DS User Conference 2018

Systems Engineering

Mechatronics & Multi-Physics Systems Modelling and Simulation

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Standards

Modelica language
Functional Mock up Interface
Modelica

A language to model physical behavior

• Equation based
• Non-proprietary
• Object-oriented
• Acausal
• Allows external interfacing

```
equation
   v = der(s);
   a = der(v);
   m*a = flange_a.f + flange_b.f;
end Mass;
```
Modelica leverages « Systems Engineering »

- Faster model development due to component oriented modelling method
- Easy to combine systems from multiple engineering domains
- Simplifies convergence by avoid co-simulation problems
- Industry-proven and open language
- Vibrant community for content development and use cases publications
- Designed for large system models
- From early conceptual phases to Hardware in the Loop validation
Functional Mockup Interface

Software/Model/Hardware-in-the-Loop, of physical models and of controller models from different vendors for automotive applications with different levels of detail.
Roles & Applications

Dymola
Dynamic Systems Engineer
Mechatronic Systems Engineer
Modelica Content
Dymola and 3D EXPERIENCE Platform

Dymola: Stand Alone Application

Modelica compliant solution to efficiently model and simulate multi-physic dynamic systems

• Best-in-class Modelica language support
• Effective real-time capabilities

For System Simulation Specialists

Looking for: Design Multi-physics systems, Assess System Performance, Design and validation of control laws

From early studies & concept to detailed design

CATIA Dymola Behavior Modeling

• CATIA Dymola Behavior Modeling application available on the 3D EXPERIENCE Platform within roles
• Applications share the same kernel
• Models and libraries are fully compatible
• Extended by Platform with:
3DEXPERIENCE Platform

System Modeling & Simulation | Roles & Content

- **2 Roles**
  - Dynamic Systems Engineer (SNK)
  - Mechatronic Systems Engineer (SQK)

- **4 Extensions for Export**
  - Systems Simulink Export (XSK)
  - Systems FMU Export (XFM)
  - Systems C Code Export (XCS)
  - System Real Time Execution (XRE)

- **22 Modelica Commercial Libraries**
Modelica Content

**VeSyMA**
Provides necessary assets and interfaces for Vehicle Systems Modelling and Analysis

**VeSyMA – Powertrain**
Model and validate the performances of the full motion of the vehicle powertrain

**VeSyMA – Suspensions**
Develop suspension systems for vehicle handling, driver and stability control models

**VeSyMA – Engines**
Develop suspension systems for vehicle handling, driver and stability control models

**Fluid Power**
Model and predict hydraulic systems behavior

**Flight Dynamics**
Model, simulate and analyze of the flight dynamic characteristics of a wide range of flight vehicles

**Thermal Systems**
Optimize Design of large and complex thermal systems

**ClaRa Plus**
Simulation thermodynamic cycle processes for electricity power generation using Clausius Rankine cycles

**Human Comfort**
Model and analyze the thermal comfort of building and vehicle occupants

**HVAC**
Optimize the design & performance of Heat, Ventilation and Air Conditioning Systems

**Wind Power**
Rapidly model and simulate Wind Turbines at system-level for optimized performances

**Design Optimization**
Optimize and tune systems parameters of a device or its controller to improve system dynamics

**Flexible Bodies**
Accelerate the analysis of large motions of flexible parts

**Electrical Power System**
Multi-level modelling of DC and high-frequency AC electrical network

**Hydrogen**
Design and validate performances of fuel cells systems

**Battery**
Bring battery simulation to the system level

**Electrified Power Train**
Assists design steps during the entire process of developing electric drives

**Brushless DC Drives**
Allows the integration of Brushless DC motors and control into systems

**Systems Cooling**
Develop cooling systems and dimension components, for batteries, electric drives and electronic thermal management

**Pneumatic Systems**
Design pneumatic systems and predict their behaviors

**Powertrain**
Model and Simulate the characteristics of vehicle powertrain systems
Vehicle Systems

E-motors & Power Electronics
- Electrified Powertrain library
  - R2017X

Vehicle Dynamics
- VeSyMA – Suspensions library
  - R2018X

Vehicle Systems Cooling
- Battery library
  - R2017X

Air Conditioning
- Thermal Systems library
  - R2018X

Hydronics
- VeSyMA – Fluid Power library
  - R2018X

R2018X

Hydrogen library
- R2018X

Fuel Cell

Hydronics

Vehicle behavior architecture & model interfaces

VeSyMA – Powertrain library
- R2018X

VeSyMA – Engines library
- R2016X

VeSyMA library
- R2018X
Energy Process & Utilities

Electricity power generation

ClaRa Plus Library
Simulation thermodynamic cycle processes for electricity power generation using Clausius Rankine cycles

Thermal Process

Thermal Systems Library
Optimize Design of large and complex thermal systems

Wind Power

Wind Power Library
Rapidly model and simulate Wind Turbines at system-level for optimized performances

Heat, ventilating & air conditioning Process

HVAC Library
Optimize the design & performance of HVAC systems
Modelica Representation of Mechanism

- Associate Modelica Representation of a 3D Mechanism
- Quick composition of the mechanism with multiple engineering domains (control, electrical...)

- Fast and physically exact simulation
- Understand precisely mechatronics behaviors
- Simplified convergence on the solutions
Modelica representation of piping/tubing 3D models

- User-defined mapping for pipes & equipment
- Components reflect pipe geometries & attributes
- Pipe flows 3D animations
- Quickly assess fluid circuit performances
- Simplifies collaboration between 3D design & simulation

User-defined mapping between the 3D elements and the selected Modelica classes from any library
3DEXPERIENCE CATIA | Mechatronics Engineering

- Requirements Engineering
- System Architecture Design
- Behavior Modeling
- 3D Modeling
- KPIs Validation
- Simulations Processes Optimization and DOE
- Dynamic Simulations
Python and JavaScript interface

- CATIA Dymola Behavior Modeling commands can be triggered from a Python or JavaScript environment

- Commands available in Python/JavaScript are corresponding to functions from the DymolaCommands library
Multi-Scale Simulation

For Specialized Simulation Analyst

To perform controlled dynamic simulation

Co-Simulation
3DEXPERIENCE CATIA | Mechatronics Engineering Values

System Engineering collaboration
Single Source of Truth
Shared Models
Shared Parameters

KPI verification/validation
Any action is verified versus targets
Real-time management decision

System Engineering Re-use
At any level
From parameters to processes

System optimization within openness
Multi-physics & Multi-scale Simulations
Simulation workflows and optimization
Open to standards

Unified System definition
One single definition for all systems roles
Consistent Systems Engineering Methods
Unified lifecycle for any object in the Platform