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Quality Through a Prism

An SwRI-developed data acquisition system improves automotive fluid and component evaluations

By Robert P. Gauss Jr. and John W. White

Evaluating automotive fuels and lubricants once required fleets of vehicles operating over highways or tracks, with only limited uniformity and quality control. Such evaluation methods remain in wide use and the results are reliable; however, they also are comparatively more expensive and can take years to complete. Over time, scientists and engineers increasingly have brought these field trials into the laboratory with engine dynamometers that can generate data quickly and economically while still correlating well with fleet evaluations.

At Southwest Research Institute (SwRI), which has conducted fluids evaluations for the transportation industry for more than 55 years, engineers determined that available, off-the-shelf computerized data acquisition and control systems could not provide the desired levels of flexibility and technical sophistication. They decided that the Institute's high-volume, highly diversified evaluation program required special features not available in commercial systems.

In response to these demands, SwRI engineers developed Prism®, a hardware and software system for data acquisition and control, to provide engine and dynamometer cell management that emphasizes accuracy, flexibility, ease of setup and scalability. To date, more than 70 Prism systems have been installed in the Institute's automotive laboratories.

How Prism works

Prism streamlines engine, lubricant and emissions evaluations using hardware and software that can be customized to run standard and client-specified procedures.

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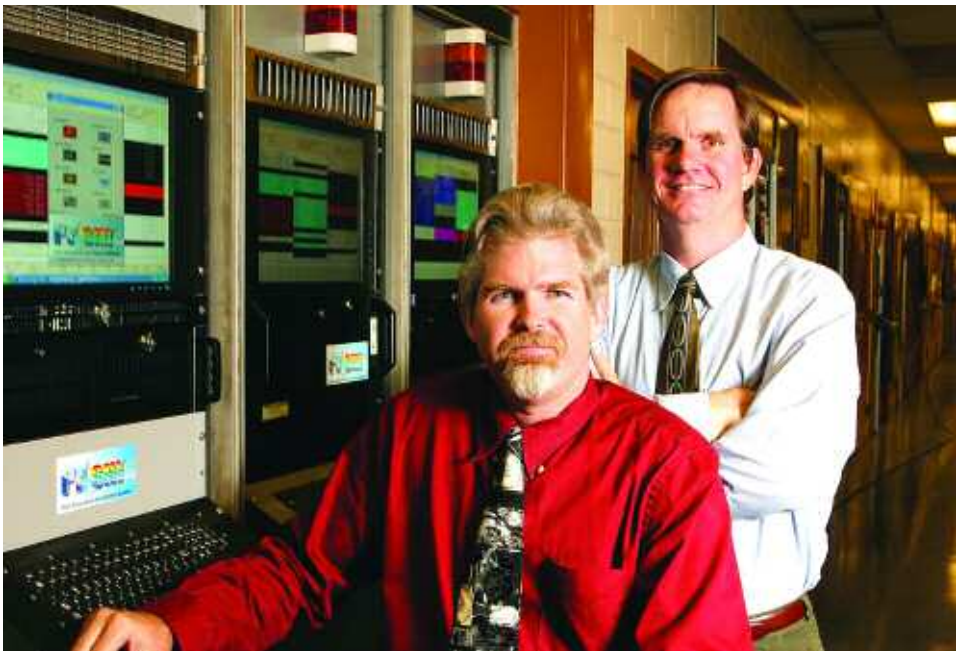

Robert P. Gauss Jr., left, is a staff engineer in the Fuels and Lubricants Research Division. His responsibilities involve engineering design, including system design, construction, programming, installation and maintenance of microprocessor-based data acquisition and control systems. John W. White is manager of the Computer and Instrumentation Section within the Fuels and Lubricants Research Division. His section is responsible for developing and supporting computerized systems that control engine test cells, acquire data and generate reports that are electronically transmitted to sponsors.

By combining off-the-shelf components with SwRI-developed equipment and software, Prism efficiently and cost-effectively performs engine, fuel and lubricant evaluation.

Prism provides the equipment to measure and condition various input parameters including temperatures, pressures, forces, speeds and flow rates. It also contains output devices such as pressure outputs, voltage outputs for heating elements and dynamometer controls, frequency outputs and digital outputs in the form of AC or DC relays. The system features automatic test sequencing, closed-loop control, database logging of data and real-time display of data. The hardware package consists of three independent industrial PC systems running Intel® Pentium® 4 processors. One PC system, the Operator Interface (OI), uses Microsoft® Windows® XP for its operating system and is used to run the Prism software suite and other Windows 32-bit applications, and also to provide networking capability.

The second PC system, the Machine Interface (MI), uses the QNX® Software Systems Neutrino® real-time operating system, along with PCI-based expansion cards, to allow hard, real-time sequencing, data logging and analog, digital and frequency input and output control. A third PC system uses the RedHat® LINUX operating system and Oracle® Database relational database software to store test sequence and stand definition information as well as logged data.

Prism, which combines hardware and software to improve control and data acquisition, has been installed in more than 70 SwRI engine dynamometer stands.

The OI and MI systems communicate via a dedicated 1-GHz LAN Ethernet connection. Message packets are sent between the OI and MI to allow for sequence definition, data display and logging. A second LAN port on the OI system communicates to the third and other PC systems through a shared network connection.

The PCI expansion cards in the MI consist of up to two 64-channel, 16-bit analog input cards, up to two 16-channel, 16-bit analog output cards, up to two 8-channel, 64-bit frequency I/O cards and one 96-channel, digital I/O card. Each analog input card also provides 32 digital I/O channels as well. Optional accessories include an analog output manual control station, uninterruptible power supply and computer climate control units.

Seven software modules within the Prism data acquisition system allow an engineer to compose, display, tune, calibrate, schedule, plot and review logged data for an evaluation sequence. No programming language knowledge is required. The software provides a consistent and intuitive user interface and attempts to minimize the number of items that must be remembered. Evaluation procedures can be developed in the laboratory, or on any office computer with a Microsoft Windows XP operating system.

Prism's application programs are based on the various operations involved in designing and carrying out evaluation operations. For example, PrismDT is used to create tests using menus and tables to define inputs, outputs and sequence. PrismRTD provides operator display and control. PrismTune performs output control and tuning. Input calibration is performed using PrismCal, and PrismPlotter is used

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Performing fluid and component evaluations involves fitting a laboratory engine with numerous sensors that relay critical operating data to the Prism system. Prism processes the data and displays the resulting information at a remote console.

for real-time plotting of operational data. Spectrum® is used for processing logged data while a procedure is in progress, or from previously run procedures, and initialization and scheduling are performed with PrismSched.

Applications of Prism

Because it is a flexible and scalable system, Prism has been put to use in a wide variety of data acquisition, dynamometer cell control and data processing tasks involved in automotive-related evaluations. To date, Prism has been used for more than 20 different ASTM lubricant evaluation procedures, as well as in other procedures involving chassis dynamometers, cold-box vehicle analyses, engine performance, engine exhaust emission sampling automation and automated engine oil sampling and leveling.

The topology used in Prism mimics the logic used in the U.S. Postal System's city-street-lot concept, creating an addressing scheme that is organized around a lab-cell-stand concept. A "lab" is a logical grouping of cells that normally corresponds to one physical building. It can have an unlimited number of cells. Within each cell there can be multiple stands controlling the engine as well as support systems such as air-fuel ratio sampling, oil leveling and safety checks.

Automotive system endurance evaluations frequently require 24-hour, seven-day-a-week operation with little tolerance for unscheduled downtime. Prism allows project personnel unprecedented access, whether from the lab, from the office or from a PC-compatible computer over the Internet. Remote access allows an engineer the same capabilities as if he or she were physically at the stand. A camera mounted inside each cell allows remote visual inspection. This increased level of access allows quicker response from lab staff and keeps project personnel closer to their evaluation systems. Prism allows remotely operated sequencing changes and initiation of evaluation procedures. Thus, Prism-equipped stands may be set up in such a way that an attendant need not be physically present at the stand, or even in the lab, while a procedure is in progress.

Since multiple point-source data, including remote data, are supported through Prism, they can be shared among Prism systems. For example, a single, central barometer may be shared across all units in a lab. This central access allows synchronization among virtual stands on a single control unit.

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Prism's graphical user interface displays important facts about an evaluation procedure at the top, with real-time operating parameters recorded and displayed below.

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Operators can use Prism's graphical user interface to initiate and monitor evaluation procedures from a computer in the laboratory or at a remote location.

The Prism system has resulted in unprecedented evaluation procedure management features, such as:

•Flexibility of program design. There are more than 300 test types within SwRI's automotive evaluation system. Designing, maintaining and updating 300 dedicated programs to support them would not be feasible.

•On-the-fly changes. Since even the best plans on paper sometimes do not work as intended, engineers need the flexibility to change a test definition while an evaluation is under way. This change requires the ability to edit the definition, load it into the test stand and continue without the need to stop and restart.

•Remote progress monitoring. Engineers need a display program that is not directly connected to the control program, but instead connects across a network so that evaluations can be monitored, tuned and controlled remotely from the engineer's office, or from home or even from another city.

•High-speed logging. Monitoring of some events, such as clutch engagement, requires database logging at rates up to 1,000 records per second. This logging must occur even as control and monitoring are taking place.

•On-test data monitoring. Frequently an evaluation procedure may provide enough information that, even though it is still under way, the engineer concludes it is unnecessary to carry it through to completion. For this reason, data must be constantly downloaded as it is generated, so that the same analysis tools used to generate final reports can also be used on this interim data.

•Multiple stands. To be cost-effective, multiple programs should be allowed to run independently on a single system to best utilize the available data acquisition and control hardware. This capability requires specialized software.

•Data sharing among computers. It is typical to have input monitoring requirements that are common to many test stands, such as ambient conditions and ancillary equipment condition. Therefore, computers must share these individual test points among themselves.

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The Prism data acquisition system combines off-the-shelf and SwRI-developed hardware and software that can be customized to client-specified standards.

Conclusion

In searching for an improved data acquisition and control system, SwRI engineers determined that their needs would be best met by developing an indigenous hardware-software system that provides for the special demands of the Institute's high-volume, highly diversified automotive evaluation program. Prism improved the rate and accuracy of data acquisition while providing new levels of control over test definition and report generation as well as improved remote-monitoring and remote-operation capabilities. The system is being offered selectively to industry and government.❖

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