Who are Claytex?

- Model-based engineering Analysis Consultancy
  - Innovators in CAE systems modelling for 20 years
  - Leading the way on zero-prototype development
  - Specialists in high-fidelity real-time simulation
- Provider of software solutions for systems engineering
  - Dymola distributors since 2003
  - Dassault Systemes partner since 2008
    - 3DEXPERIENCE, Reqtify, ControlBuild, AUTOSAR Builder
  - rFpro system integrator and distributor since 2009
- Simulation tool developers
  - Modelica libraries
  - FMI based tools
  - Test automation tools
  - Autonomous vehicle simulators
- Training course provider
  - Dassault Systemes Certified Education Partner
Who are Claytex?

- 4 Offices on 3 continents
  - Head office in Leamington Spa, UK
  - North Carolina, USA
  - Michigan, USA
  - Cape Town, South Africa

- Global network of distributors for our tools and solutions through Dassault Systemes
  - Libraries are also integrated into the Dymola and 3DEXPERIENCE product portfolios

- Customers include:
  - Motorsports: Formula 1, IndyCar and Formula E teams; NASCAR teams and manufacturers
  - Vehicle OEM’s, technology providers and suppliers
  - Aerospace and Industrial Equipment Manufacturers
  - Universities and Research organisations
What we do
Modelica and FMI

- Modelica Libraries
  - VeSyMA
  - FluidPower
  - FlexBody
- FMI Tools
  - FMI Blockset for Simulink, Excel and Windows
  - Cloud Simulation Platform
- Other Related Tools
  - Regression Testing Tool
  - MultiRun Tool
  - rFpro
- Consulting
- Training
Vehicle Systems Modelling and Analysis

- Suite of Modelica libraries for Vehicle Systems Modelling and Analysis
- Core platform enables performance, fuel economy and energy analysis
  - Drive cycle simulation
  - Straight line performance
  - Gradeability
- Application specific extensions provide detailed models across many areas
- Built on the VehicleInterfaces open standard model architecture
- Compatible with many other libraries including the Electrified Powertrains Library and other solutions from Dassault Systemes
Performance, Fuel Economy and Energy usage prediction for ground vehicles
Main purpose is to provide a platform for the design and analysis of vehicle systems and components
For Engines

- 1D thermofluids for air-path, fuel-path, cooling
- Multibody mechanics
- Oil and coolant circuits for a battery electric vehicle with auxiliary power unit (range extender)
For Transmissions and Drivelines

- Model the whole powertrain as a MultiBody system
- Detailed shift dynamics including dog clutches, detents, synchronisers
- Wet and dry clutch models
- Dynamic torque converter model for studying launch
- Thermal effects in clutches and loss models
- Driveability, launch feel, shift quality
For Vehicle Dynamics

- Comprehensive range of experiments
  - Rig, static and dynamic tests
    - From quarter car to full vehicle
  - Open and closed loop driver models

- Suspension models for cars
  - MultiBody models provided include: double wishbone, integral link, multi-link, trailing arm and MacPherson strut
  - Table based suspension models
For Vehicle Dynamics

- 3D roads and circuits
  - ISO road roughness, curbs, irregular roughness data
  - OpenDRIVE support for complex roads
- Closed loop drivers follow paths defined in the road
  - Function of centreline or defined in global coordinates
- Multi-point tyre contact patch
• Tyre models
  – Pacejka MF 5.2, 6.1 and 6.2
  – FTire integration
• Single wheel test rigs

• Support for
  – bushes with frequency and amplitude dependent effects
  – flexible bodies in the suspension, subframes and vehicle body
• Suspension models for motorsport applications
  – Double wishbone
  – NASCAR
• Include a full range of physically defined suspension adjustments

• Dedicated motorsport orientated experiments
  – Setup tests
• Designed for real-time simulation
• Dedicated Kinematics solver to assemble complex suspension
For Driver-in-the-Loop

- Integration of vehicle dynamics and rFpro
- Includes the templates and complete tool chain to compile the vehicle model
- Supports static and full motion systems from multiple manufacturers

- rFpro provides high fidelity graphics, audio and real world locations: race tracks; proving grounds and public roads
- Supports ADAS and autonomous vehicle development by feeding data to sensor models
Assembling Kinematic Systems

- Developed to calculate suspension hard points from an assembly of parts defined in local coordinate systems
- Calculate pivot points, toe, camber, caster from assembly
- Sweep contact patch position to obtain key characteristics e.g. toe and camber curves
- Fast simulation
- Initially developed for NASCAR and Dirt Late Model race cars
For the simulation of hydraulic systems

- Designed to be easy to use
  - We don’t want to have to place components in a particular order or configuration to suit the solver
  - Models should be easy to parameterise from data sheets and shouldn’t be coefficients of a particular equation formulation
Include Flexible Bodies

- Use Finite Element models with the Modelica MultiBody library
- Nastran, Genesis or Abaqus do the model reduction
  - Craig-Bampton reduction to equivalence a full finite element model to a number of boundary nodes (attachment points) capturing modes within the frequency range of interest
    - Also known as super-elements
- Standard output files are used to import the model directly into Dymola
  - Preprocessor provided to convert these files into a Modelica readable format
FMI Tools
• Enables FMI compliant models to be used in a number of different tools
  – Supports Simulink R2010B and later
  – Supports Microsoft Excel 2016
  – Supports running on Windows with simple UI generating csv result files
• Allows the import of FMU’s into the host application
• Supports FMI 1.0 and 2.0
• Distribute models containing configured FMU though supply chain!
• Simulation models need to be made accessible to enable data driven decision making processes
• Modelica is very powerful but not for the casual user or project manager who needs to make a decision
• FMI provides a standard for encapsulating models
• New Cloud simulation platform
  – Serverless application for running FMU’s
  – Common platform, multiple UI to suit different users
  – Enables multiple simulations to be run in parallel
Other Related Tools
Regression Testing

- Automated Regression Testing
  - Monitors revision control repository and run tests after each commit
  - Or, test on demand
- Distributed testing across multiple PC’s utilising every available core
- Uses Dymola to check and test models
- Annotations in the models control the tests
• MultiRun tool reads the Modelica Library and identifies experiments
  – User selects models to be run
• Starts multiple instances of Dymola
  – One instance per CPU core
• Save test selections and reference results for easy reuse
• GUI and command line driven
Virtual Development and Testing

• rFpro ADAS workstation supports the full virtual testing of ADAS and Autonomous systems
• Claytex develops:
  – Sensor models (LiDAR, radar, ultrasound, etc.)
  – Plugins to capture semantic data
  – Vehicle physics models
  – Test automation tools
• We can deliver the complete ADAS/Autonomous vehicle test system
Generic sensor models for rFpro

- Radar provides an object list
- LiDAR provides a point cloud
- Ultrasound provides minimum distance
- Camera feeds
- Support UDP and TCP/IP messaging
- Perfect sensors
Device specific sensor models

- Building a library of models that represent real sensors
  - For example: Ibeo Scala B2, Velodyne VLP-16 “Puck”, Delphi ESR 2.5, Continental ARS430
  - Produce the same output message format
  - Capture the dynamics of the sensor e.g. rotation of sensor with time
  - Appropriate lighting of scene for LiDAR
  - Weather effects and other relevant noise effects

- Semantic recorder captures every available detail about the scene to file

- Replacement control panel for rFpro to ease management and configuration of sensors

- Active R&D projects to increase fidelity of sensor models under 2 Innovate UK projects
  - They will take into account weather effects and other significant sources of noise
Velodyne “Puck” Sensor Model

rFpro ParisStreets digital road model
rFpro hosted LiDAR sensor model
Real-time data stream visualised in native software
Traffic objects controlled by IPG CarMaker
Summary

• Claytex develops:
  – Modelica libraries: VeSyMA; FlexBody; FluidPower
  – FMI tools for desktop and cloud simulation
  – Automated testing tools e.g. Regression testing of libraries

• Active in the development of simulation tools to support the development of Autonomous vehicles
  – Our focus is on sensor modelling and test automation
  – Participating in 2 UK government funded projects (Streetwise and dRISK)

• We offer consulting and training on all these topics
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