The
ITEA Journal
of Test and Evaluation

September/October 2004
Volume 25, Number 3

"INSTRUMENTATION FOR TEST & EVALUATION"

FEATURED FACILITY

**Electronics Test Site (ETS),
Lockheed Martin Missiles and Fire Control,
Orlando, Florida**

TECHNICAL PAPER ABSTRACTS:

Validation of F/A-22 Propulsion System T&E Instrumentation Using Modeling and Simulation

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With the long-term goal of developing joint ground/flight modeling and simulation capabilities, Arnold Engineering Development Center and the Air Force Flight Test Center have teamed to apply these data analysis tools to two major propulsion flight test programs, the F/A-22 and the F-35. The emphasis of this paper is on the development and application of a nonlinear, aerothermodynamic,component-level model that serves as the basis for the model-based analysis and fault identification process. Model-to-data comparisons and model-based fault detection and analysis results for F/A-22/F119 propulsion ground and flight tests are also presented for a variety of flight conditions.

A New Technique of Wind Estimation in Airdrop Testing

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A new technique for wind estimation using a global positioning system-tracked payload under a calibrated tri-lobe canopy has been developed. Validation studies confirm the accuracy of the system to provide estimates of wind velocity to within 0.3 feet per second (ft./s.) The method has been applied for estimation of the vertical wind component, as well as the horizontal components. The parachute system, called the WindPack, is commonly deployed along with the system under test to collect real-time wind statistics used in post-processing data analysis for test parachutes.

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The Defense Acquisition University Partners With ITEA to Advance Cooperation in T&E

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On July 7, 2004, Dr. Jim McMichael, vice president of the Defense Acquisition University (DAU), and Gary L. Bridgewater, president of the International Test and Evaluation Association (ITEA), signed a Memorandum of Understanding (MOU) to share a mutual commitment to excellence in the training and education of the test and evaluation (T&E) professional community.

Miniature Probes for Hypersonic Propulsion Environments

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Arnold Engineering Development Center (AEDC) has a long history of developing probes for use at its testing facilities. Throughout the past decade, AEDC has used a standard rake body with interchangeable probes. This design used no exotic materials, and the probes were internally cooled by high-pressure water. Advances in engine technology and the need for new measurements now have led designers to change many aspects of past probe designs. Current probe developments for the stream thrust probe, Mach flow angularity probe and total temperature probe are discussed in this paper. Future probe designs and fabrication, including fiber optic imaging probes, are described in detail. Miniaturization and embedded instrumentation, as well as advanced materials and manufacturing processes, are discussed as they apply to future probe designs.

Epoch-by-Epoch™ Real-Time GPS Positioning in High Dynamics and at Extended Ranges

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Civilian and military applications increasingly require precise positioning. Geodetics Inc., La Jolla, California, has demonstrated centimeter-level position solutions using its Epoch-by-Epoch™ (EBE) technology. EBE technology provides computational algorithms for instantaneous differential GPS processing of raw GPS measurement data (pseudorange and carrier phase) from one or more base stations and one or more rovers. EBE has been shown to have significant advantages over conventional GPS real-time kinematic (RTK) algorithms in several ways, including: (1) no initialization or re-initialization delays; (2) extended ranges over which dual-frequency GPS receivers can provide precise positioning; and (3) graceful degradation when a full set of measurement data is not available. This paper provides empirical data that were gathered during a test program, sponsored by the Office of the Secretary of Defense, to assess the performance in real time of EBE technology on realistic advanced range data system (ARDS) maneuvers.

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IEEE 1451 Smart Transducer Standards: Overview, Core TEDS and Common Standard Set

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Smart transducers are a technology that will enable advances in data acquisition by providing direct communication with sensors and actuators. This will allow self-identification and retrieval of information such as calibration data, status and overall functionality. Such direct communication will also enable configuration and control of sampling schemes, low-level data fusion and self tests. The Institute of Electrical and Electronics Engineers (IEEE) 1451 Smart Transducer family of standards is a nonproprietary set of standards that is aiding the transformation of the transducer industry. There are now seven parts of this family either approved, in work or in review. This paper provides an overview of the different family members and provides detail about the IEEE P1451.0, which is providing a common interface to the other family members.

Technology-Enabled T&E Process Transformation

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Embedded instrumentation (EI) is more than just miniaturized sensors and high-capacity data storage devices integrally designed into warfighting systems. Rather, it is an unparalleled source of technical and performance information that could have a profound impact on the entire acquisition process, as well as on the operational employment of the systems involved. Collecting data from every unit ever made, in every operational environment ever encountered, over the full lifetime of the warfighting system, has the power to transform the test and evaluation process. This paper examines the EI Focus Area of the Office of the Secretary of Defense Test and Evaluation/Science and Technology Program with a visionary eye toward the future uses and benefits of EI.

The Von Braun Center in Huntsville, Alabama,was the setting for the highly successful 2004 ITEA Annual International Symposium that was conducted in conjunction with the Army's T&E Days from August 30 to September 2. The final returns are not fully tabulated, but all indications point to another record in terms of number of attendees, number of exhibitors, and revenue generated—all in all, a magnificent event. While there are many individuals to thank for this outstanding performance, it was truly a team effort. Dr. John B. Foulkes, director of the Army's Test and Evaluation Management Agency (TEMA) and a former ITEA president, established the foundation for success by agreeing to combine Army T&E Days with ITEA's Annual International Symposium into a fully coordinated Test Week.

Two ITEA chapters, the Rocket City Chapter in Huntsville, along with the Volunteer Chapter at the Arnold Engineering Development Center (AEDC), Arnold Air Force Base, Tennessee, provided the horsepower to ensure logistic support was in place and the technical programs were ready. In the meantime, the ITEA National Headquarters staff collaborated with the local team to ensure registrations went smoothly, exhibits were in place and awards were ready to be presented.

The second evening of the ITEA portion of Test Week marked the annual recognition for the Association's award recipients—an event conducted in the best of style by John T. "Tom" Best, the Awards Committee chairman—and highly anticipated by all attendees. In addition to the presentation of awards, the event heralded the announcement of the new members and officers of the ITEA Board of Directors, as well as recognition of those finishing their volunteer terms of service. Dr. John Foulkes, chairman of the ITEA Elections Committee, was pleased to recognize the election of Thomas J. Macdonald, Russell "Rusty" Roberts, Scott P. Foisy and Lawrence Camacho to the Board, and the appointment of Amy J. Markowich, Judith Wetting, John Smith and George J. Rumford to the Board for one-year terms. Richard "Dick" F. Bell, Tom Best and Dr. Patricia A. Sanders were lauded for their years of service and contributions to the Association as ITEA's three outgoing Board members.

Gary L. Bridgewater

The new officers of the Board were also announced at the symposium. Vice President for the new term is Tom Macdonald; Secretary is John Smith; and Treasurer is Dr. John A. Wiles.

As ITEA's out-going National President, it was my privilege to transfer the gavel of the office of the President symbolically to our new President, Robert T. Fuller. Bob has served dutifully as ITEA's Vice President for the past two years and will be a great leader to the Board and to the Association in general.

As your President, I was given the opportunity to present the "State of the Association" report to the assembled members. I would like to share highlights of those remarks so that you, too, can appreciate the hard work that the members of the Association have been doing, and as a testimony to the many volunteers that keep our Association alive and well. ITEA cannot prosper without its chapter leaders, committees, officers and the many dedicated members at the grass-roots level that sustain ITEA as the premiere professional organization for the T&E community.

- ***Membership:*** Our individual membership remains healthy, hovering around the 2,000 mark. Our corporate membership has continued to prosper at 90 members, which has been a challenge, considering the large number of acquisitions and mergers that have reduced the number of T&E-related companies.
- ***Workshops:*** Nine workshops are planned for this year, with an average of approximately 200 attendees per event. This year also marked the re-emergence of ITEA's participation in the Royal Aeronautical Society's Aerospace Forum in London, England; a new Technology Review workshop that has the

potential for major growth; our continued joint workshop with the Directed Energy Professional Society (DEPS); and, of course, our collaboration with Army T&E Days for our 2004 Annual International Symposium.

n ***Short Courses and Tutorials:*** Five short courses are scheduled, with a new course on "Introduction to Information Assurance," which proved to be very popular. To date, 11 tutorials have been conducted in conjunction with four workshops for a total attendance of more than 200 attendees.

n ***Initiatives:*** The four President's Initiatives are mature to the point that they are now included within the ITEA committee structure, and we have signed a Memorandum of Understanding with the Defense Acquisition University *(see page 67)* to collaborate on areas of professional interest to our shared T&E community. A similar memorandum has been signed with the American Institute of Aeronautics and Astronautics.

n ***Scholarships:*** Scholarship support is one of our most important products, and the Association continues to provide financial support at the chapter level to deserving students in the chapters' local communities, and with the support of matching funds at the National level.

I am proud to have served as your President for the past two years, and I am indeed humbled by the experience of serving our members. I would like to thank everyone for their outstanding support at every level of the Association, and I look forward to my continued presence on the Board and to providing active support to our new President.

Sustaining Innovation From the Commercial Supplier Base

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The test and evaluation (T&E) instrumentation community stands at a crossroad. Rapid technology changes, commercial off-the-shelf (COTS) solutions, declining budgets and a shrinking supplier base are among the many areas that are radically altering the T&E landscape. Defense spending makes up only a small share of the $5.5 to $6 trillion economy, so great care must be taken in the policy decisions that guide investment profiles and stimulate the innovation required in this changing environment. The choices we make today—the policies we embrace, and the skill with which we transition to this new era—will all play a large role in shaping the T&E instrumentation community, both Department of Defense (DoD) and commercial, for years to come.

Burt Smith

Economists estimate that technical progress is the single largest contributor to economic growth, accounting for as much as half of the U.S. gross national product (GNP) over the last 50 years. We know technology improves the productivity of labor, but economists have found a greater influence on the productivity of capital, that is, new technology makes a given quantity of capital go farther. In our world, this capital is really the measure of testing productivity, where better integration of commercial tools and products extends the reach of T&E dollars. It is important to note that technology and the capacity for innovation are not just T&E or DoD issues, but are core economic issues for the United States. One of the strongest paths for maintaining technical progress and "stretched capital" is to continue to foster innovation from the commercial supplier base.

Simply put, innovation is essentially a new way of doing things, implying constant and creative change. In the commercial supplier base, the regular and timely movement of products from research and development to production is tantamount to long-term financial success. As DoD continues to innovate in key areas of leading-edge research, such as low-observables and directed energy, the pace at which that innovation is actually moved into production programs often lags well behind that of commercial industry. These longer-term science and technology and research programs tend to create specific windows of opportunity for specialized instrumentation suppliers.

In the face of cyclic market opportunities, it is difficult for the supplier base to maintain a steady stream of research investment that sustains the innovation the T&E community requires. This problem is multiplied by program sourcing decisions that develop unique in-house solutions, rather than adapting commercially available products, thus further reducing the available market in which commercial suppliers can recoup their investments. In important commercial industry sectors such as computers and microelectronics, development cycle times can run as long as six to 12 months, as opposed to the years—if not decades—that major DoD programs and systems take to transition to production. This should be carefully noted, because in many ways, these sectors have the closest parallel to the types of technologies and products that come out of the core instrumentation supplier base. Leading-edge research without the promise of production falls somewhere between "interesting" and "maybe" for commercial suppliers as they make investment decisions that fund innovative research.

The development of new products and methods often occurs through the fusion of many technological disciplines. No single firm, or even a single industry, is likely to possess all of the knowledge and technology needed to sustain the innovation required for T&E of next-generation platforms and systems. We must leverage and share. Today's business units drive research and development (R&D) away from long-term, exploratory research toward shorter-term development and process improvement—to reduce costs, improve quality and strengthen their near-term competitive position. In the DoD test community, R&D is viewed as more of a national resource or a science project and less as something that affects economic policy and long-term viability.

Of the many forces that are shaping our landscape, the continued consolidation of defense suppliers ranks among the most evident and thought provoking. Over the last decade, 58 companies abandoned the aerospace business, and the five largest defense contractors are made up of 75 individual heritage companies. In the instrumentation design and development sector alone, the number of defense-related manufacturers has been reduced by more than 75 percent in the last decade. How much market forces will continue to further the consolidation of the government supplier base is unknown, but this trend may have unknown long-term consequences for the T&E community and major range and test facility base (MRTFB) if left unplanned for. The impact will be felt not just by the suppliers involved, but by the entire T&E community, including the ranges, laboratories and prime manufacturers.

Historically, DoD and its related T&E community have benefited greatly from the existence of a strong set of mid-tier, "black box" companies, bringing new and innovative solutions funded mostly through internal research and development (IR&D). The aforementioned reduction in the supplier base has already had a profound impact on this stream of investment. Rapid insertion of COTS technologies and a slowdown of major new platform developments have mitigated the impact of this reduction somewhat.

Will the future be as kind? How will we respond to the challenges of shifting technologies? The smaller supplier base has a reduced ability to deal with these issues without a strong formulated policy that encourages the desired behaviors and investments. A mindset that continues to demand COTS solutions, as opposed to joint partnering with those that have certain domain-specific institutional knowledge, has the unintended consequence of furthering consolidation and driving investment profiles that focus on non-T&E or instrumentation-specific solutions. As businesses look for return on their investment, they often consider defense-related IR&D to be excessively complex, characterized by high risks, as well as having both a restricted cash flow and a lower financial return.

"…what can we do to help foster the innovation necessary to prepare our community for tomorrow's test challenges? First, we need to show some clear incentives."

Lack of a cohesive strategy that encourages investment by the remaining community of suppliers will allow continued erosion in the "instrumentation-specific research" that is required to sustain the level of excellence the T&E community has demonstrated over the years. This continued drive toward more lucrative commercial developments will stifle the T&E-specific innovation necessary for sustaining T&E technological dominance. This loss of critical mass is important. We either need a large number of suppliers and users or sustained investment capital, whether government or privately funded, to sustain innovation.

So, what can we do to help foster the innovation necessary to prepare our community for tomorrow's test challenges? First, we need to show some clear incentives. The late President Ronald Reagan stated that "Freedom and incentives unleash the drive and entrepreneurial genius that are the core of human progress." Innovation is at the heart of productivity growth, and growth is at the heart of the commercial businessman, so showing potential return on investment for investment capital is the equivalent of creating new and useful tools and products. We must continue to develop strategies and methods that foster and nurture relationships based not solely on price, but on "capabilities understandings" and joint needs as well.

Secondly, because innovation requires a degree of risk, the T&E community needs to find new ways of either sharing risk or diminishing its financial impact on commercial partners. One good way to reduce risk is to

establish and foster long-term partnerships between DoD, major primes and specialized instrumentation suppliers. A better definition of the roles that each of these major stakeholders have must be developed to assist in formulating the strong partnerships necessary for moving forward.Because federal business is a highly regulated area, especially with respect to contract structure and procurement methods (rightfully so), care should be used in deciding how to approach new requirements before using the same old contract vehicles and methods.

Finally, the government must create a business environment that attracts capital, fosters innovation and enables private sector competitiveness. To create such an environment, long-term partnerships, open and honest communications, and trust are paramount. While a focus on product development and process improvement has proven successful for many companies in the short term, it threatens to dry up the pool of new and emerging technologies from which we must draw in the future to remain competitive. Given the desirability of continued business innovation, it is vital that companies wishing to innovate feel that they are part of a team and are working in an attractive and competitive business environment. In short, today's innovators will be tomorrow's leaders—in industry as well as in government.

What should our future T&E world look like with proper innovation? The Internet will have moved into the realm of the ether. Electronic devices from video recorders to bit synchronizers will have embedded web servers and the ability to be accessed from any web browser through the use of platform and O/S agnostic software. Test vehicles will log on to the switched fabric of the range in the same way that a typical WiFi PC user does today.

Commercial network technologies will enable evaluators to analyze telemetry data and video, as well as to automatically set up their displays, datasets and algorithms. Spectral efficiencies will continue to be gained through advanced modulation and compression techniques, allowing ever-expanding data requirements to be met. Packet data streams will allow for the seamless acquisition and propagation of metadata over the vast wired and wireless multi-terabit network infrastructure that will exist in both the vehicle under test and in the facilities that provide for the test itself.

A massive worldwide grid of parallel COTS processors will support processing requirements, as engineers will no longer have to reside at the test facilities, thanks to worldwide connectivity. Engineers might utilize software agents to collect test data while working other engineering problems in real time. Neural networks and artificial intelligence will assist in real-time decision-making, allowing technologists to focus on their specialized disciplines; or as some in the business world would say, "get back to their core competencies."

Jeffrey Immelt, chairman and chief executive officer of General Electric, said that "Good leaders prepare the organization to innovate." Leaders must ask themselves if they are preparing their organization to innovate? Do they foster joint partnerships and the creation of development teams? How willing are they to share risks in the development cycle for new and innovative solutions? Are they creating an environment that attracts capital and invites competitiveness? Do they encourage out-of-the-box thinking in areas such as contract formulation and funding profiles?

In short, the future holds great promise for all in the test communities, including government, academia and industry. Hopefully, we are developing a new mindset that understands the primacy of science and technology and the benefits of commercial innovation in the T&E community. With this proper perspective, we should see more clearly the challenges we face, the vision to which we must aspire, and the path that will lead us to it. o

BURT SMITH *is president of L-3 Communications' Telemetry-West division, San Diego, California. Telemetry-West serves commercial, military and civilian customers worldwide with a product offering that includes telemetry ground system components and solutions, TT&C satellite transponders, high-data-rate satellite transmitters, high-power amplifiers, high-reliability receivers/transmitters,encryption/decryption units, video compression/decompression units, tactical intelligence radios, terrestrial high frequency (HF) and microwave radios and specialized telemetry and surveillance products. Mr. Smith joined Telemetry-West from L-3's Ocean System division, where he held numerous operations and business management positions, most recently as chief operating officer. Prior to joining L-3, he had a distinguished career in operations, materials management, manufacturing and test engineering with Allied Signal's Air Transport Avionics Division and IBM's Personal Computer Division. He holds a bachelor of science degree in mechanical engineering from the University of Virginia.*

ITEA held its first annual Technology Review from June 6–10, 2004, in Monterey, California. The review featured 70 technology presentations across a broad spectrum of topics of importance to the test and evaluation (T&E) community. There were 230 participants from laboratories, universities, industry and, of course, T&E centers and agencies. This edition of "TechNotes" highlights three of the presentations and technologies from the review. A complete CD of the presentations from the event can be obtained by e-mailing a request to ITEA at itea@itea.org.

Out-of-this-world testing

A featured Technology Review speaker was Dr. Robert Mitcheltree from the National Aeronautics and Space Administration's (NASA's) Jet Propulsion Laboratory. Dr. Mitcheltree led the Descent and Landing Validation for the *Spirit* and *Opportunity* Mars Rover Program. He chronicled the tense moments prior to descent and landing of the vehicles; the exhilaration when telemetry again burst from the rovers; and the validation tests that enabled the successful mission. In his presentation, "How on Earth Do You Test a Mission to Mars," he outlined two key components of the test program that uncovered design flaws and eventually saved the missions. Parachute tests highlighted a weak parachute that failed prematurely under the intense loads. This design was corrected and successfully passed subsequent developmental and operational testing. NASA also conducted skidding tests on the protective balloon, simulating the bouncing and abrasion that would eventually occur on Mars. Specially designed test instrumentation captured the balloon's unexpected rupture as it collided with rocks during simulated landings. Further analysis determined that the impact load did not rupture the balloon, but instead, the material tore as it skidded across the rock before bounding forward.

Epoch-by-Epoch™ GPS technology: Providing precise positioning

Dr. Jeffrey A. Fayman and Dr. Lydia Bock of Geodetics, Incorporated, presented a program to evaluate the precise positioning performance of global positioning system (GPS)-based Epoch-by-Epoch (EBE) technology for T&E applications. During a test program, EBE software was integrated with a number of commercial and military receivers. These receivers were then tested in both live and simulated tests, under strenuous environments, including high dynamics and extended range from a GPS reference receiver base station.

EBE yielded cm-level real-time accuracies (one standard deviation) for all of the high dynamic aircraft maneuvers that were evaluated. In addition, EBE technology was shown to have significant advantages over conventional GPS real-time kinematic (RTK) algorithms in several ways, including: (1) an instantaneous integer ambiguity re-initialization (as compared to a post-processing package, which required 8 seconds to resolve the integer ambiguity); (2) extended ranges from the base station over which dual-frequency GPS receivers can provide precise positioning; and (3) graceful degradation when a full set of measurement data is not available. In these tests, the data were edited manually after the solutions were generated to remove outliers. Robust data editing in real-time is planned for future work.

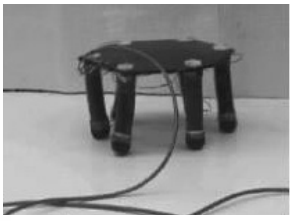
Electro-active polymers (EAPs): "Artificial muscles"

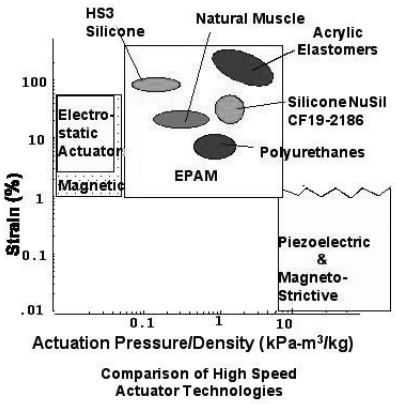
Ron Pelrine, SRI International senior scientist, described a new class of polymers that change dimension when electrically stimulated. The materials are also termed "artificial muscles." The key feature is demonstrated very large strains (10 percent to more than 300 percent) compared to more common materials, such as piezoelectrics. EAPs, such as acrylic elastomers, expand in one direction and shrink in another under applied voltage.

Typical properties, compared to natural muscle, are shown in the diagram below. These materials also develop pressures over 1,000 psi. Devices with 1, 2 and 3 degrees of freedom have been developed. In a linear actuator configuration, EAPs are 85 percent lighter than a corresponding electromagnetic actuator. Demonstration devices include "wall-climbing inch worms" and "multi-legged walkers" *(photo inset, below).* Potential applications in T&E include snake-like manipulators for improved access in severely constrained spaces; low-cost embedded diagnostic manipulators; large-strain sensors; and controlled surfaces for many-point probing. ❑

Dielectric Elastomers Fill Muscle Gap

- **Dielectric Elastomer EAPs have a unique combination of performance and operational characteristics**
- **Good *Overall Performance* is key to versatility**
- **Low Cost is also key**





Comparison of High Speed Actuator Technologies