Plug-and -Play Model Architecture and Development Environment for Powertrain/Propulsion System

Final CRADA Report

Energy Systems

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Energy Systems, Argonne National Laboratory

Participants: General Motors

February 01, 2013

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Final CRADA Report**

Date: _____

CRADA Number: C0601001

CRADA Title: Plug-and -Play Model Architecture and Development Environment for Powertrain/Propulsion System

CRADA Start/End Date: 07/12/2007 to 01/30/2013

Argonne Dollars: \$2,000,000.00

Participant Dollars: \$700,000

Argonne PI: Aymeric Rousseau

Participant(s):

<u>General Motors</u>	<u>\$700,000.00</u>
Name	Participant Dollars

Complete Address

_____	\$ _____
Name	Participant Dollars

Complete Address

_____	\$ _____
Name	Participant Dollars

Complete Address

DOE Program David Anderson
Manager:

Summary of Major Accomplishments:

Autonomie tool was developed (www.autonomie.net)

Autonomie has been designed to be used as a single tool throughout the different phases of Model Based Design (MBD) of the Vehicle Development Process (VDP). Model-Based Design is a math-based visual method for designing complex control systems and is being used successfully in many motion control, industrial, aerospace, and automotive applications. Autonomie's development has been focused on allowing users to customize the tool during each phase of the Model-Based Design, including component models, controls, and processes.

Summary of Major Accomplishments:

Several tools already exist to develop detailed plant model, including GT-Power, AMESim, CarSim, and SimScape. The objective of Autonomie is not to provide a language to develop detailed models; rather, Autonomie supports the assembly and use of models from design to simulation to analysis with complete plug-and-play capabilities. Autonomie provides a plug-and-play architecture to support this ideal use of modeling and simulation for math-based automotive control system design. Models in the standard format create building blocks, which are assembled at runtime into a simulation model of a vehicle, system, subsystem, or component to simulate. All parts of the graphical user interface (GUI) are designed to be flexible to support architectures, systems, components, and processes not yet envisioned. This allows the software to be molded to individual uses, so it can grow as requirements and technical knowledge expands. This flexibility also allows for implementation of legacy code, including models, controller code, processes, drive cycles, and post-processing equations. A library of useful and tested models and processes is included as part of the software package to support a full range of simulation and analysis tasks, immediately. Autonomie also includes a configuration and database management front end to facilitate the storage, versioning, and maintenance of all required files, such as the models themselves, the model's supporting files, test data, and reports.

During the duration of the CRADA, Argonne has worked closely with GM to implement and demonstrate each one of their requirements. A use case was developed by GM for every requirement and demonstrated by Argonne. Each of the new features were verified by GM experts through a series of Gate. Once all the requirements were validated they were presented to the directors as part of GM Gate process.

Summary of Technology Transfer Benefits to Industry:

Autonomie tool was licensed to more than 150 organizations worldwide. A commercial partnership with LMS was developed to support the commercialization. LMS is responsible for licensing, training and level 1 support while Argonne continues to develop new features and provide level 2 technical support. Autonomie is also been made available to companies, universities and research organizations at no cost to support US Government funded research.

Other Information/Results: (Papers, Inventions, Software, etc.)

- R. Vijayagopal, A. Rousseau, "System Analysis of Multiple Expert Tools" SAE 2011-01-0754, SAE World Congress, Detroit, April 2011
- Halbach, S., Sharer, P., Pagerit, P., Folkerts, C., Rousseau, A., "Model Architecture, Methods, and Interfaces for Efficient Math-Based Design and Simulation of Automotive Control Systems" SAE 2010-01-0241, SAE World Congress, Detroit, April 2010

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