A Short Introduction to Autonomie
Autonomie
Plug & Play Architecture
Virtual Engineering Accelerates the Vehicle Development Process

Problem:
- Heavy reliance on hardware builds leads to high cost and longer development time
- Integration of new technologies in a system lowers the expected benefit

Result:
Wasted Opportunities, Time, and Resources (People & $)

Solution:
OEMs are moving towards an increasing reliance on modeling and simulation to accelerate the introduction of advanced technologies
Autonomie Main Capabilities

- Ready to Go
- Open
- Customizable
- Reusable

- Processes
- Architectures & Models
- Detailed Plants
- Analysis
- Simulink Models
- StateFlow Controls
- Matlab scripts
- Model Management
- Import / Export (system, process, analysis...)

Plug&Play Software Architecture
What is Autonomie?

- Build and compare large number of system models
- Run batch mode & Distributed computing
- Easy selection & implementation of data, models or control
- Generic Processes
- Ensure simulation traceability, model compatibilities
- Analyze and compare test and simulation data
- Simulink based software environment and framework for automotive Powertrains & Control system design, simulation and analysis
- Enables MIL, SIL, HIL, CIL
- Database Management (SysDM)
Autonomie Models are Ready to Go

More than 40 Plant Models (inc. driver, engine, electric machine, fuel cell, energy storage, torque converter, gearbox, chassis...)

More than 75 Low and High Level Control Strategies

Hundreds of Initialization Files

More than 130 Powertrain Configurations

- Series
- Parallel
- Power Split

Numerous Turn-Key Vehicles
Models Organized Based on a Hierarchical Architecture

Example of Default Conventional Automatic Vehicle

Vehicle

Level 1 – Vehicle Powertrain Architecture

Level 2 – Engine Plant and Control

Level 3 – Engine Control
Hierarchical Architecture Can be Customized to Match Hardware Setup (i.e., facilitates xIL)

Each System is Optional

Any System can have Nested Subsystems To Accurately Represent Hardware Architecture

Example: GM 2 Mode HEV Transmission Plant

Electric Machine #1

Electric Machine #2

Gearbox
Numerous rule based vehicle level control provided with Autonomie, including:

- Shifting algorithm
- Micro, mild hybrids
- Full hybrids (pre-trans & post-trans parallel, power split, through-the-road, series, series-parallel, Voltec...)
- Plug-in hybrids

Existing advanced control algorithms (i.e., Dynamic programming, DIRECT, instantaneous optimization...) could be made available in the future

Processes can be customized to use optimization
Use Cases based on Medium & High Fidelity Models
Plant Model Refinement using Imagine.Lab AMESim

- Simulation of the complete system
- Description of physical phenomena based on few “macroscopic” parameters
- Multi-physics / Multi-level approach
- The simulation model is an assembly of components
- Components are described with analytical or tabulated models
- We are looking for static/dynamic responses (time & frequency domains)

Autonomie model
Control Development and Test through **SIL** (or **VHIL**)

- **Vehicle Plant**
  - CARSIM

- **Transmission / Hydraulics Plant**
  - AMESIM / Simulink

- **Engine Plant**
  - GT Power / Simulink

- **Controller Models**

- **Plant Models**

- **Controller Models**

- **Algorithm Models**
  - Hybrid Algo
  - Trans Algo
  - Engine Algo

- **Virtual Controls Integration Platform**

- **Front End Tool for:**
  - GUI
  - CM interface
  - Model assembly
  - Automated SIL

- **Virtual calibration**

- **Virtual calibration**


[Link to SAE 2010-01-2325]
Multi-Controller Simulation

- Opens new doors for control engineers holy grail: multi-controller optimization
- Next challenge: improve execution time (i.e., multiple processors...)

![Diagram of Multi-Controller Simulation]

- Driver
- Environment
- Vehicle Controller
- Vehicle Propulsion Architecture
  - Engine: GT-Power
  - Transmission: AMESim
  - Veh.Dynamics: CarSim
Autonomie Supports **Component-in-the-Loop**

Evaluate a hardware component in a virtual vehicle environment

- Complete vehicle model MINUS the component hardware
- **Real Time Processor**
- **A/C Dynamometer**
- **Electric Machine & Its Controller**
- **Communication (sensors...)**

[Link to SAE 2012-01-1280]
Engine In-Loop block diagram

- **Autonomie Virtual Vehicle (dSPACE)**
- **Dyne Systems’ IL5 Dyno Controller**
- **Dynamometer**
- **Emissions sampling to Horiba MEXA 7100 bench with EGR measurement.**

**Components:**
- Speed, Torque feedback
- 2.2 L DI ECOTEC engine with dyno ready ECU with full calibration access.
- Vehicle grade engine coolant loop (Vectra)
- Low inertia AC dyno.
- Close coupled TWC (Opel Vectra)

**Details:**
- HBM T 10F contactless speed and torque sensor, MP60 signal processing module.
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Summary

- Establishes tool and framework for enterprise-wide collaboration
- Common framework for all MBSE activities
- Integration of legacy models, processes...
- Very large expertise in energy management
- Simulates single components, subsystems or entire vehicles
- Support processes from research to production (MIL, SIL, HIL, RCP, CIL)

Model, Software and Hardware -in-the-Loop (MIL, SIL, HIL)
Rapid Control Prototyping (RCP)
Controller-in-the-Loop (CIL)