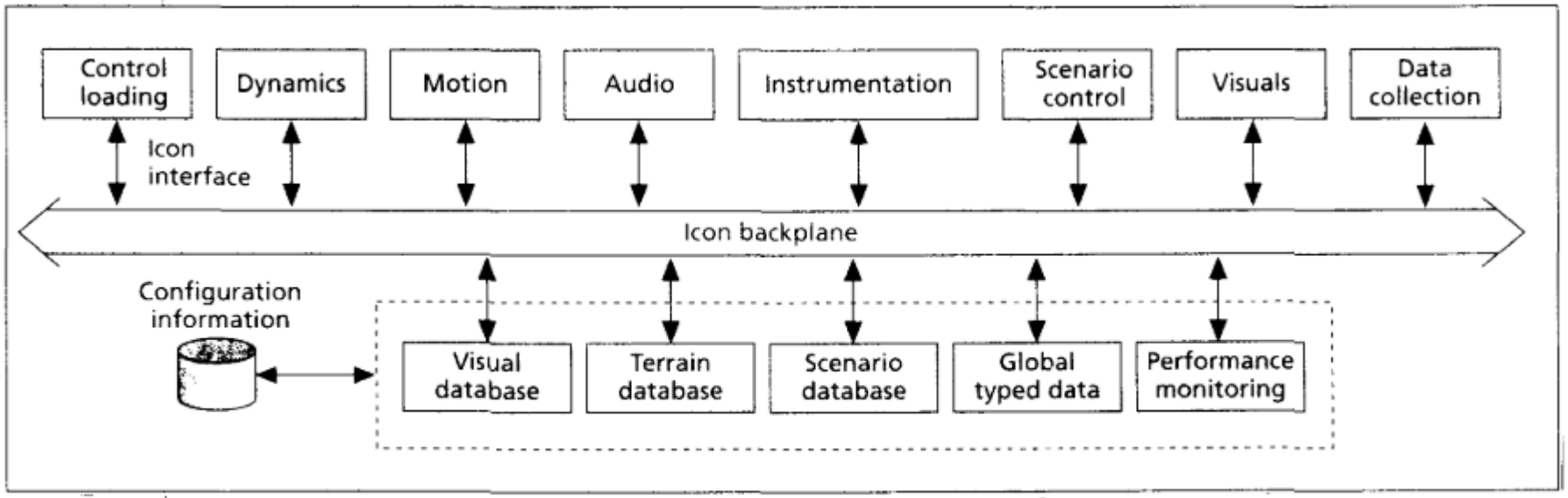

Figure 4. The software architecture of the IDS. The Icon (Iowa Driving Simulator Control) program controls the software backplane.

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Replaced with DDS (2000)

SimCreator/Wanted to Support a Whole Product Approach

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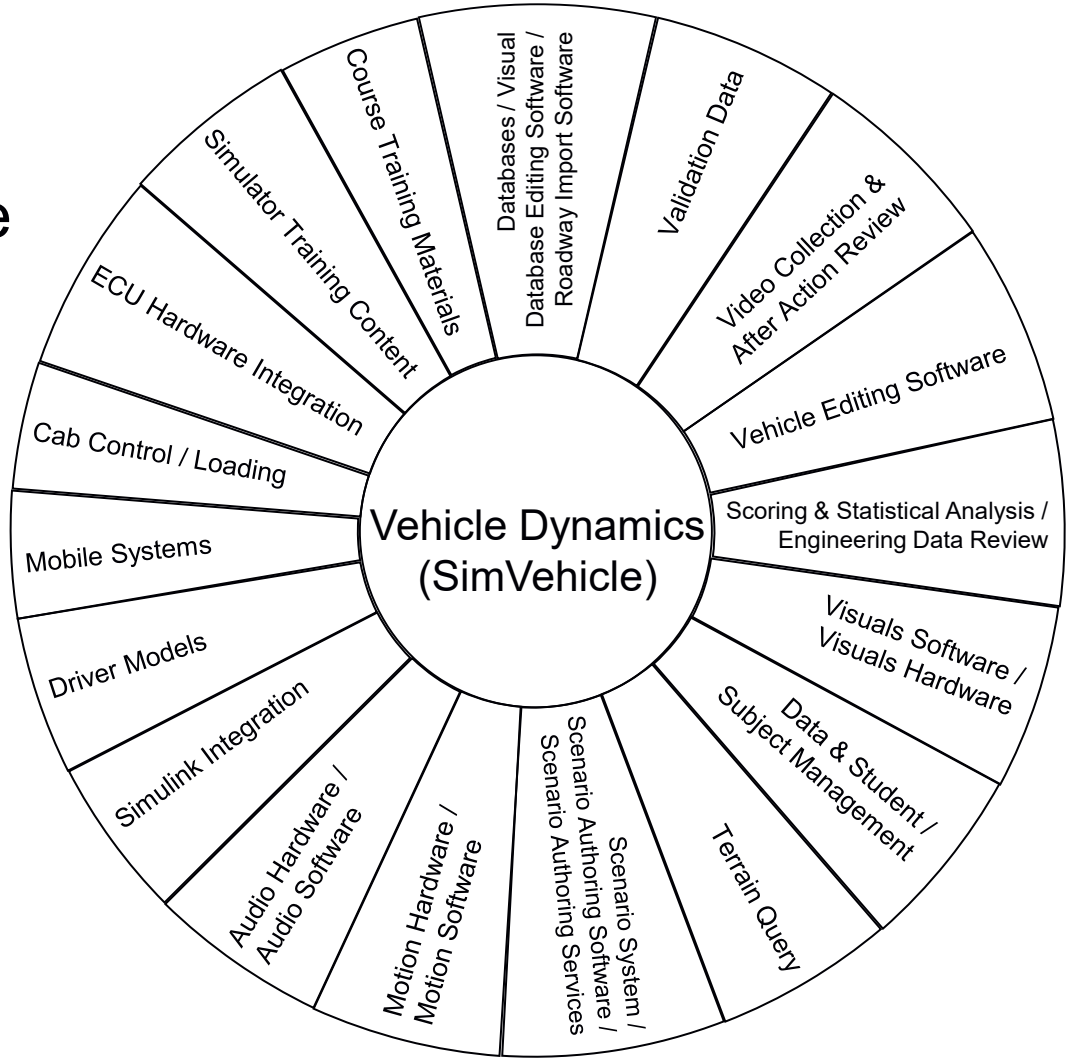
Different market segments will require different elements of the whole product

Must be easily reconfigurable



Built SimCreator

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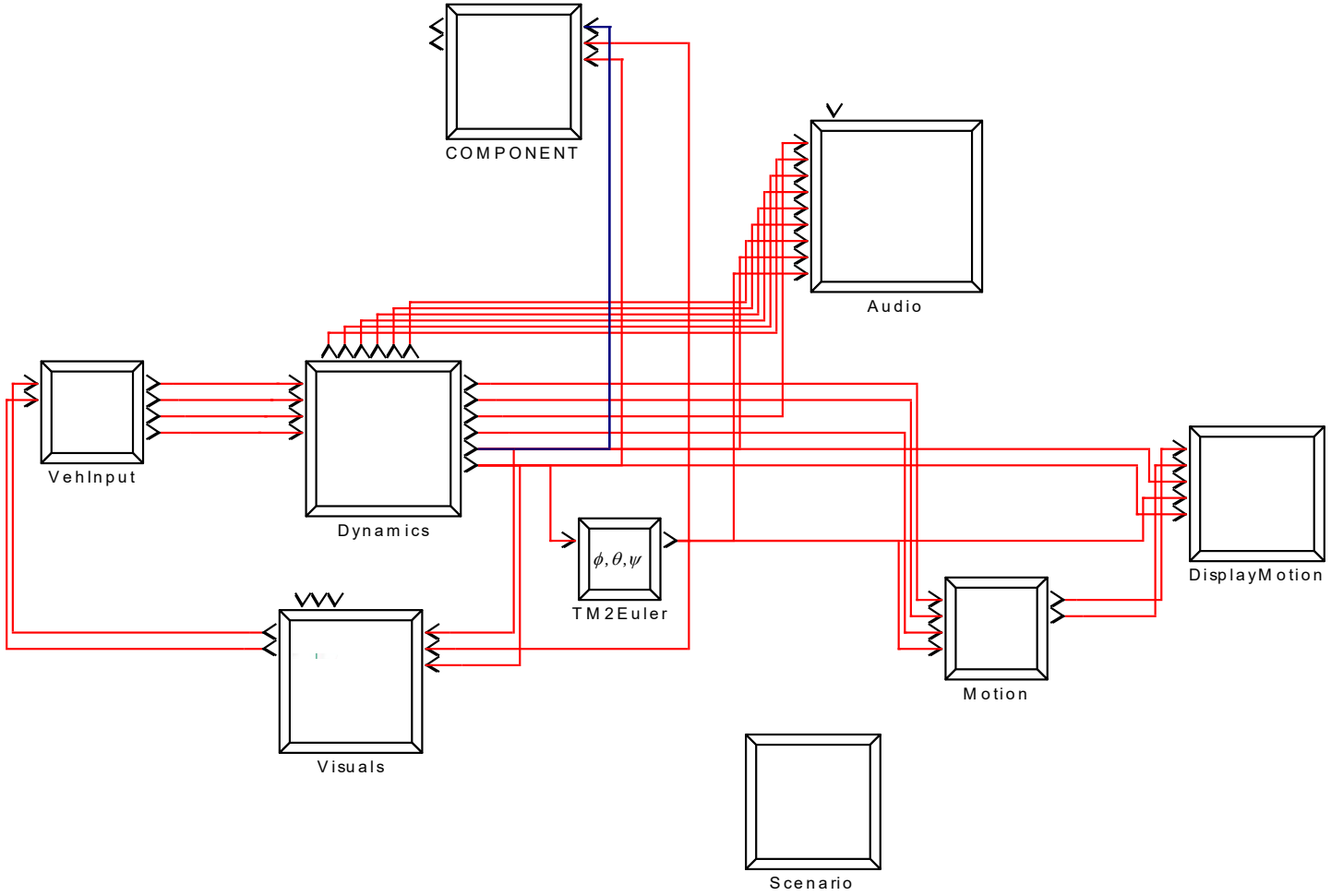
A vertical tool supporting distributed simulation, vehicle dynamics, hardware in the loop, etc.



Easily build and configure custom simulators to meet a customer's need.

Multi-Body Dynamics

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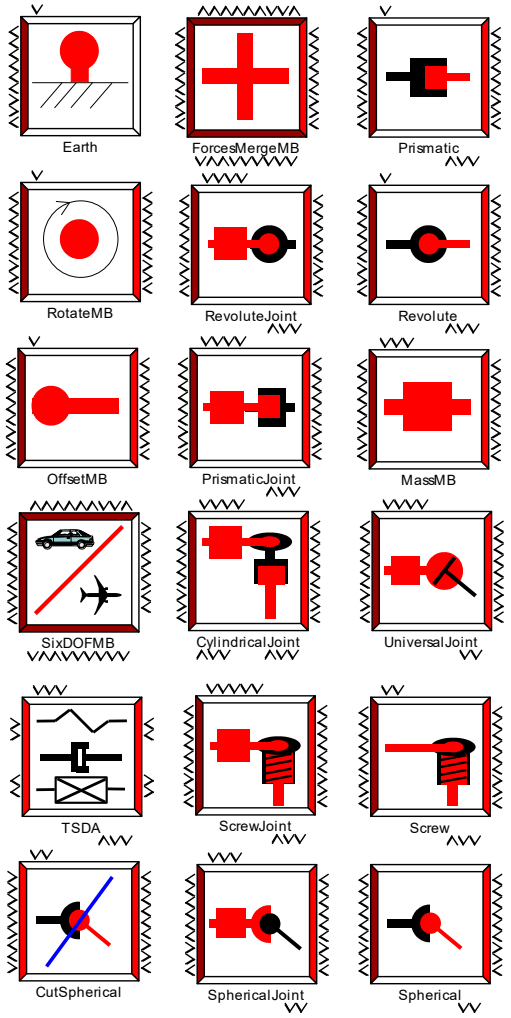
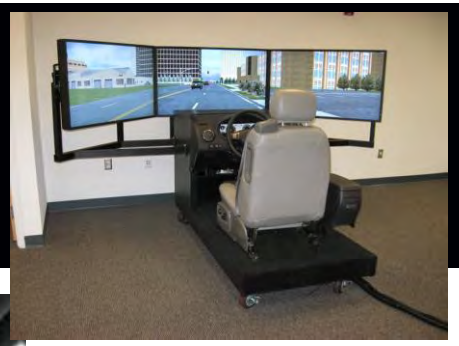
SimCreator's multi-body dynamics component library is based on Composite Rigid Body Methods (CRBM) (recursive method)

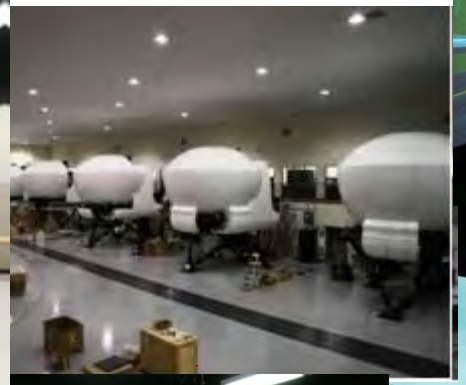
CRBM method is used for open kinematic chains

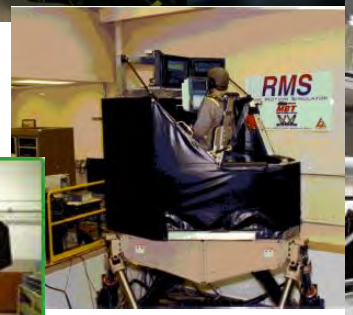
For closed kinematic chains, constraint equations with corresponding Lagrange multipliers are introduced and are used to augment the mass matrix



Example Simulators







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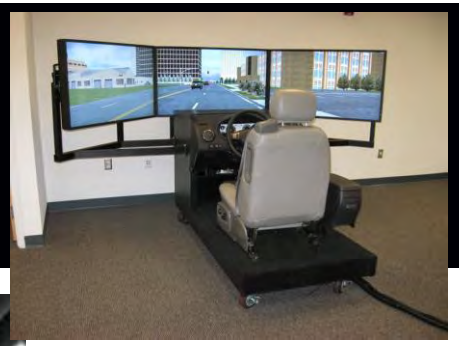

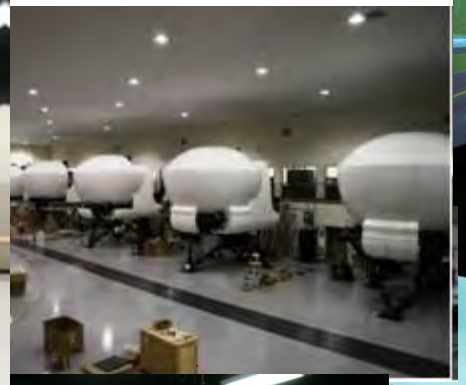

Why did we succeed? Because of reconfigurable software

SimCreator/Automated Vehicle Testing Software in the Loop

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Nissan integrates and tests their various software systems inside their driving simulator in Silicon Valley. (2013)

Realtime technologies, inc

www.bizjournals.com/sanjose/news/2013/07/31/inside-nissan-motor-cos-silicon.html

SimCreator/Software in the Loop

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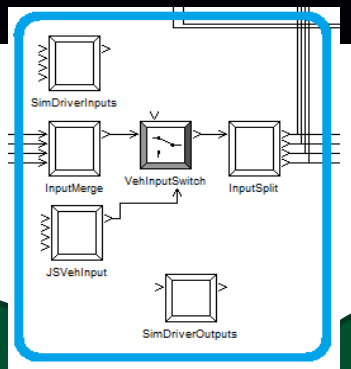

Lane Position Distance and Speed of Car Ahead (Simulator)

Map of Simulated Road GPS Location

Control Strategy (Nissan Software)

Steering Wheel Acc/Brake Pedal

Fast Forward: Leeds/2021

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Virtuocity:

Simulation Based Testing Focused on Human Performance and Behaviour

Fast Forward: Leeds/2021

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HIKER Pedestrian Simulator – Most Advanced in the World

Leeds
Still Working with Nissan!

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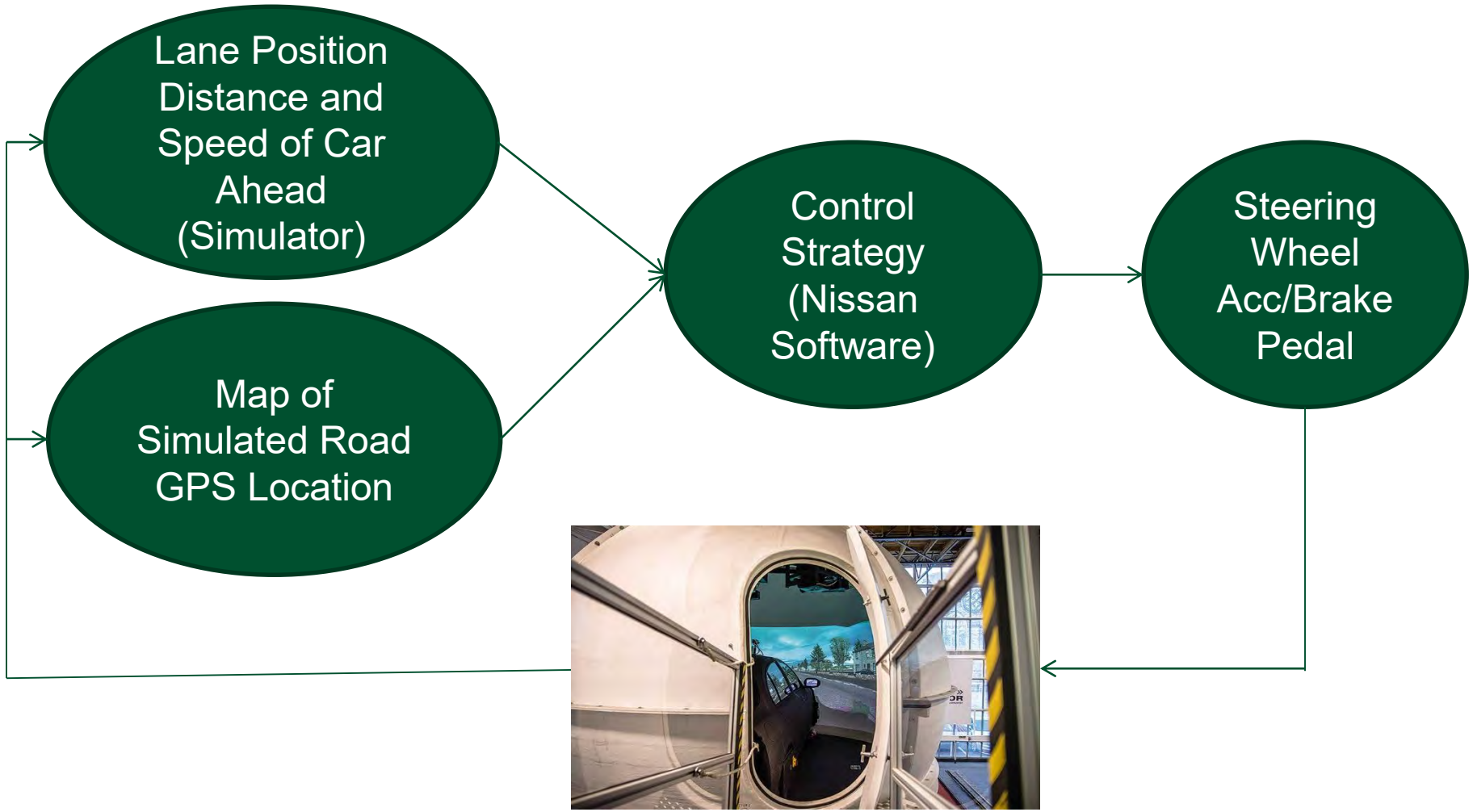

Now Using ROS and Unity

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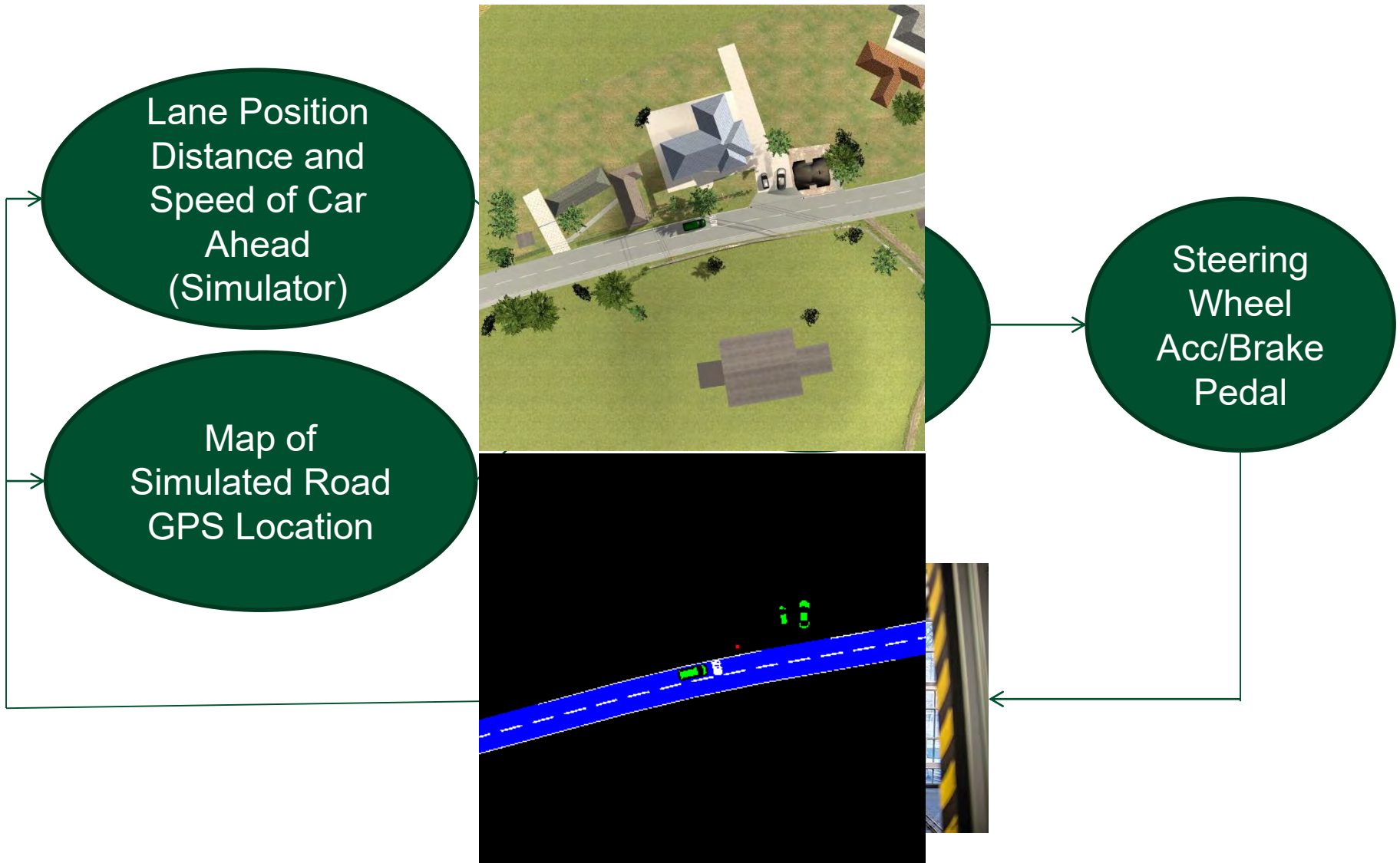

Where

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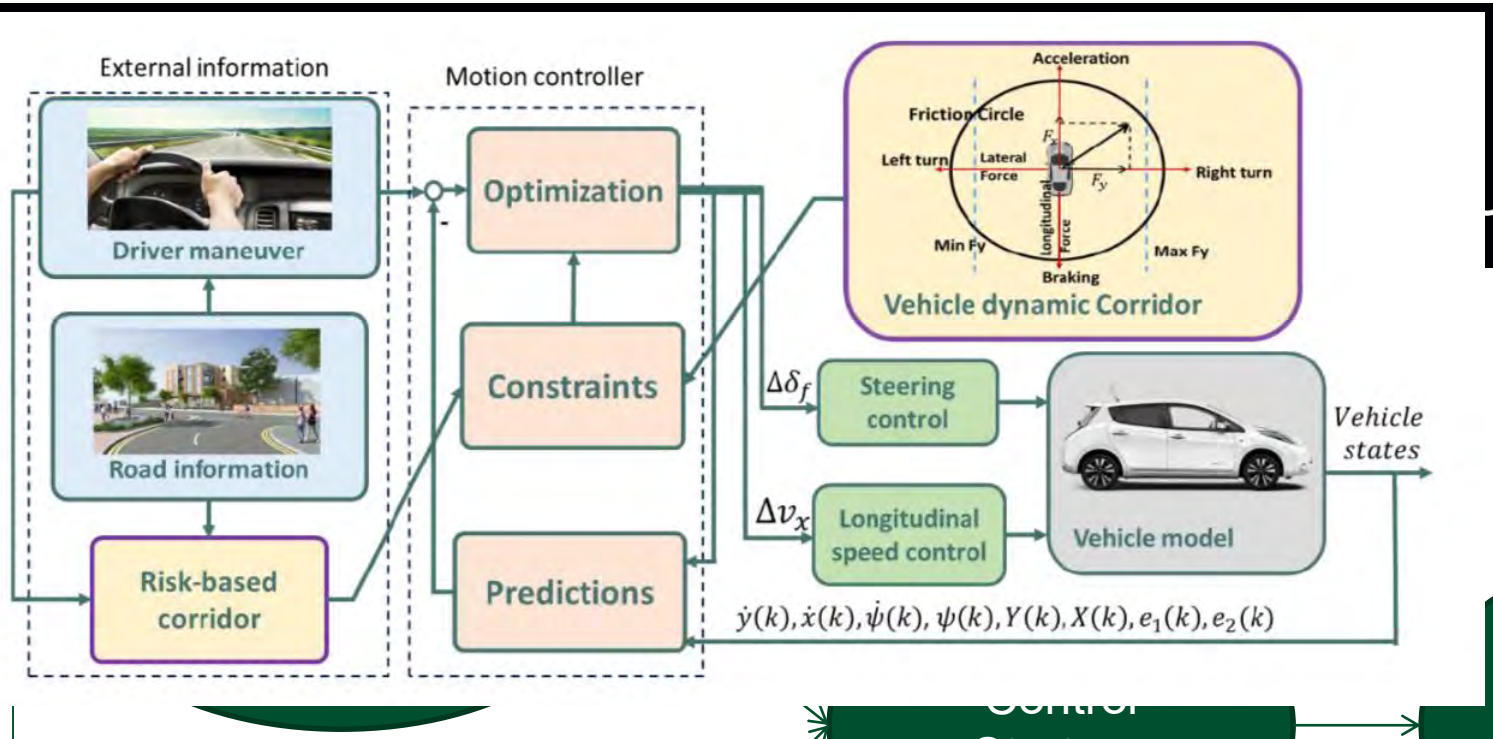

Strategy

Steering Wheel Acc/Brake Pedal

Map of Simulated Road GPS Location

Building Human Like Controllers

Tomorrow's Problems: Interactions

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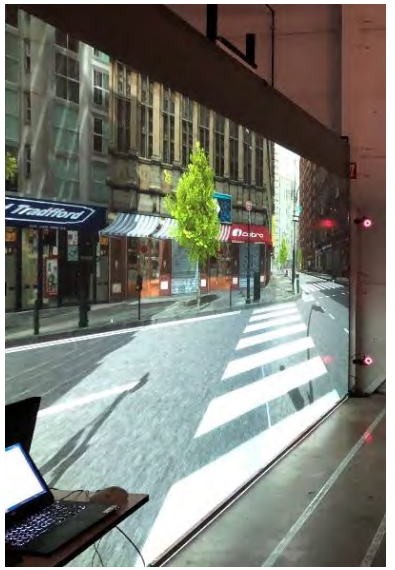
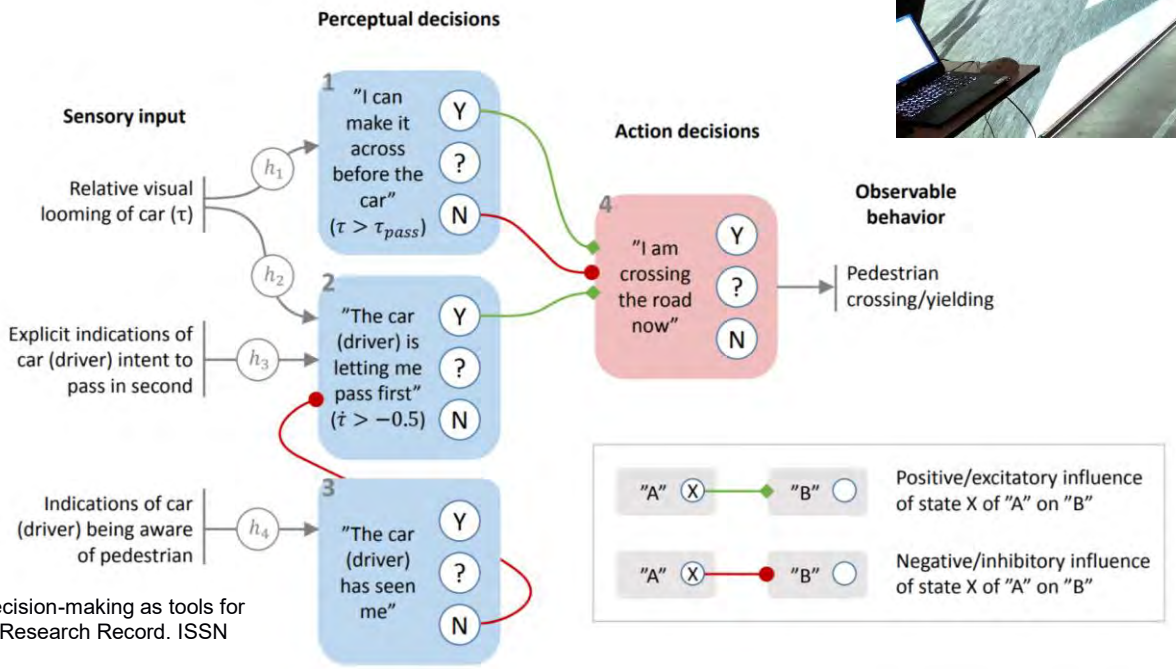
When would you cross the road in front of a vehicle?

When should a vehicle stop for a pedestrian?





Markkula, G , Romano, R , Madigan, R et al. (2018) Models of human decision-making as tools for estimating and optimising impacts of vehicle automation. Transportation Research Record. ISSN 0361-1981

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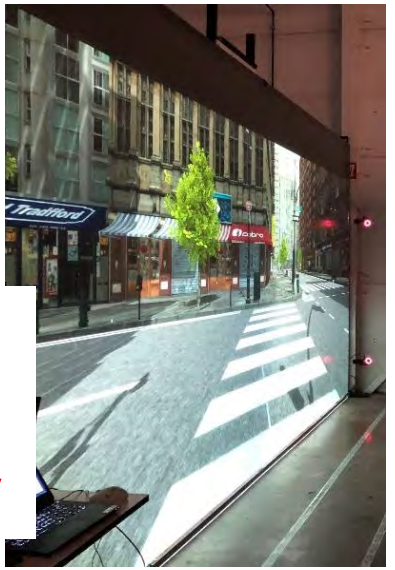
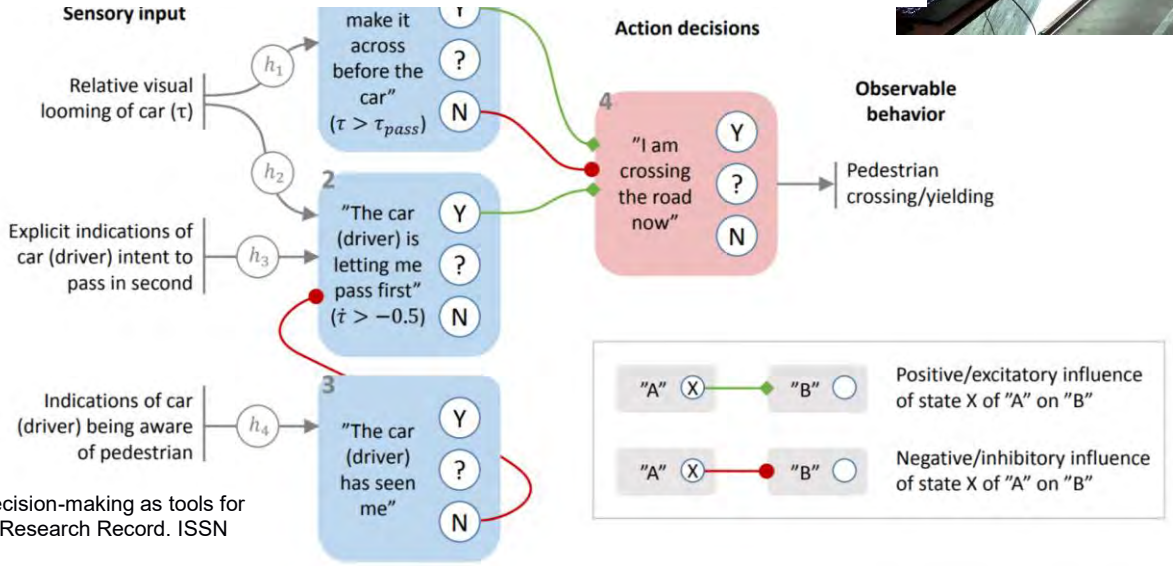


AV must detect the pedestrian, determine their trajectory, infer their intent, possibly negotiate for right of way



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My Motivation for Distributed Simulators

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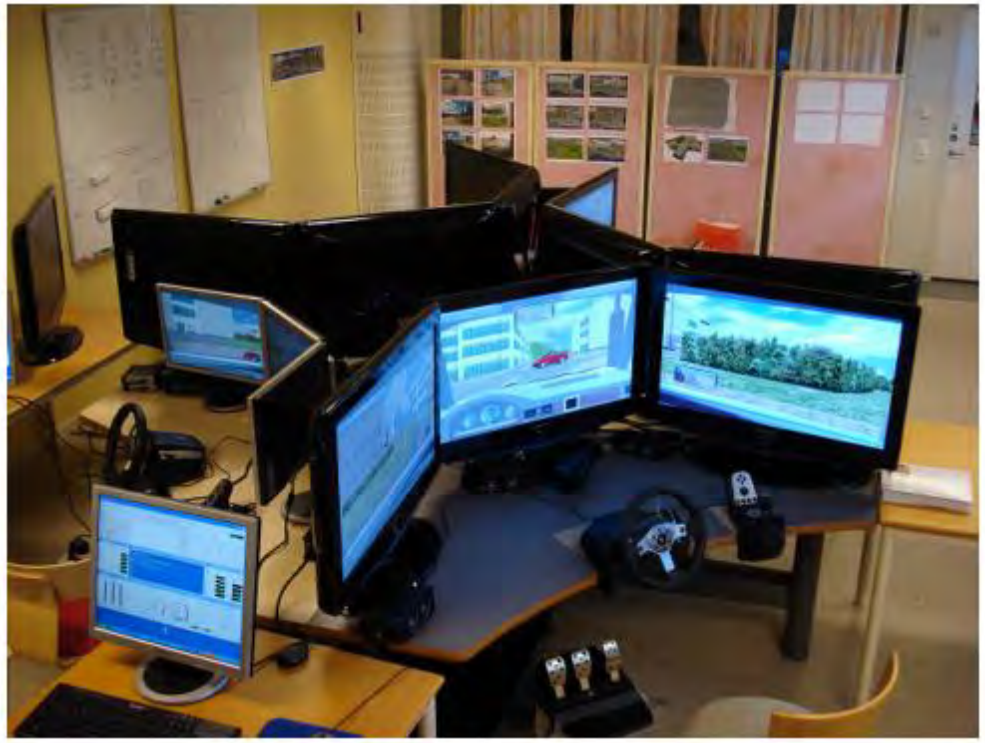
Driving simulators (as well as micro simulations) are good at A/B comparisons (new design versus baseline).

- How do we compare human drivers interacting with each other with human drivers interacting with automated vehicles?
- How do we test automated vehicles interacting with pedestrians? (Need to compare this with traditional vehicles interacting with pedestrians)



Driving Simulators at Linkopings Universitet, Sweden

Work at Leeds: Integrating Pedestrian and Driving Simulation

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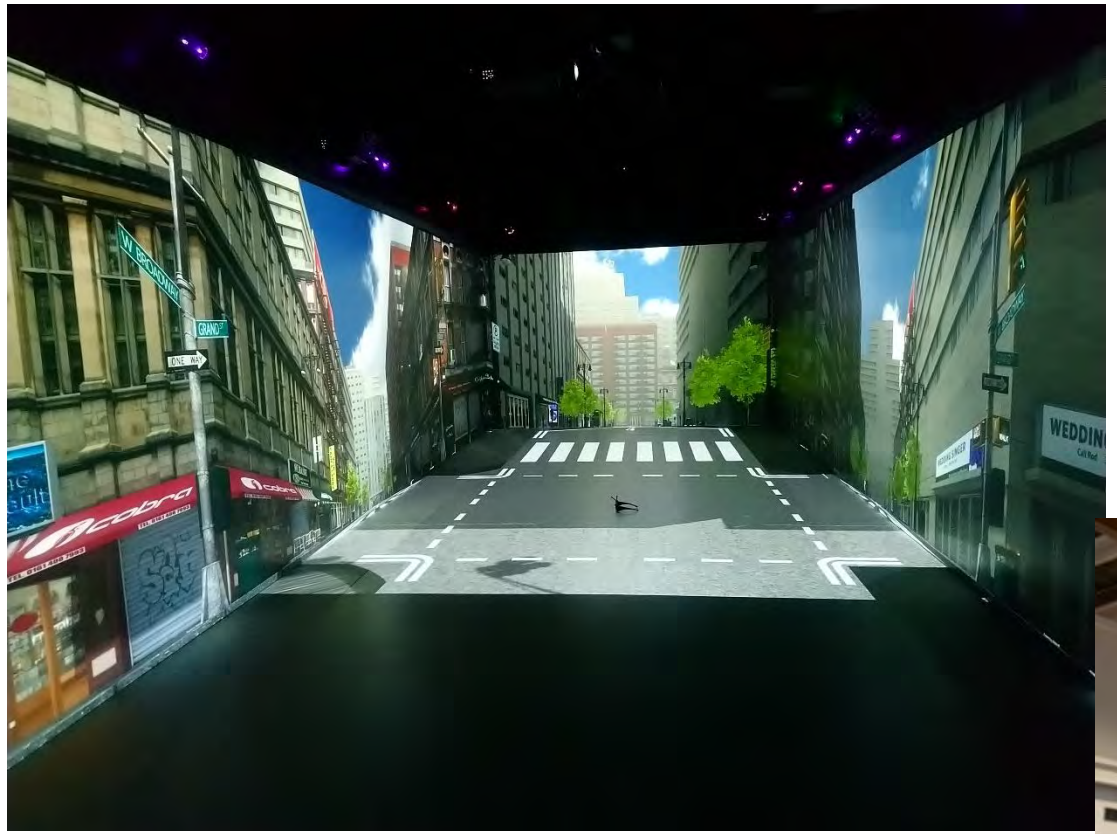

Local Implementation at Leeds
Use our internal distributed network

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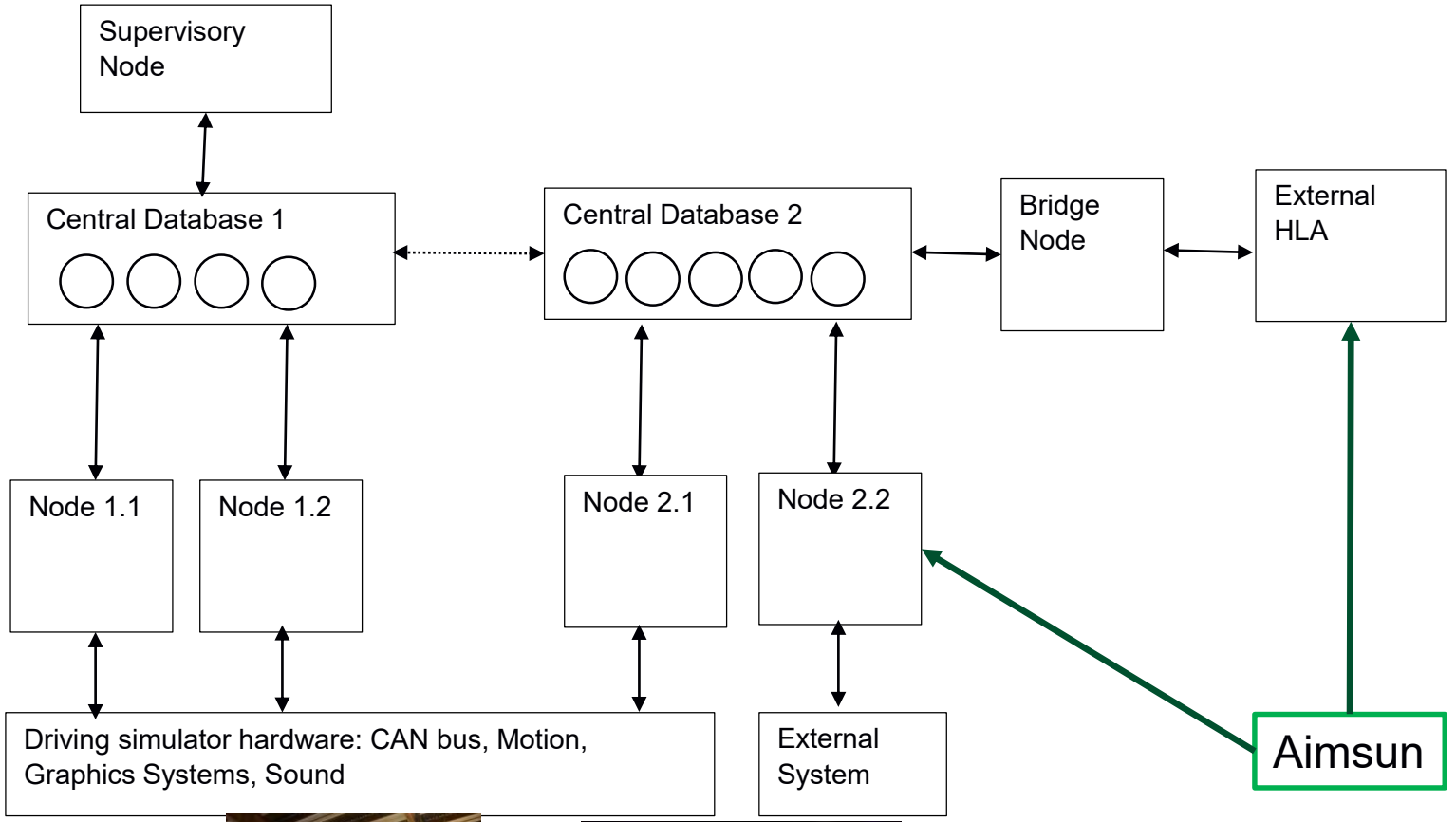

Distributed Simulation for the UK CAV

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Interoperable Simulation PoC

Driving Simulator

IPG CarMaker

rFpro

VISSIM

Customer ADS Function

Next Phase

UK Distributed XiL Simulation Environment

DDS Data Bus (Middleware)

Global Customers

Evolution of Networking to Address the Challenges of Distributed Simulation

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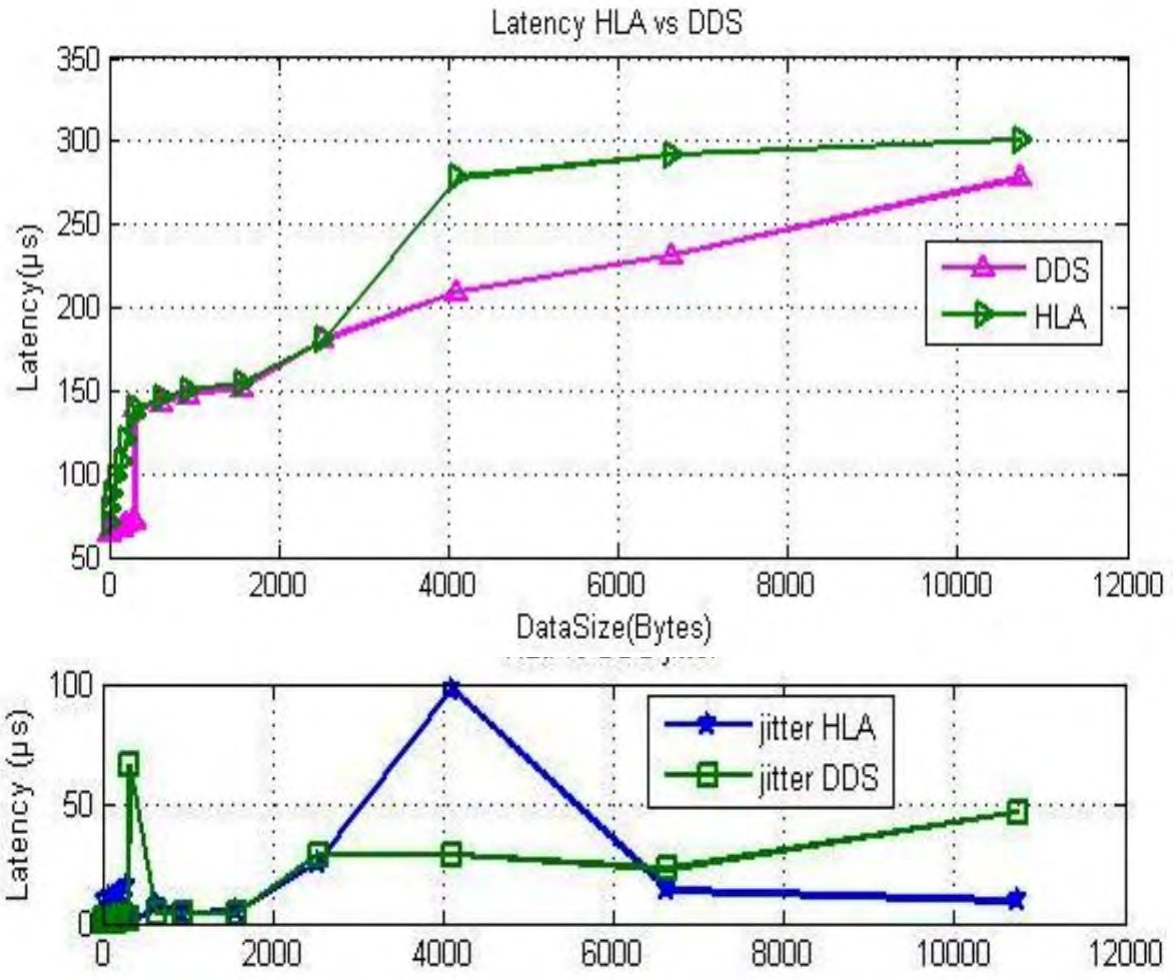
1. SIMNET (1980s)
2. Distributed Interactive Simulations (DIS) (1990s)
3. High Level Architecture (HLA) (2000s)
4. OMG Data Distribution Service (DDS) (2010s)



Hakiri, A., Berthou, P., Gayraud, T., 2010. Addressing the Challenge of Distributed Interactive Simulation With Data Distribution Service. Eur. Simul. Interoperability Work. 103–111.

Levels of Distributed Integration

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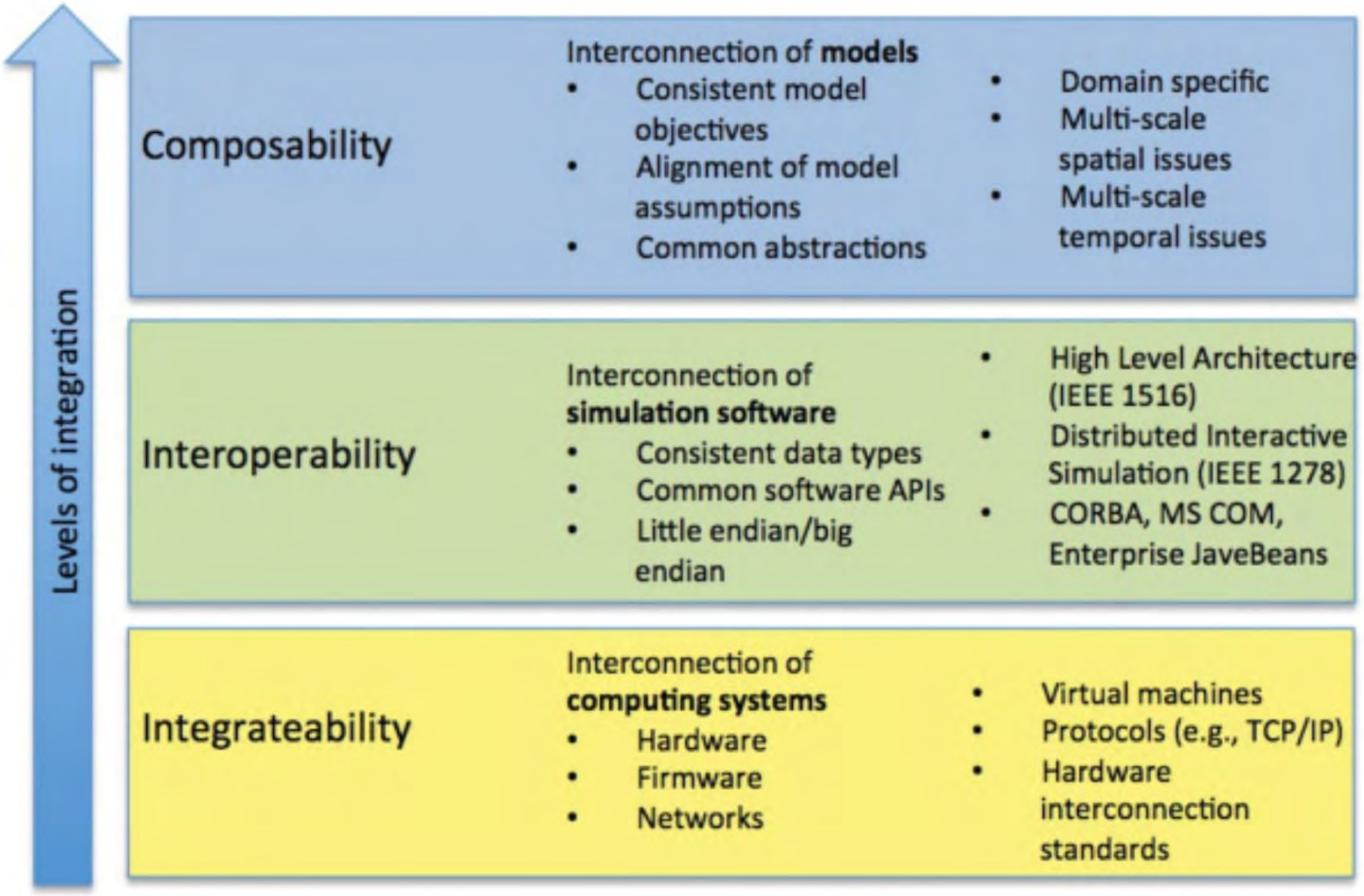

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Levels of Distributed Integration

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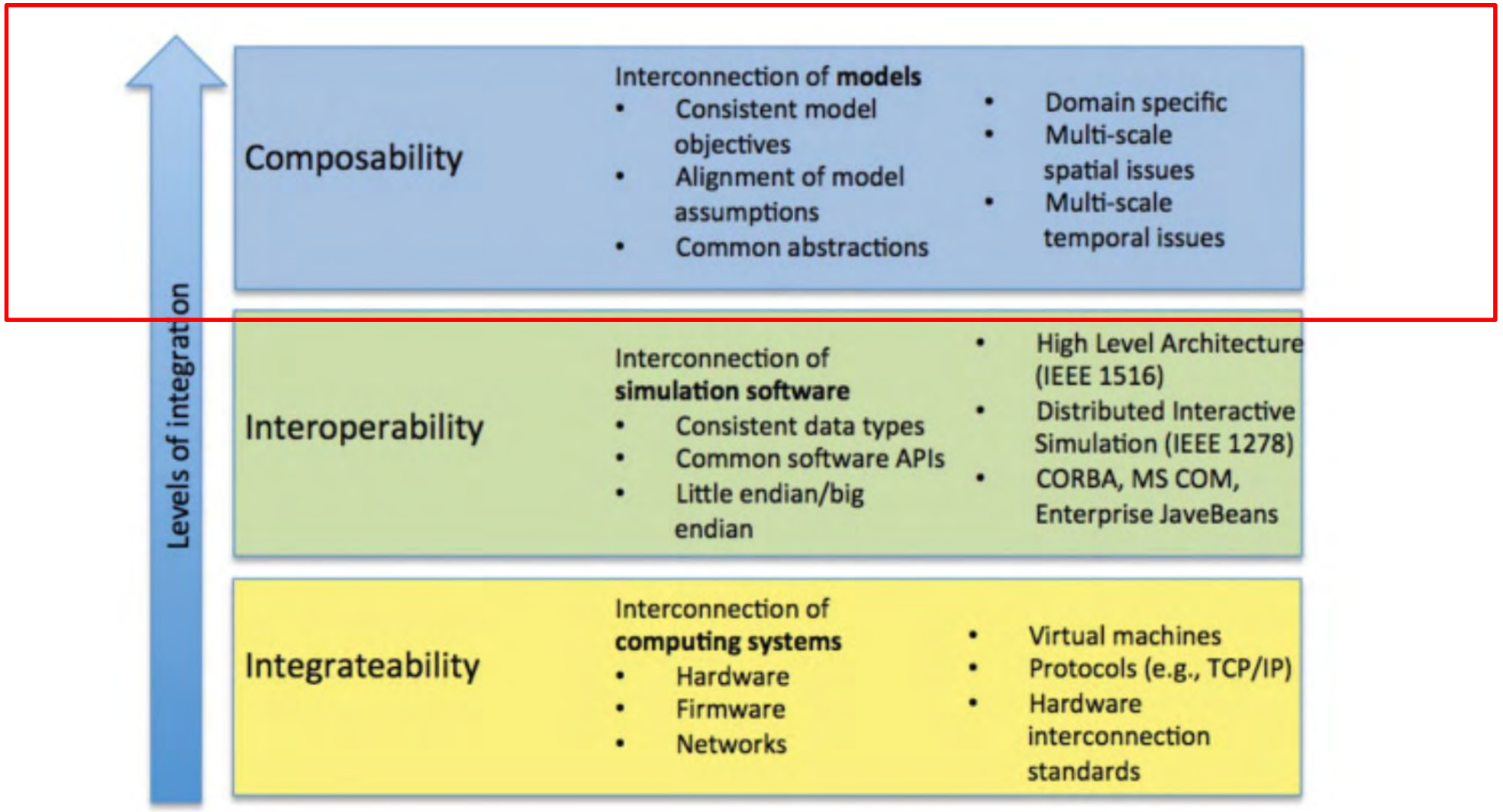

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Levels of Distributed Integration

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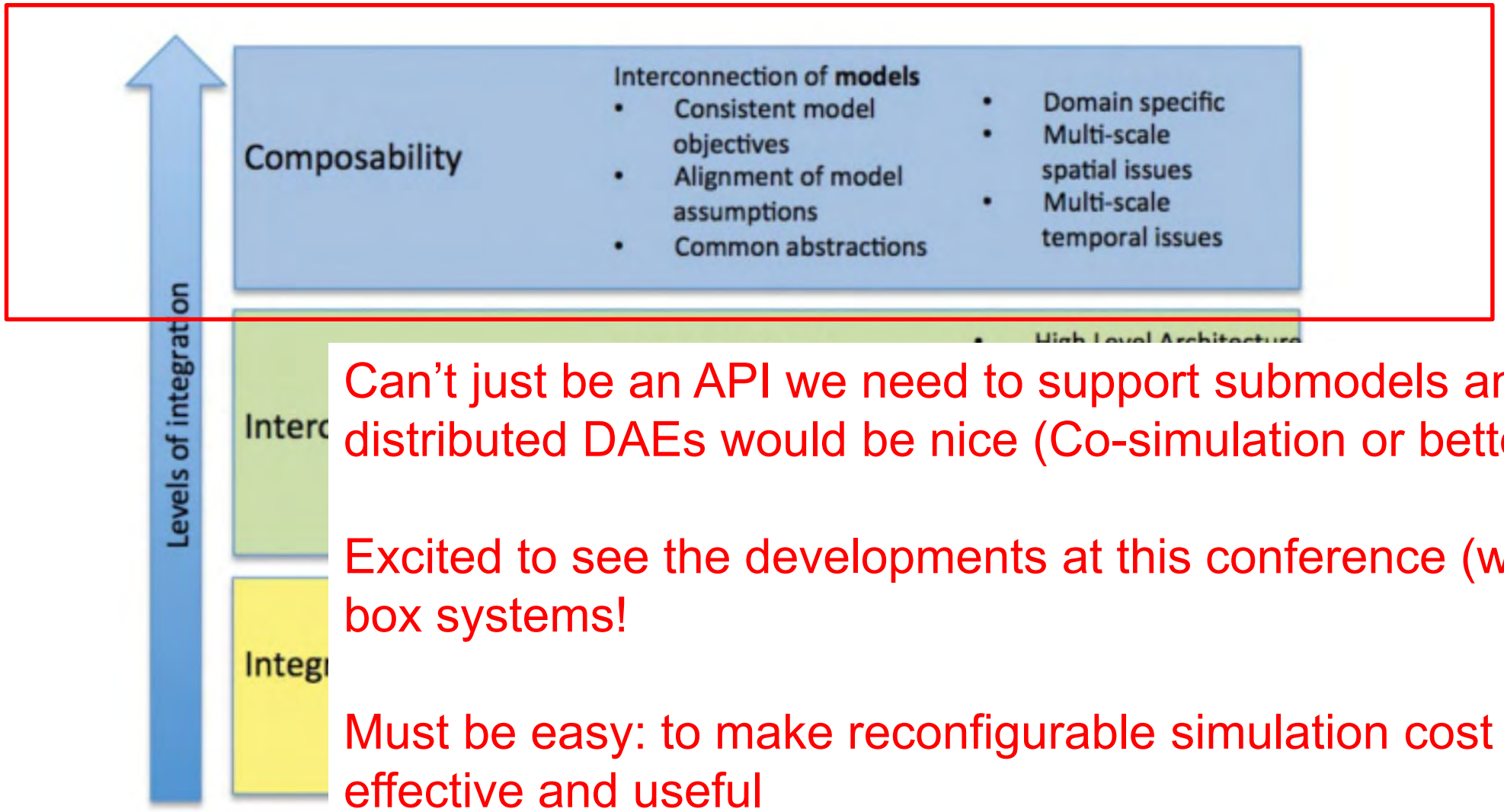

Can't just be an API we need to support submodels and distributed DAEs would be nice (Co-simulation or better)!

Excited to see the developments at this conference (white box systems!

Must be easy: to make reconfigurable simulation cost effective and useful

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Questions?

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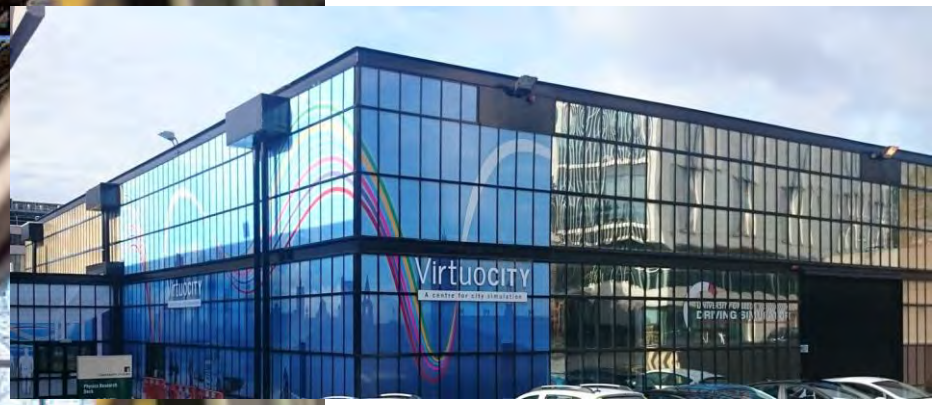

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