



# Powertrain Control Technology

Southwest Research Institute®  
San Antonio, Texas

## Southwest Research Institute®

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**V**ehicles and power sources face increasingly stringent performance, emissions, and fuel economy standards driven by regulatory and market forces. With more than 50 years of experience in testing, developing, and improving automotive components, Southwest Research Institute (SwRI) helps solve problems in meeting these tough standards through the use of sophisticated, real-time electronic control systems.

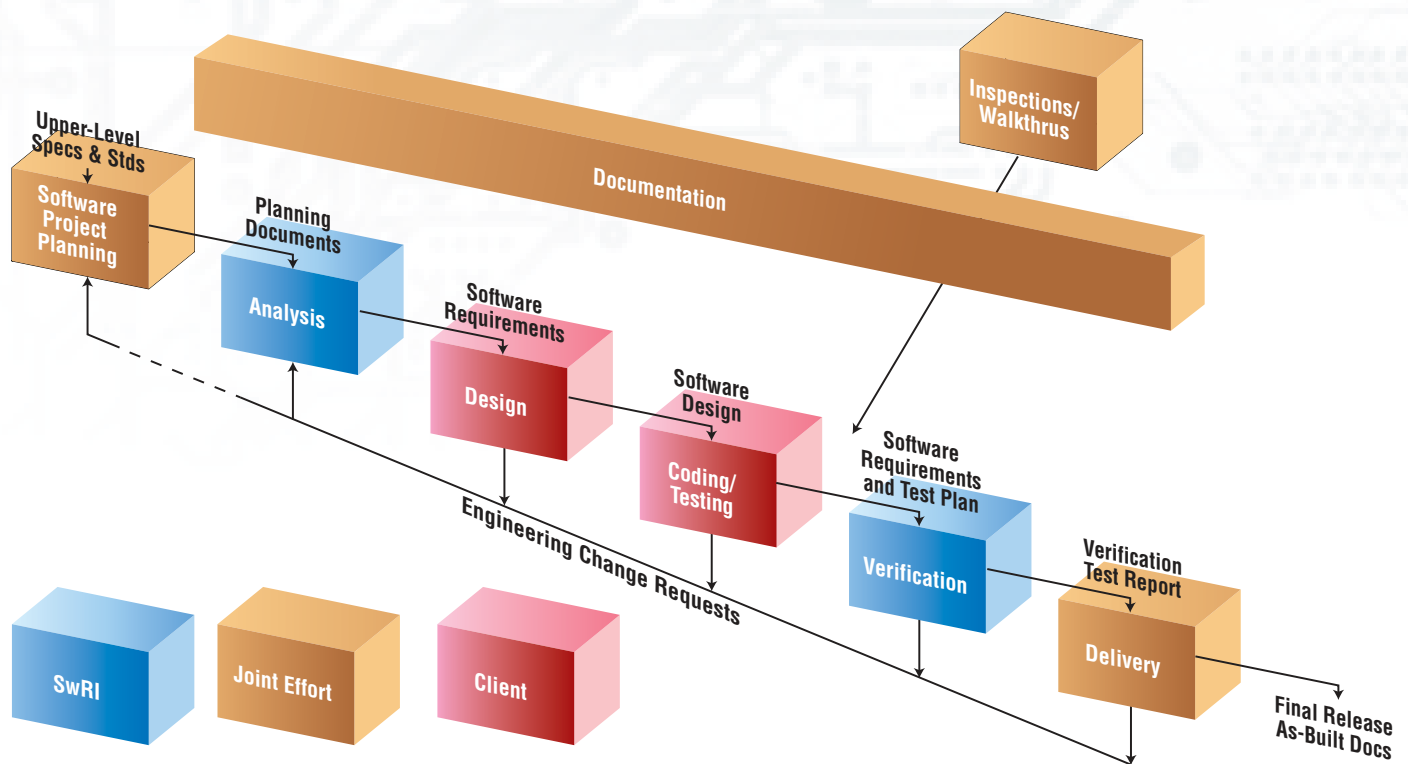
SwRI has worked with engines ranging from 5 to 6,000 horsepower and with vehicles from lawn mowers to locomotives. This extensive experience enables Institute engineers to offer a wide spectrum of services to automotive, engine, and equipment manufacturers. These services include:

- Systems engineering
- Control algorithm development and software implementation
- Powertrain control system development, integration, and calibration
- Hardware development
- Rapid prototyping control development

# Systems Engineering

SwRI's experience with advanced system development provides staff members with the expertise to develop and document production systems. Services include:

- Initial requirement analysis
- Creation of algorithms and specifications for hardware and software
- Hardware and software implementation
- Verification and validation in both laboratory and vehicle
- Hardware-in-the-loop simulation and electronic control unit rapid prototyping support as required for early prototypes

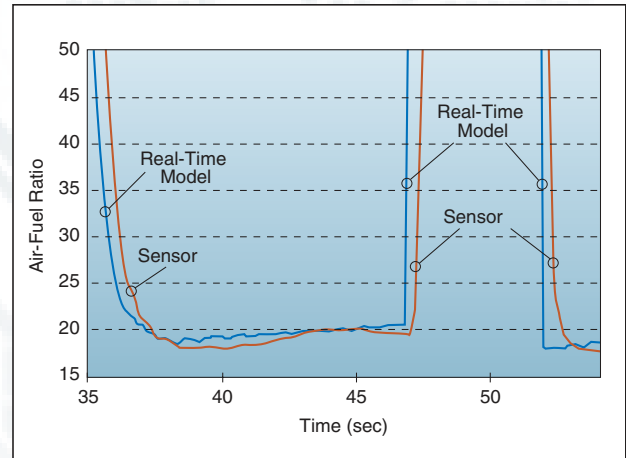


SwRI engineers offer systems engineering services to aid in designing and building embedded powertrain control systems. This software life cycle diagram illustrates how SwRI can provide partial or complete services for all development stages, depending on the client's needs.

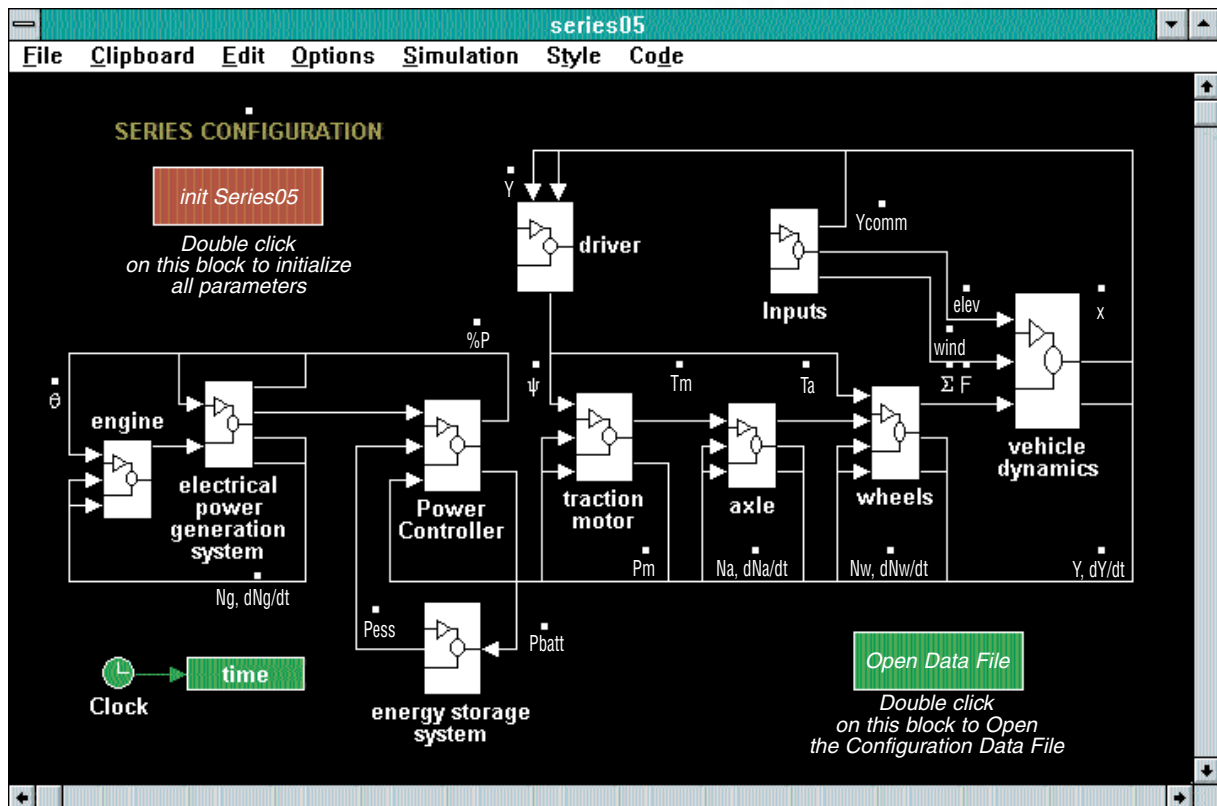
# Control Algorithm Development and Software Implementation

One key to effective control system implementation is the development of effective application-specific algorithms, based on detailed analysis and understanding of system dynamics. Using this comprehensive understanding to improve automotive technology, Institute engineers provide:

- Real-time, model-based control
- Diagnostic algorithms
- Adaptive learn algorithms
- Hardware-in-the-loop simulation
- Advanced signal processing
- Classic control algorithms
- Source code development, using C, other assembly languages, and graphical development tools



Modern powertrain controllers are increasingly dependent on model-based control techniques. With an in-depth understanding of final target systems and real-time controllers, Institute engineers develop realistic models that can be embedded in real-time, model-based control algorithms.



SWRI staff members develop and test simulations and associated control algorithms in a rapid prototyping environment to meet client requirements for faster and more intuitive development environments.

# Powertrain Control System Development, Integration, and Calibration

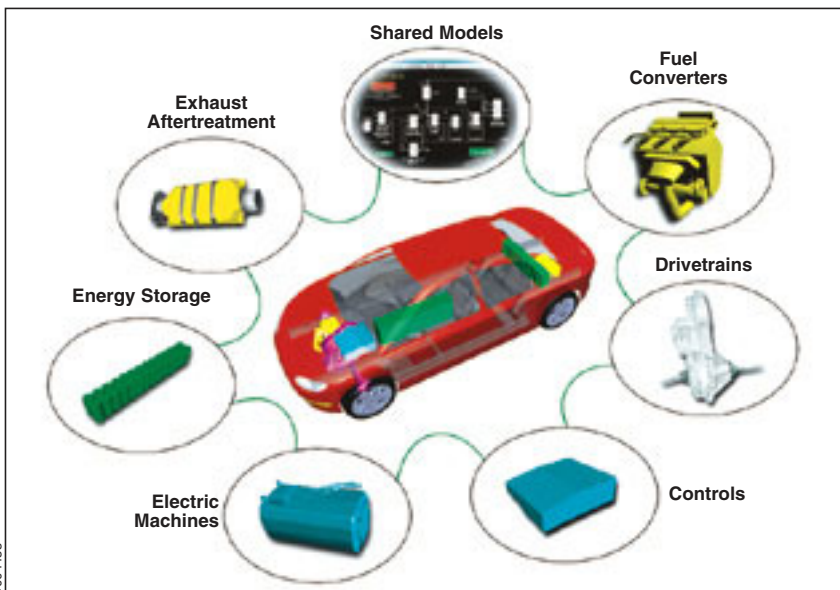


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Institute engineers develop and integrate systems on a wide variety of applications. SwRI's extensive testing facilities allow engineers to evaluate these systems under severe operating conditions, including extremely low temperatures.

Creating successful systems requires attention to individual subsystems, how the subsystems are assembled, and how they interact. SwRI puts all the pieces together, from early clean-sheet simulations through rapid prototyping, system integration, calibration and testing, including:

- Full powertrain component and system modeling and simulation capabilities for conventional and hybrid vehicles
- Rapid prototyping electronic control system (RPECS) capability
- Performance and emission development in test cell and vehicle
- Automated test cell data acquisition and mapping
- Integrated powertrain control
- Integrated hybrid vehicle control
  - Multiplexed communications
  - Component specification and sourcing
  - Wiring and prototype harness design and assembly
  - Full-emission certification capability for vehicle- and test cell-based light- and heavy-duty test cycles



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With a comprehensive understanding of a vehicle and its subsystems, SwRI automotive and electronic specialists evaluate tradeoffs between subsystem performance and system requirements to provide full-system development and integration services.

# Hardware Development

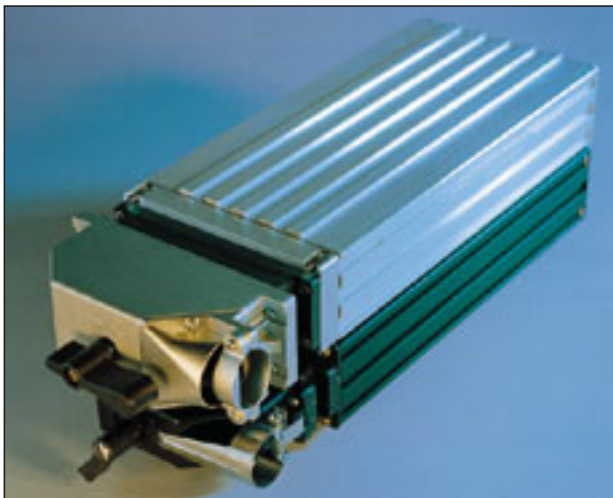
Experimental hardware systems are necessary to develop and test control systems, especially in a research and development environment in which off-the-shelf solutions are seldom sufficient. SwRI's engineers have broad experience in finding or developing hardware solutions, including:

- Embedded electronic control unit design and prototype build using 8-, 16-, and 32-bit central processing units
- Rapid prototyping and data acquisition systems
- Custom signal conditioning and drive electronics
- Custom microprocessor-controlled systems for high-pressure compression-ignition, direct-injection systems with pilot injection and rate-shaping capabilities, proportional gaseous fuel metering, knock/misfire detection, engine monitoring and protection, and environmental testing



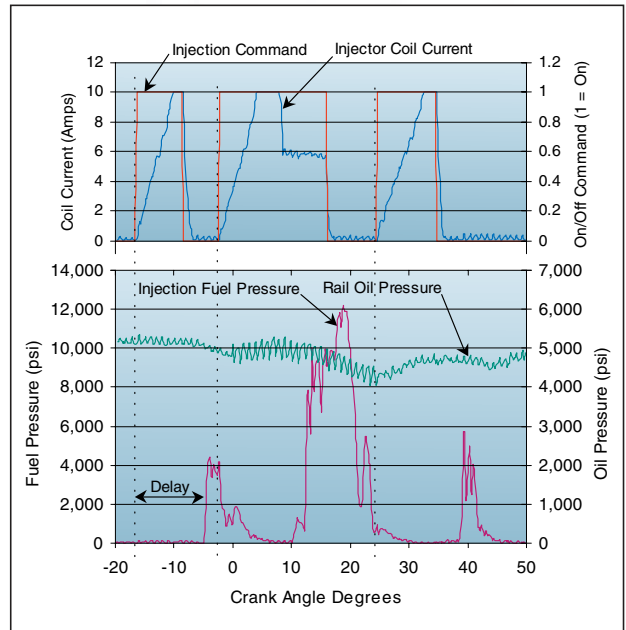
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Experienced engineers develop experimental equipment to provide proof-of-concept for innovative systems. SwRI designed and built this smart, low-pressure, natural gas metering valve to meet the fuel control needs of large, stationary, alternate-fueled engines.



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To provide in-vehicle control systems solutions, SwRI engineers design a variety of control units and components, including circuit board designs and compact, rugged enclosures for harsh environments.



SwRI develops customized hardware and software for advanced research and development requirements. This plot shows high voltages and currents, precise timing accuracy, and multiple injection events for an advanced diesel injection system.

# Rapid Prototyping Control Development

The Institute has developed a powerful, cost-effective, personal computer-based software tool for use in prototyping real-time electronic control systems. RPECS (Rapid Prototyping Electronic Control System) supports high-level algorithm development; provides convenient user-friendly calibration and

data acquisition; and permits remote networking for test cells and vehicle-based operation. The RPECS tool enables Institute engineers to offer a broad spectrum of services, such as:

- Developing experimental and production-intent control strategies for a wide range of equipment and vehicles. The system has been used with spark-ignition (SI) and compression-ignition (CI) light-, medium-, and heavy-duty powertrains, lean-burn natural gas SI engines, stationary engines and gensets, and locomotives.
- Benchmarking existing original equipment manufacturer powertrains
- Providing automated test cell data acquisition and mapping
- Developing experimental fuel systems.
- Performing hardware-in-the-loop simulation



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*Systems developed in the test cell are often refined in a vehicle. Engineers use compact RPECS versions to evaluate production-intent vehicles in post-test cell development.*



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*The SwRI-developed RPECS, used extensively in test cell developmental applications, is easy to modify and troubleshoot.*

Using RPECS, Institute engineers have developed and tested a variety of advanced systems, including:

- Integrated exhaust gas recirculation and boost control with variable nozzle and variable geometry turbochargers for heavy-duty CI engines
- Electronically controlled intake and exhaust valve systems
- Hybrid vehicle supervisory and subsystem control
- Real-time water injection for diesel engines



*Southwest Research Institute is an independent, nonprofit, applied engineering and physical sciences research and development organization with nine technical divisions using multi-disciplinary approaches to problem solving. The Institute occupies 1,200 acres and provides nearly two million square feet of laboratories, test facilities, workshops, and offices for more than 2,700 employees who perform contract work for industry and government clients.*

We welcome your inquiries.  
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