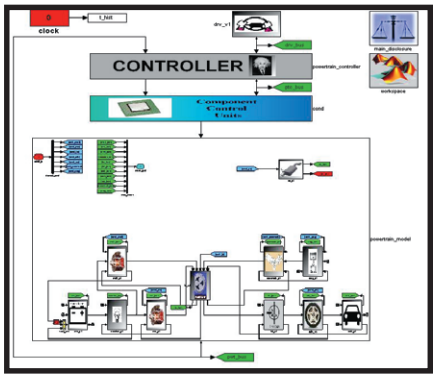
POWERTRAIN SYSTEMS ANALYSIS TOOLKIT (PSAT)

A Flexible, Reusable Model for Simulating Advanced Vehicles

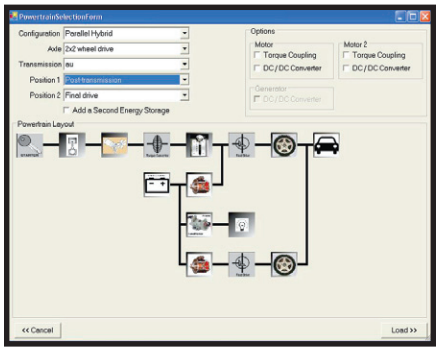
In a world of growing competitiveness, the role of simulation in vehicle development is increasingly critical. Because of the large number of possible advanced vehicle architectures, it is impossible to manually build every single powertrain configuration due to time and cost constraints. The Powertrain Systems Analysis Toolkit (PSAT) is a state-of-the-art flexible and reusable simulation package, developed by Argonne National Laboratory and sponsored by the U.S. Department of Energy (DOE). The software provides accurate performance and fuel economy simulations. It gives automotive and truck manufacturers and their suppliers the ability to efficiently assess advanced technologies and support their product decisions.

Designed to serve as a single tool applicable to multiple projects, PSAT allows engineers to reuse existing simulation work without investing a large amount of extra time or expense. PSAT is a graphical user interface (GUI)-driven application, which makes it very easy to use.



Developed with Matlab/Simulink, the software simulates more than 200 predefined configurations, including conventional, electric, hybrids, and fuel cells. Users can also choose two-wheel drive or four-wheel drive. Such a capability is only possible due to PSAT's ability to build all these drivetrain configurations according to the user's inputs, drawing from a large library of component models.

Using test data from Argonne's Advanced Powertrain Research Facility, conventional and mild-hybrid vehicles have been validated within 2% and full hybrid vehicles within 5% for both fuel economy and battery state-of-charge on several driving cycles.



HOW DOES IT WORK?

With PSAT, a driver model follows any standard or custom driving cycle, sending a power demand to the vehicle controller, which, in turn, sends a demand to the propulsion components (commonly referred to as "forward-facing" simulation). Component models react to the demand and feed back their status to the vehicle controller, and the process iterates on a sub-second basis to achieve the desired result (similar to the operation of a real vehicle controller).

Because of its forward architecture, PSAT component interactions are "real world." Consequently, control strategies can be implemented directly and tested on the bench or in a vehicle (using PSAT's extension for control prototyping, PSAT-PRO).

FEATURES

PSAT gives users the capability to:

- Study fuel economy
- Simulate performance and gradeability
- Size components
- Perform parametric studies
- Compare
  - Component technologies
  - Control strategies
  - Drivetrain configurations
- Integrate proprietary
  - Drive cycles
  - Data
  - Component models
  - Control strategies
- Define component and vehicle-level requirements
- Import test data
- Animate and compare test and simulation data

BENEFITS

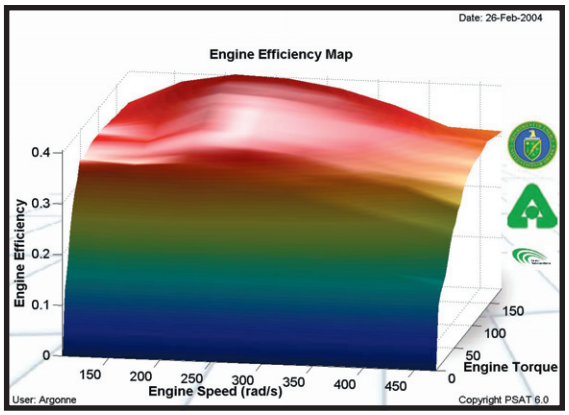
PSAT offers the following benefits:

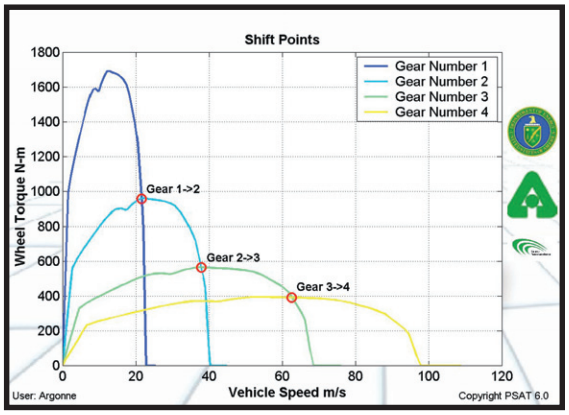
- Reusability
- User friendliness
- "Real world" interactions
- Large number of powertrain configurations
- Innovative post-processing tools

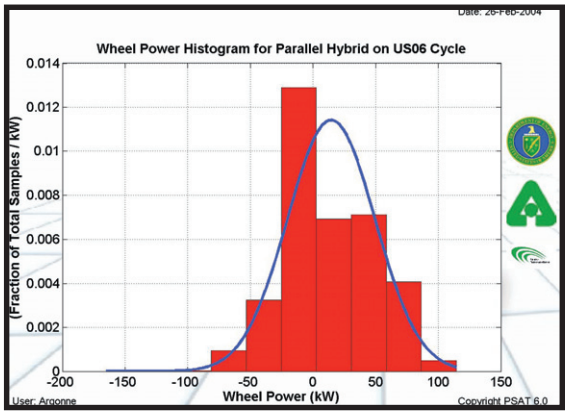
APPLICATIONS

Since PSAT is so flexible, Argonne and other users have applied it to a wide range of applications, such as validating models of advanced vehicles (e.g., the Toyota Prius, Honda Insight, and Ford P2000); simulating advanced vehicles for industry, the U.S. Army, and student competitions; evaluating the potential of fuel cell and hybrid technologies; conducting fuel cell sub-system and system requirements and energy storage requirements for fuel cell vehicle applications; well-to-wheel evaluation of advanced vehicles with the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model (http://greet.anl.gov); and teaching and research.

Overall, several hundred representatives from industry, academic, and government sectors have downloaded a demo version of PSAT from Argonne's transportation website. Licensed PSAT users to date include major automotive suppliers, energy companies, research institutions, and universities.







PSAT post-processing plots (top to bottom): Engine Efficiency Map, Shift Points, and Wheel Power Histogram for Parallel Hybrid on US06 Cycle

PSAT is also widely used by major companies and universities through DOE subcontracts.

These users include:

- Ford Motor Co.
- DaimlerChrysler Corp.
- General Motors Corp.
- VALEO
- University of Michigan, Ohio State University, Penn State University, University of California-Davis, University of Wisconsin-Madison

FOR MORE INFORMATION

To download a 30-day demo version, go to Argonne's transportation website (www.psat.anl.gov). If interested in licensing the version, contact Paul Betten, Argonne Office of Technology Transfer (630/252-4962, betten@anl.gov). For more technical information, contact Aymeric Rousseau (630/252-7261, arousseau@anl.gov).

"We have been working on the modeling, simulation, and testing of fuel cell and other alternative powertrains. PSAT, developed by Argonne National Laboratory, is one of the major simulation packages we have chosen to leverage our research. There is a rich collection of models, both at the component and vehicle levels, for advanced powertrains in PSAT. These will certainly accelerate our research. In addition, thanks to the flexibility and user-friendliness of PSAT, we plan to develop and implement some of our models for hybrid vehicles in PSAT. We believe we will benefit tremendously from PSAT."

David Wenzhong Gao, Assistant Research Professor
at the Center for Advanced Vehicular Systems (CAVS),
Mississippi State University

"Flexible, feed-forward vehicle system simulations such as PSAT require a transient engine simulation module capable of accepting a command from the driver or power controller and producing a realistic engine response in terms of torque and speed variation. Integrating the physically based Turbocharged Diesel Engine Simulation (TDES) module, developed by Assanis & Associates, Inc., in PSAT provides a critical link in the assessment of various control strategies and their impact on the fuel economy and emissions potential of the propulsion system, especially under transient conditions. This greatly expands the capabilities of both PSAT and TDES by providing a complete package for realistic engine-in-vehicle studies."

Dr. Dennis N. Assanis
President, Assanis & Associates, Inc.