# Hybrid Modeling Improves Health and Performance Monitoring

## Originating Technology/NASA Contribution

Scientists and engineers have long used computers to model physical systems. Physical modeling is a major part of design and development processes, as well as failure analysis. At NASA, scientists and engineers rely heavily on physical modeling to evaluate the overall health and performance of all mission-related flight vehicles.

Hidden in the architecture of flight vehicles are computers to control and monitor their health and performance. Early versions of these computers lacked the ability to evaluate all of the operating and environmental conditions, which is important to fully understand the response of the equipment. Furthermore, traditional physical modeling methods necessitated significant computing power, making the process fairly complicated.

NASA scientists and engineers needed a simplified, but more complete, understanding of the health and performance of flight vehicles during their operation in near-real time. The comparison would allow the users to understand if the equipment was performing as expected.

## Partnership

Scientific Monitoring Inc. specializes in condition monitoring and equipment health software and services for a wide range of equipment applications. NASA's Dryden Flight Research Center awarded the Scottsdale, Arizona-based company a Phase I **Small Business Innovation Research (SBIR)** contract to create a new, simplified health-monitoring approach for some of the Agency's flight vehicles and flight equipment. The main objective of the SBIR project was to create a simple software-based model that used the principles of physics, but did not require large amounts of data or computing resources to make accurate assessments in a timely fashion.

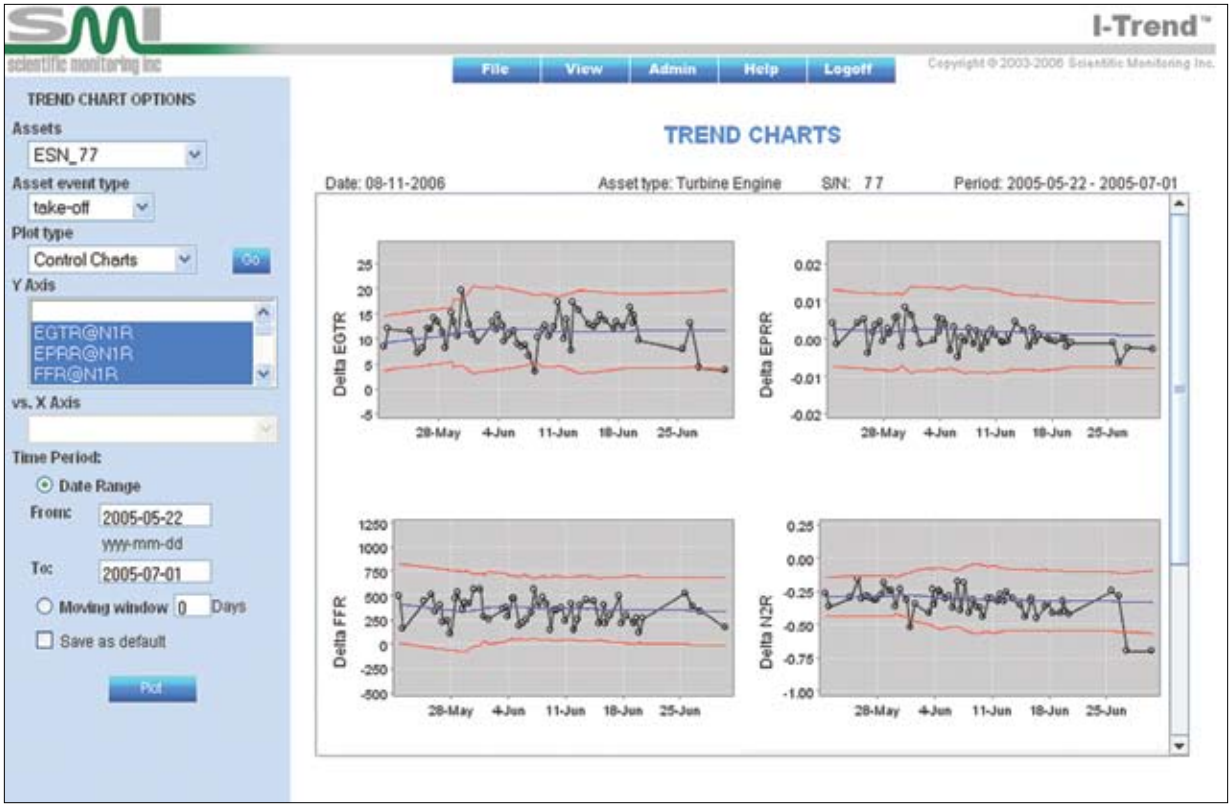
During the project, Scientific Monitoring developed a hybrid physical model concept that provided a structured approach to simplifying complex design models for use in health monitoring. The modeling approach used a simplified analytical model and a classical data analysis technique to assess the performance of a piece of equipment and determine if it was within an expected range for the environmental and operating conditions. It allowed the output or performance of the equipment to be compared to what the design models predicted, so that deterioration or impending failure could be detected before there would be an impact on the equipment's operational capability.

The hybrid physical model was successful, as it made health and performance analyses of complicated equipment possible in near-real or real time for rapid diagnosis. Scientific Monitoring quickly realized its resulting software had broad application for many industries beyond the aerospace sector. Medical health monitoring, security, and financial transactions, for example, are other areas of application the company thought might be fitting for its new development, since each contains an underlying physical basis or characterized relationship which can be used to ensure that the behavior or performance is within expectations for the operational conditions.

## Product Outcome

Marking the successful completion of the NASA-funded research project—and subsequent maturation of the model from U.S. Air Force funding—Scientific Monitoring released a commercial health- and performance-monitoring software product, based on the original modeling technology it developed for NASA. The company calls the software I-Trend for its intelligent trending, diagnostic, and prognostic capabilities.

I-Trend comes with a configurable interface, and easy-to-use back-end analysis tools to simplify Six Sigma analysis of equipment health and performance. Control charts, regression fit charts, usage charts, and many other tools provide information in an easily recognizable format.




I-Trend is a Web-based condition-monitoring application specifically developed for analysis, trending, and alert functions on a wide range of equipment types.

I-Trend uses the hybrid physical model to better characterize the nature of health or performance alarms that result in "no fault found" false alarms. Additionally, the use of physical principles helps I-Trend identify problems sooner. According to Scientific Monitoring, I-Trend represents the state of the art in condition-monitoring software. It is part of the company's complete ICEMS (Intelligent Condition-based Equipment Management System) suite of software targeted for customers who have important equipment and require accurate monitoring and advanced alerting. I-Trend's advanced alerting module provides forecast capabilities that allow maintenance for many types of problems to be scheduled and planned in a proactive way, eliminating reactive behavior that occurs when alarm bells sound.

I-Trend comes with a configurable interface and easy-to-use analysis tools to simplify Six Sigma analysis of equipment health and performance. (Six Sigma is a highly structured process-improvement methodology that utilizes data and statistical analysis to gauge and enhance a company's operational performance, practices, and systems. It identifies, prevents, and eliminates defects in manufacturing and in service-related processes.) I-Trend can be used as a Web application, or specific interfaces can be tailored to allow it to operate with existing applications. It is built in a Java J2EE framework with XML (eXtensible Markup Language) interfaces to allow platform portability. Control charts, regression fit charts, usage charts, and many other charts and tools provide information in an easily understood graphical format.

I-Trend technology is currently in use in several commercial aviation programs, and the U.S. Air Force recently tapped Scientific Monitoring to develop next-generation engine health-management software for monitoring its fleet of jet engines. As for the medical, security, and financial applications that Scientific Monitoring envisioned upon completing the NASA-funded project, they just might come to fruition one day.

"The benefits of the hybrid modeling technology used in I-Trend for equipment monitoring are clear," said Dr. Link Jaw, president and chief executive officer of Scientific Monitoring. "It's the potential use in non-equipment applications which we find intriguing. It could easily evolve to allow people to monitor their own health and physical performance."

After development of the I-Trend software, the company continued the original NASA work, this time under a Phase III SBIR contract with a joint NASA-Pratt & Whitney aviation security program on propulsion-controlled aircraft under missile-damaged aircraft conditions. ❖