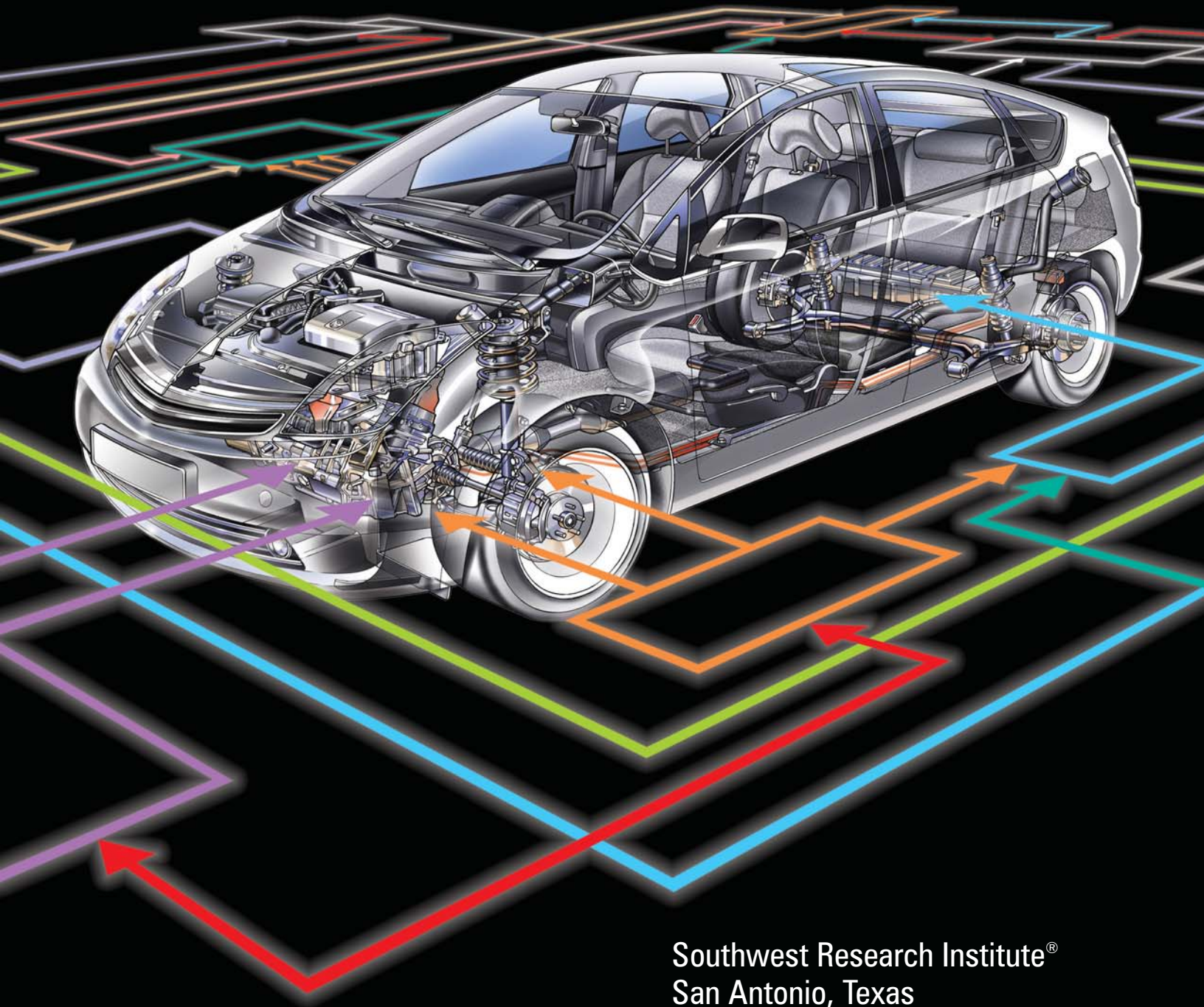


Vehicle Modeling, Simulation and Control Technology



Southwest Research Institute®
San Antonio, Texas

Southwest Research Institute®

Founded in 1947 as an independent, nonprofit research and development organization, Southwest Research Institute (SwRI®) provides a significant research, engineering, and testing resource for industry, business, and government. The Institute uses a multidisciplinary, integrated approach to solving complex problems in science and applied technology. Almost one-third of SwRI's 3,000 employees work on automotive projects that range from vehicle concept to production.

The Institute has earned 28 R&D 100 awards for developments recognized by *R&D Magazine* as among the 100 most significant technical accomplishments of their respective year.

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Today's vehicle engineering problems and product development cycles place an increasing emphasis on reduced cost and time to market. With more than half a century of experience in the automotive industry, Southwest Research Institute (SwRI) is strategically placed to offer extensive expertise in vehicle modeling, simulation, and controls. Institute automotive engineers focus on software and hardware approaches to vehicle research and development. Scope and activities include the following:

- Fuel economy, performance, and emissions simulation
- Systems analysis
- Control systems development
- Hardware-in-the-loop (HIL) evaluation of powertrain components
- Reliability assessments
- Hybrid electric and hydraulic vehicle development
- Prototype development
- Component design and testing
- Fuel cell integration and testing
- Vehicle integration, testing, and evaluation
- Engine accessory control development
- Automated manual transmission control development

SwRI's automotive staff emphasize the economic benefits of mathematically based and laboratory-based development, while helping clients minimize dependence on road-based testing. Simulations are performed primarily in the widely recognized MATLAB®/Simulink® programs, with exceptions for specific client needs.

For real-time applications, SwRI engineers have extensive experience with:

- Real-time operating systems using compiled Simulink models (QNX®, OPAL-RT, dSPACE)
- Digital signal processing to communicate with physical hardware device I/O signal streams

Modeling and Simulation Using Raptor® Powertrain Program

The Institute's R&D 100 award-winning software is used to model and simulate powertrains incorporating gasoline and diesel engines and employing manual,

The SwRI-developed RAPTOR® uses vehicle and component models in MATLAB®/Simulink® to simulate vehicles ranging from automobiles to heavy trucks. Simulation results help Institute engineers design better vehicle powertrain systems.

The RAPTOR software has proven to be useful in developing component and system controls in simulation and test cell environments.

SwRI engineers demonstrate real-time RAPTOR application to engine HIL testing.

automatic, and continuously variable transmission technology. This program was developed to offer the following services:

- Provide load histories for component design activities
- Determine heat rejection requirements of powertrain components
- Support reliability studies through its link to SwRI's probabilistic reliability assessment program NESSUS®

Control Systems Development

With an in-depth understanding of hardware and real-time control, SwRI engineers are experienced in:

- Development of realistic models for optimization of control algorithms
- Control schemes for specific vehicle components and powertrains
- Government and commercial applications
- Transmission shift quality evaluation and autocalibration

Hardware-in-the-Loop System Development

An emerging discipline is the melding of software engineering and controls with live hardware under test conditions. Institute development efforts include:

- Virtual vehicle transmission test stand, an award-winning, full hardware-in-the-loop research station for transmission evaluations
- Engine HIL test system to evaluate engine performance, efficiency, and emissions while supporting engine calibration processes

Selected SwRI Publications

- "Roadmap for Hybridization of Military Tactical Vehicle: How Can We Get There?" SAE Paper 2202-01-3048, 2002.
- "A New Approach to Improving Fuel Economy and Performance Prediction Through Coupled Thermal Systems Simulation," SAE Paper 2202-01-1208, 2002.
- "Modeling, Simulation, and Hardware-in-the-Loop Transmission Test System Software Development," SAE Paper 2203-01-0673, 2003.
- "Vehicle HIL—The Near-Term Solution for Optimizing Engine and Transmission Development," SAE Paper 2205-01-1050, 2005.



Southwest Research Institute is an independent, nonprofit, applied engineering and physical sciences research and development organization using multidisciplinary approaches to problem solving. The Institute's main facility, located in San Antonio, Texas, occupies more than 1,200 acres and provides nearly two million square feet of laboratories, test facilities, workshops, and offices for more than 3,000 employees who perform contract work for industry and government clients.

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The Engine, Emissions and Vehicle Research Division of Southwest Research Institute has achieved certification to ISO 9001:2000 and ISO 14001, internationally recognized quality standards.