A view from Automotive and Aerospace

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Managing Director

Unlocking Innovation in Rail

CLAYTEX

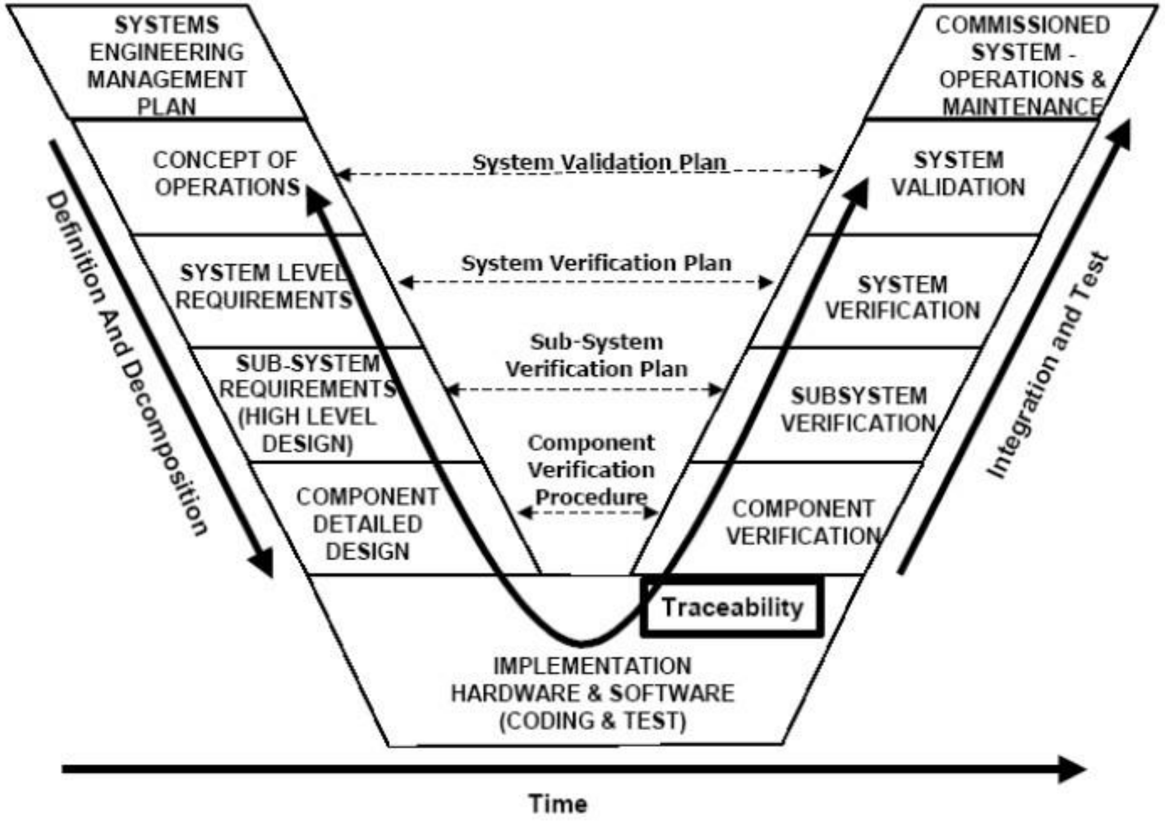
Claytex Services Limited

Software, Consultancy, Training

- Based in Leamington Spa, UK
  - Office in Cape Town, South Africa
- Experts in Systems Engineering, Modelling and Simulation
- Business Activities
  - Engineering consultancy
  - Software sales and support
  - Modelica library developers
  - FMI tool developers
  - Training services
- Global customer base
  - Europe, USA, India, South Korea, Japan
  - Automotive OEM's and suppliers
  - Formula 1, NASCAR, IndyCar
  - Aerospace OEM's and suppliers

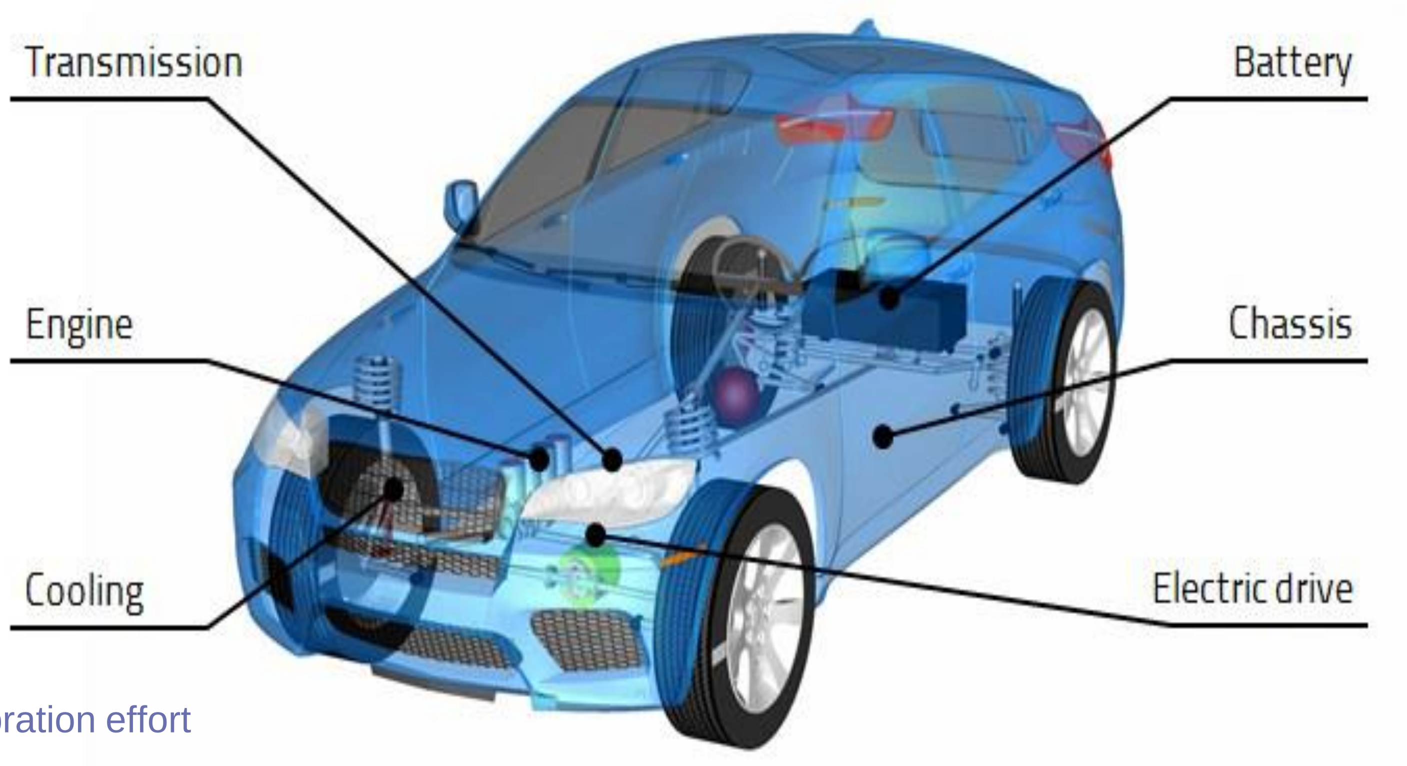
Model Based Systems Engineering

- Claytex provides software tools and services to support the complete systems engineering process
- Traceability
  - Reqtify connects to your existing tool chain and automates the tracing of information
  - Supports impact analysis and change management
- Definition and decomposition
  - Dymola and ControlBuild provide a hierarchical model based approach to systems engineering
  - Dymola is used to model the physics of the system
  - ControlBuild is used to develop the control systems and generate robust PLC code
- Integration and Test
  - Dymola and ControlBuild support Hardware-in-the-Loop testing
  - rFpro supports Driver-in-the-Loop testing



Challenges facing Automotive

- Market demands
  - Improved efficiency
  - Lower emissions
  - Improved reliability
  - Noise quality
  - Driveability
  - Performance
- Engineering solutions
  - More active systems
    - Increases complexity
  - Better control of existing systems
    - Increasingly complex control requiring large calibration effort
  - Tighter integration of all vehicle systems
- Management demands
  - Faster time to market
  - Lower development and manufacturing cost



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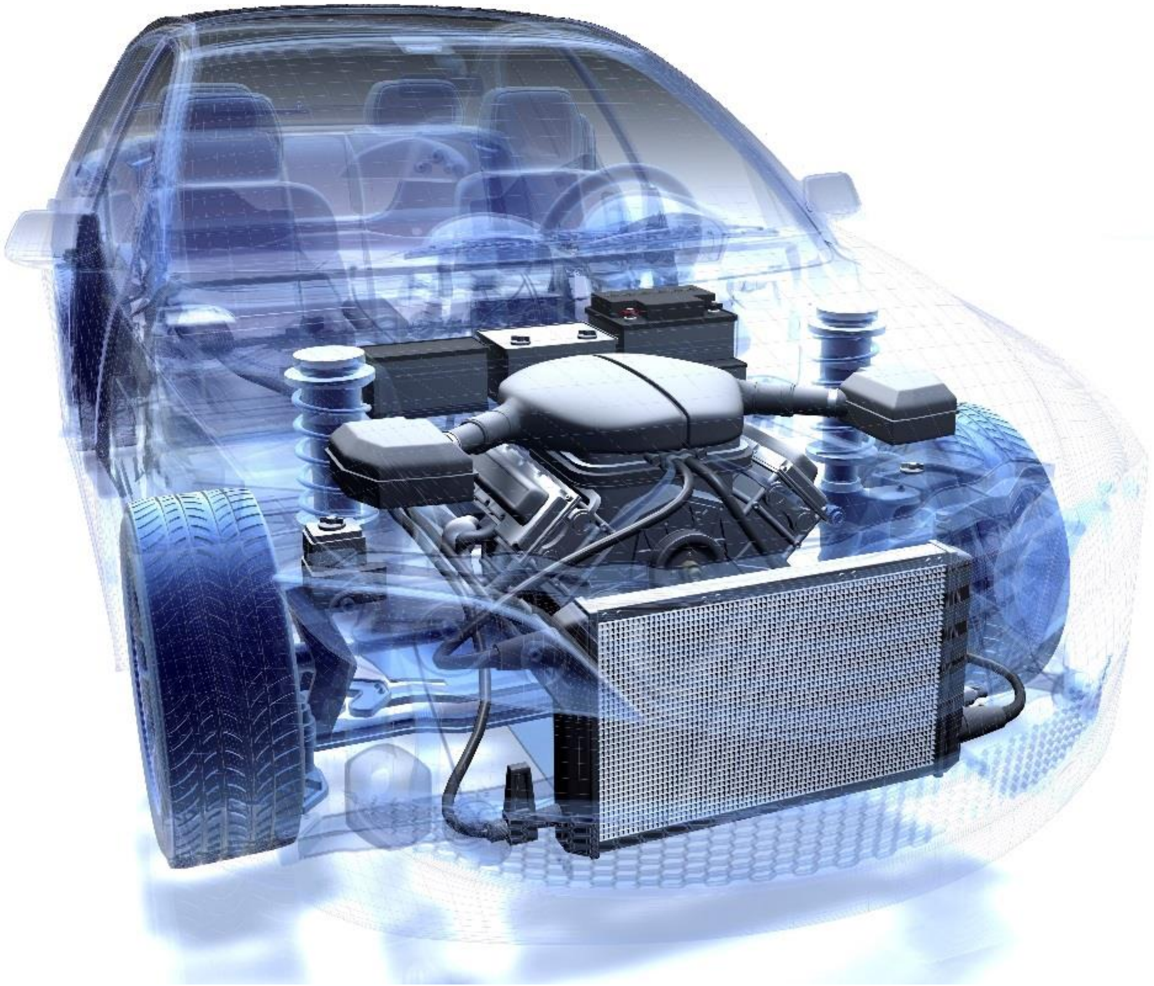
The need for modelling and simulation

- Automotive products are complex systems covering many domains
  - Mechanical, Electrical, Hydraulic, Pneumatic, Thermal, Chemical, Control, Magnetic, …
- No longer sensible to wait for prototypes to verify that all these systems interact in a good way
  - Many OEM's share the vision of zero prototyping
- It's not practical, or perhaps even possible, to fully verify and validate control systems using prototypes
- Need to use predictive models and not just functional ones to make simulation useful from an early stage of the project
- Need a complete virtual test environment



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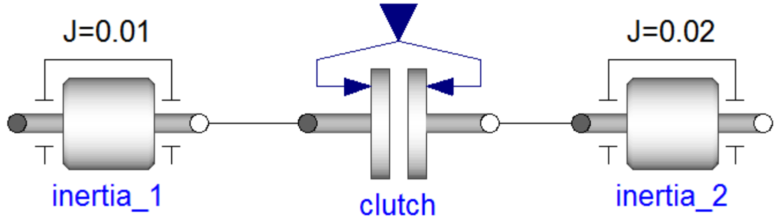
Functional and Predictive models

- A Functional model is one that captures the key function of the model
- A Predictive model allows us to predict the behaviour and explore it's characteristics



- The clutch is there to make sure the two inertias rotate at the same speed when engaged
- Functional model
  - Would reduce the relative speed across the clutch in a predefined manner
  - The controlling parameter would be the engagement time
- Predictive model
  - Would include a model for friction and the torque transfer would be a function of the clutch clamp load, relative speed, temperature, …
  - The parameters would include the geometry and friction characteristics
  - The engagement time could be predicted under different operating scenarios

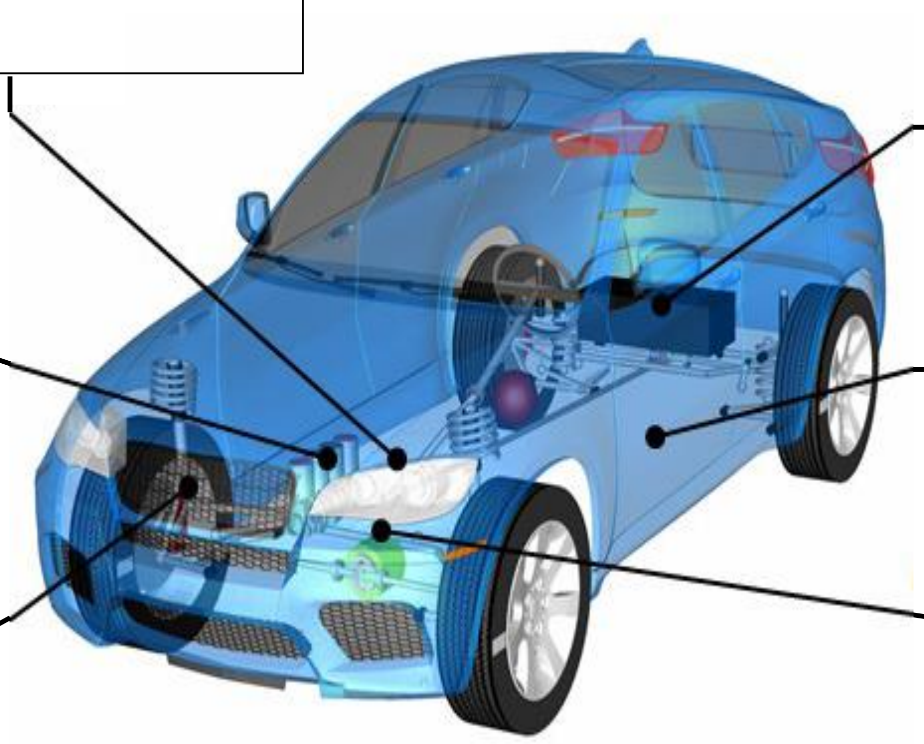
Vehicle Modelling

Rolling stock is built up from many of the same systems and therefore the same simulation technology could be applied

- Gearbox and Driveline
  - Mechanics
  - Thermal
  - Hydraulics
  - Electrification
  - Control
  - Cooling

- Engine
  - Air flow
  - Mechanics
  - Cooling system
  - Fuel system
  - Control system
  - Electrification
  - Hydraulics

- Thermal Management
  - Engine Cooling
  - HVAC
  - Battery Cooling
  - Power Electronics Cooling



- Battery
  - Electrical
  - Thermal
  - Cooling
  - Control

- Chassis
  - Mechanics
  - Active systems
  - Control

- Electric Drive
  - Electrical
  - Thermal
  - Control

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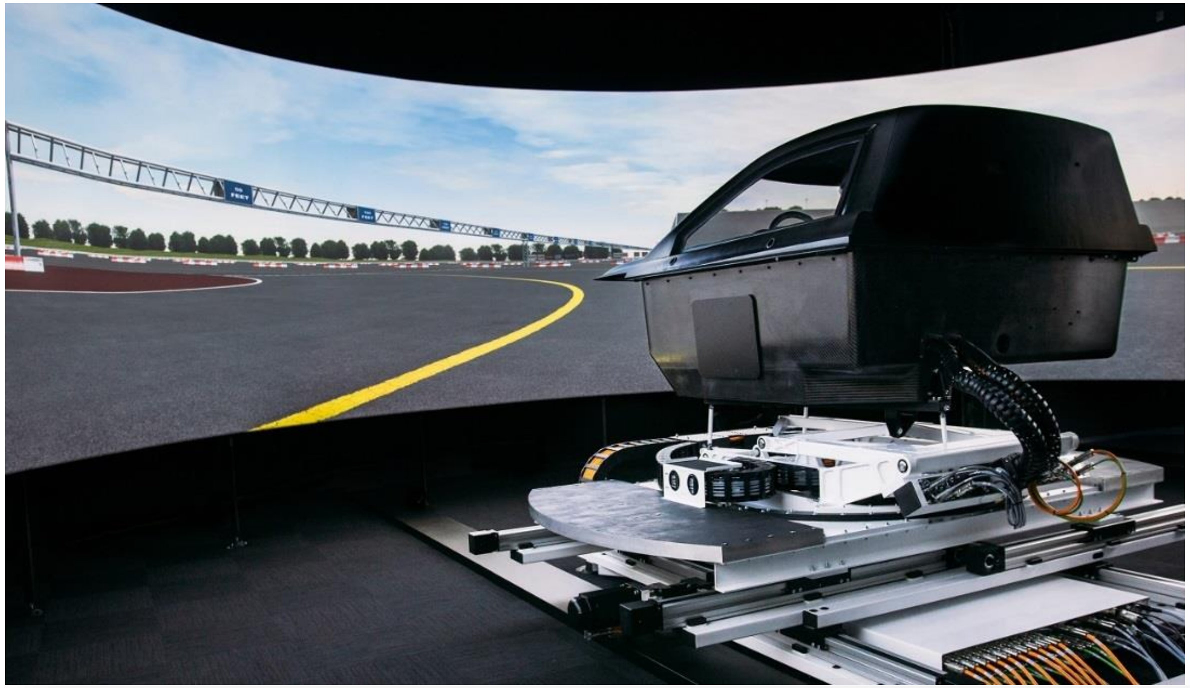
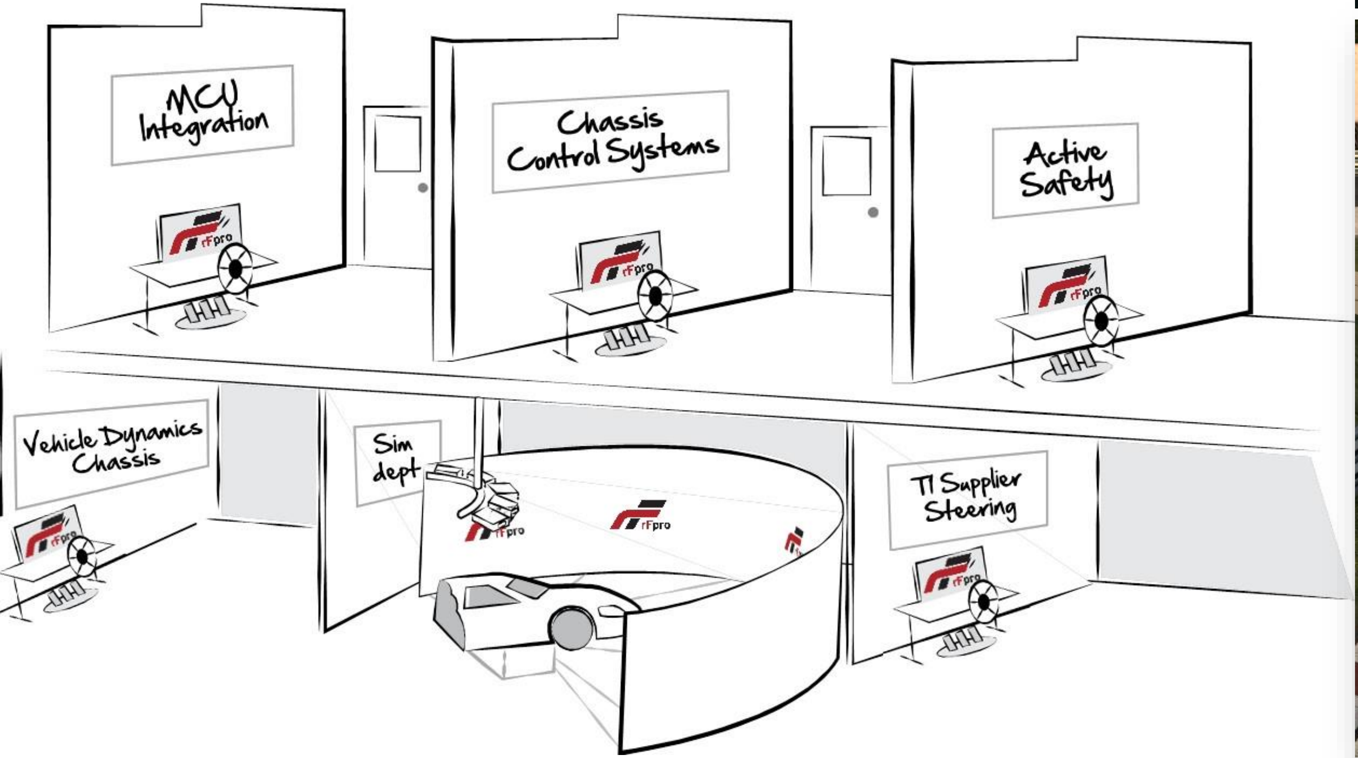
Virtual Test Environment

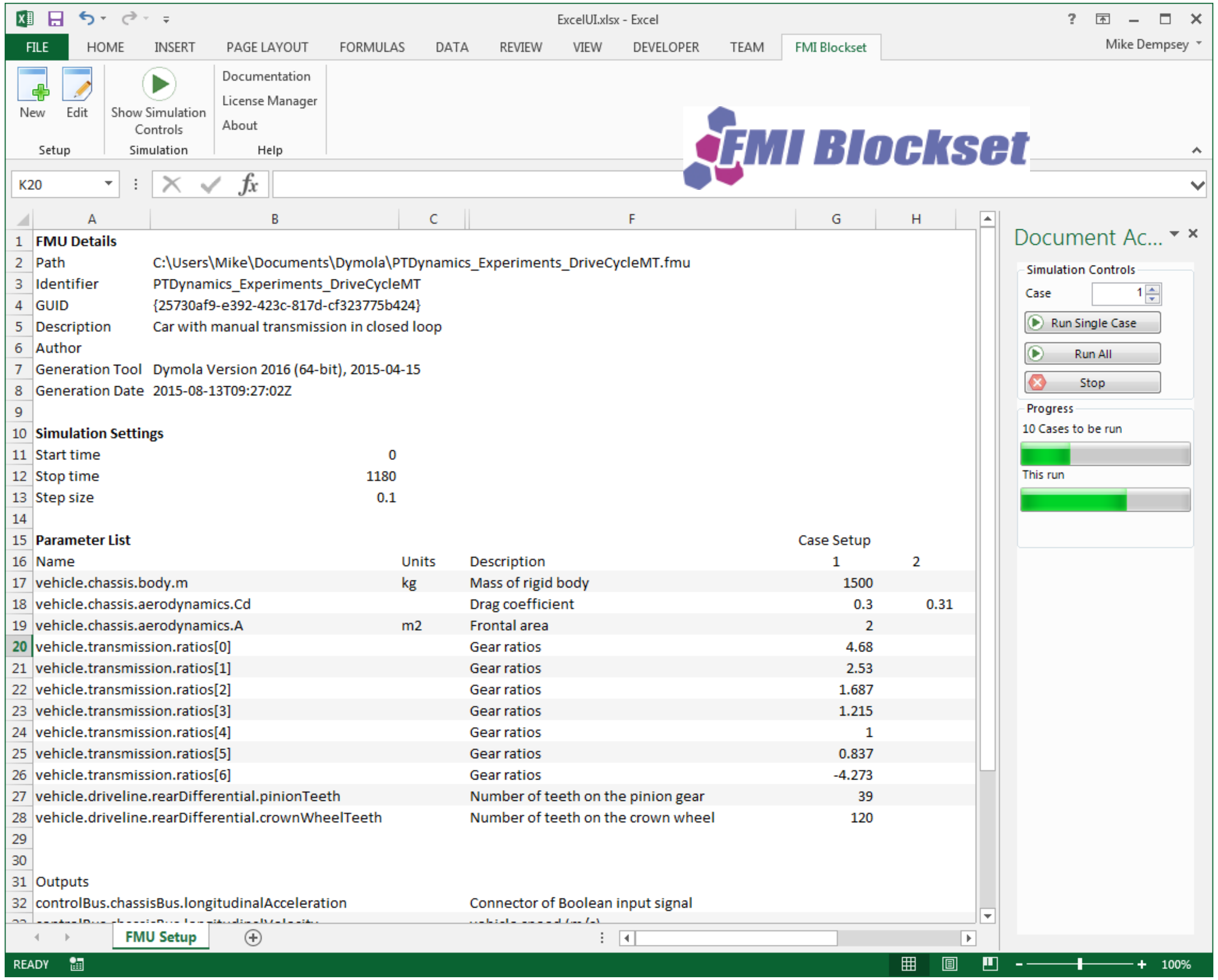
- Complete virtual environment with high fidelity track/road data and vehicle models
- Scaleable from workstation to full motion simulators
- Allows you to reintroduce the human test driver into the model based development process
- Supports the development of ADAS





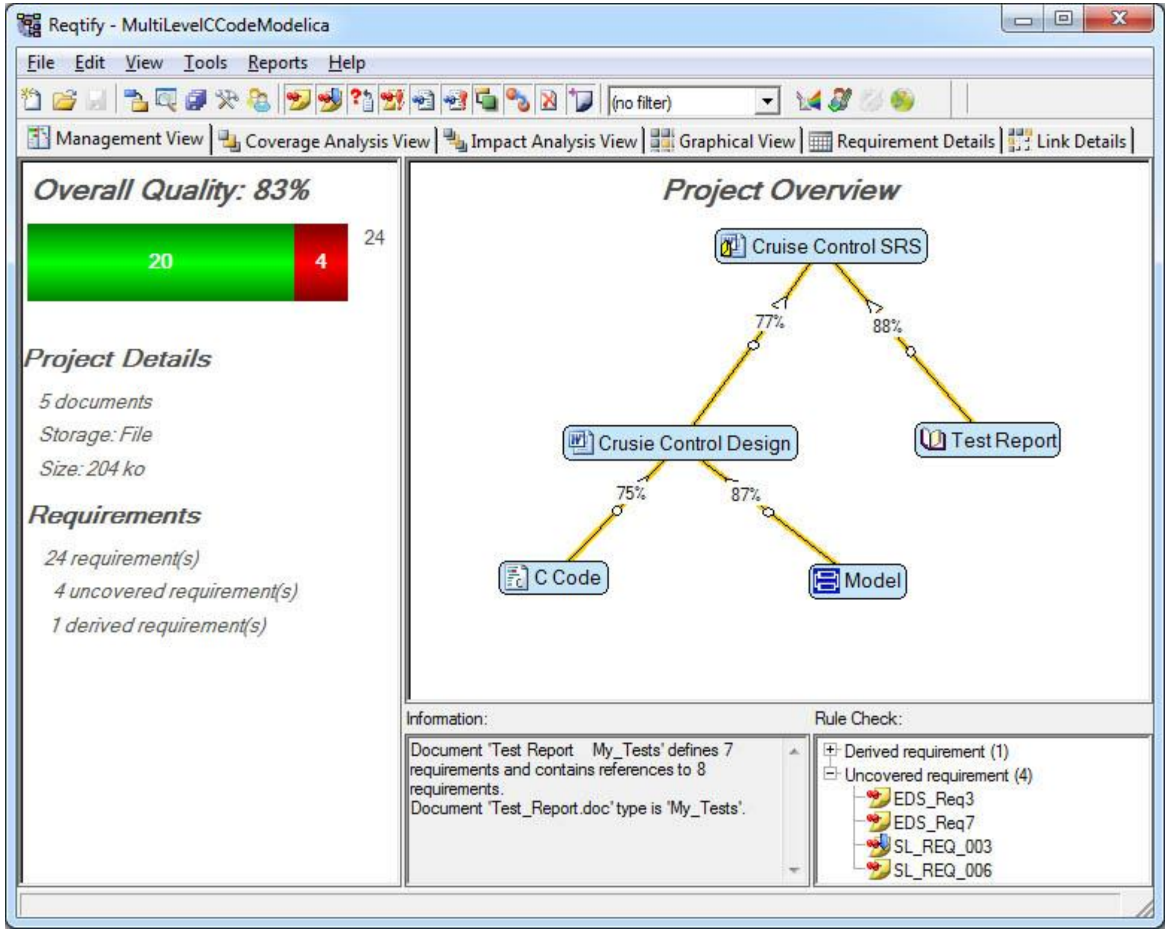
Deployment and reuse of models

- To unleash the real value in models we need to be able to reuse them in many different ways
  - In Motorsport we find the same models used in the design office, trackside tools, telemetry systems and test environments
- We use open standards for sharing models between tools
  - Functional Mock-up Interface Standard
  - Supported by 80+ tools from many different developers
    - Dymola, Simulink, Excel, ControlBuild, dSpace, Simpack, ….
- Provide engineers and programme managers with easy to use and familiar tools backed up with complex, robust simulations
  - For example, using Microsoft Excel as the user interface allowing access to a limited number of parameters



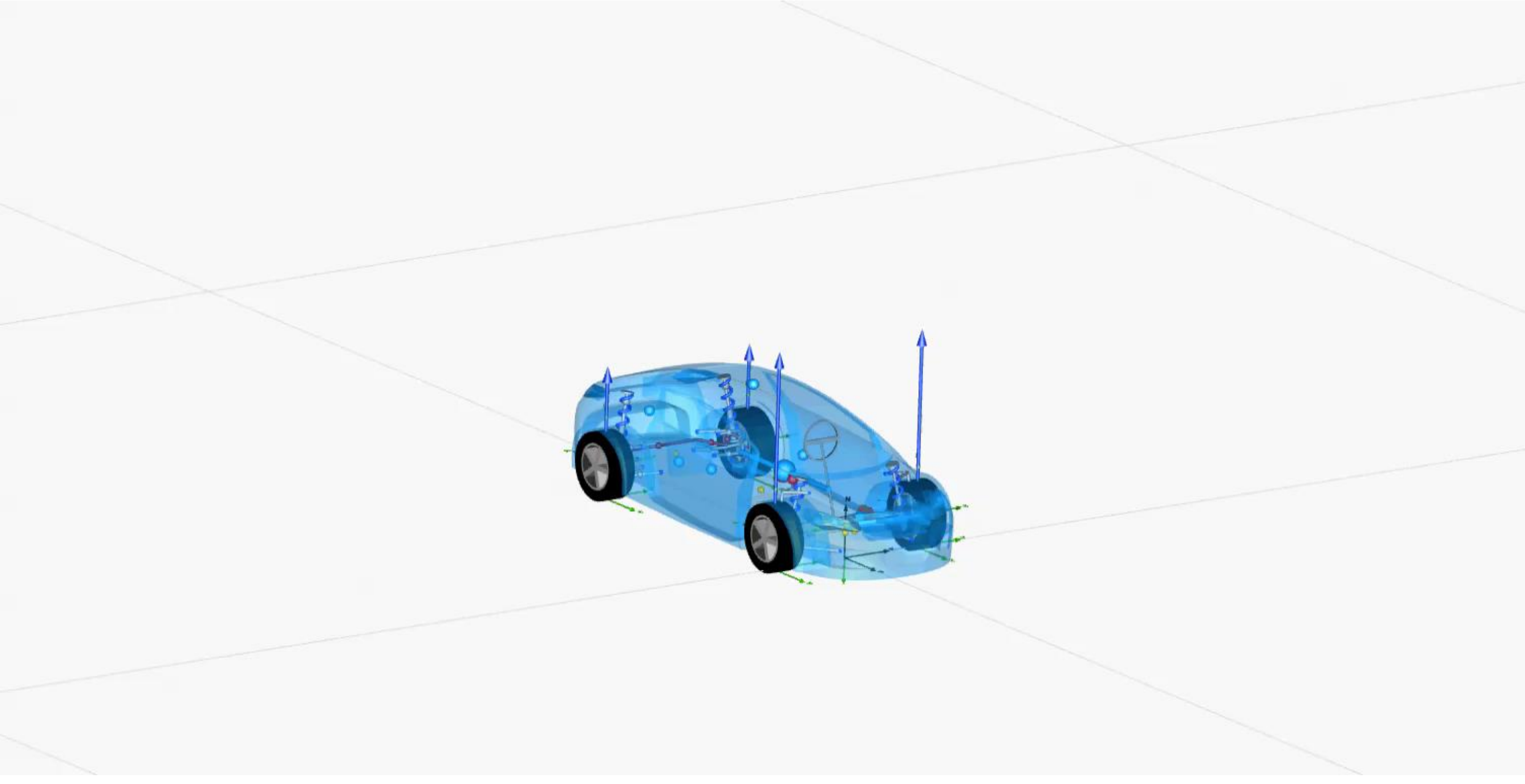
ISO 26262 – Road vehicles – Functional Safety

- Similar in concept to IEC 61508 and EN50128 in Rail
- Goals of ISO 26262:
  - Provides a lifecycle safety framework
  - Covers functional safety aspects of the entire development process
  - Provides a risk-based approach for determining risk classes (Automotive Safety Integrity Levels, ASILs)
  - Uses ASILs for specifying the item's safety requirements to achieve an acceptable residual risk
  - Provides requirements to ensure a sufficient and acceptable level of safety is being achieved
- What does this mean?
  - You need traceability throughout the development process
  - You need to generate and keep evidence to support your decisions



Summary

- Automotive is moving towards “zero prototype” development process
- To achieve this requires tools and processes to support the whole systems engineering process
  – Traceability
  – Model based approach to systems engineering
    - Simulation based on predictive models
    - Potential for automation of repetitive tasks, DOE, reviews
  – Reuse of models
  – Virtual test environments
- For further information:
  – www.claytex.com
  – 01926 885900



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