Reflections on T&E, Part II

Development of Test Technologies • International Cooperative Test and Evaluation

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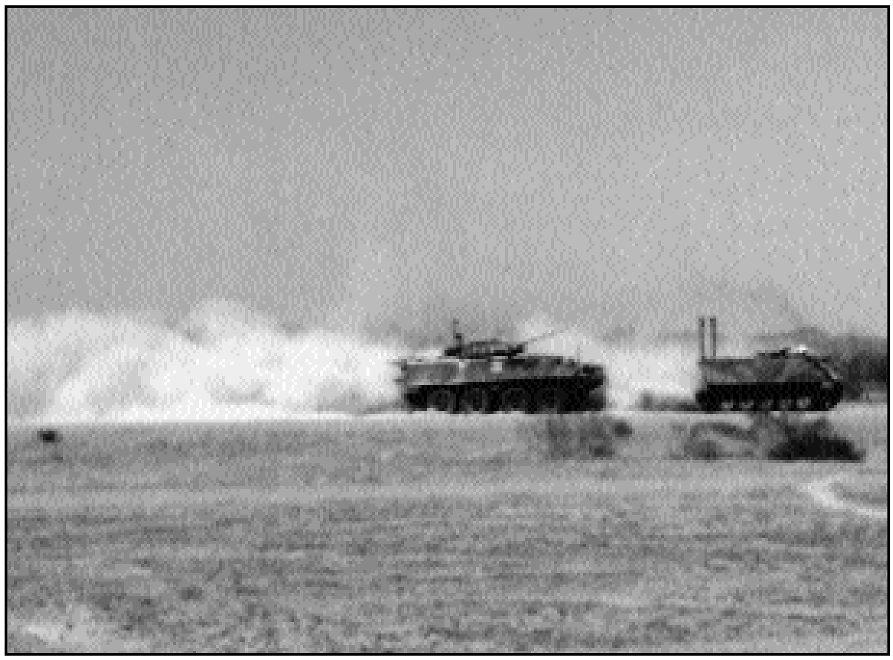
This article is Part II of an article appearing in the July-August 2002 issue of *Program Manager* (pp. 56-62). That article, "Reflections on Test and Evaluation," presented the views of authors John F. Gehrig, Gary Holloway, and George Schroeter on three important aspects of Test and Evaluation: State of the T&E Infrastructure, Lessons Learned in Reengineering Army T&E, and Critical Attributes for a Viable Test Range Complex.



The Canada-United States Test and Evaluation Program agreement expands each country's option to utilize unique facilities not available at home. Pictured is a dust test being conducted by Canada at Yuma Proving Ground, Ariz. DoD photo

We could not emerge from the experiences and opportunities afforded by our lifelong careers as testers, engineers, and evaluators, without formulating several strong opinions concerning the direction of DoD Test and Evaluation (T&E). In an effort to document several of these opinions and experiences, this article—the second of two entitled "Reflections on Test and Evaluation"—covers two themes we co-authored: Development of Test Technologies and International Cooperative Test and Evaluation.

Development of Test Technologies—Yesterday, Today and Tomorrow

Test technology has become very high-tech, complex, and expensive. No longer can it be developed by individual dedicated test engineers in the "back room," but must be pursued in a systematic way under a structured program that encourages such development and provides the necessary resources. A Test Technology Base Program for the Test and Evaluation community is essential to fulfill future test requirements.

Welcome to Yesterday's Museum of Testing

If there were a Museum of Testing, one could visit that museum and trace the evolution of what we now call Test Technology. It wasn't long ago that we were still using strip charts and the term "photogrammetrics"; that is, taking measurements from photographic images was the "biggie" of its time.

Remember cinetheodolites and ballistic cameras? How many remember (or ever knew) the early—*really* early—days of testing when we started testing some new weapon systems called rockets? We lined up a bunch of soldiers and sailors in a trench, equipped them with a clip-

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board and pencil, and instructed them to observe a missile firing and record their observations about the flight path and performance.

We quickly got beyond that approach and started using movie cameras, shooting though a wire grid with a clock hung on a corner of the grid within the camera's field of view. The grids were calibrated to provide angular references and the clock provided a time tag so that images from several similar set-ups could be time-correlated to provide position in space data referred to as Time-Space Position Information.

Another museum item might be the pieces of cardboard called Yaw Cards that were placed in the trajectory of a projectile to get some idea of a projectile's stability—was it yawing or tumbling? A clean, round hole indicated that the projectile was flying true (at that point). An elongated hole indicated that the projectile was pitching and/or yawing. What does it mean when one gets an "L" shaped hole? Yes, there were holes like that.

Photographic techniques were also used extensively in ballistic work. The "Streak" or "Smear" camera could capture the image of a projectile in flight to determine if it was flying true—at least at that particular point—if it had shed its sabot, and if it was intact. Two such cameras placed strategically along the trajectory of the projectile could give a measurement of spin. Streak or Smear Cameras ran (streaked) a length of motion picture film along a slit at the focal plane. The speed of the film was regulated (synchronized) to correspond in scale to the velocity of the projectile.

Thus the image of the projectile was "painted" (or "smeared") on the film. One can see how the fond names of Streak or Smear cameras were derived. The "techies" of the day however, officially called them "Syncho-Ballistic Cameras." Improper synchronization of the speed of the film across the slit with the velocity of the projectile yielded an elongated or compressed image. Photogrammetry was used so much in the "yester-years" of testing, that silver recovery from the silver halides of photographic film was a serious consideration.

The Test and Evaluation Community sorely needs a Test Technology Base Program to develop the test technologies and instruments that will be needed for the new millennium weapon systems.

To be sure, some vestige of photogrammetry and other yester-year test technologies still remains, but much of these [then] very capable but inefficient (by today's standards) technologies, have mostly been replaced. If photo-optics was the mainstay of testing past, then the microprocessor might be considered the mainstay of testing present and future.

The Evolution Continues

The evolution of test technology grew to a large extent, from the innovations of dedicated individuals faced with the need to make some measurement or make it better. Who else for example would think of using Yaw Cards, or of firing a magnetized projectile though two coils of wire spaced a given distance apart to detect time of passage from magnetically induced currents, and thus a measure of projectile velocity.

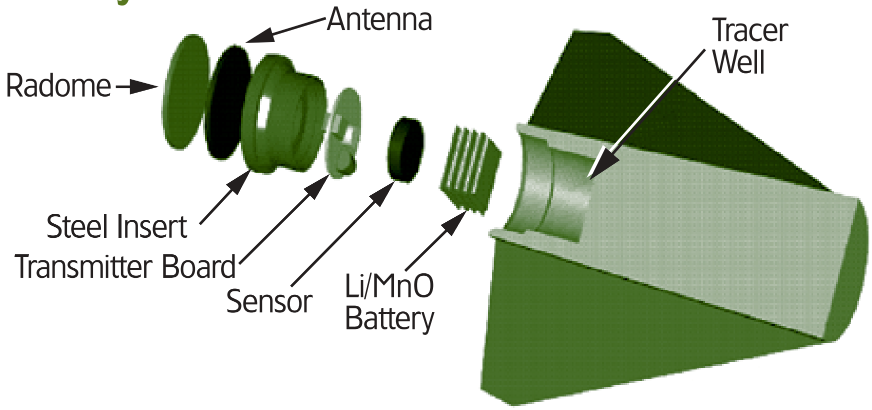
Or who would think of placing a copper sphere in a cylinder, capping the cylinder with a plunger, and inserting this device in the chamber of a gun to measure peak pressure from the deformation of the copper sphere (an old approach, but this "Copper-Crusher Gage" is still in use today throughout NATO countries). Test technology innovations were also adaptations of technologies developed for other applications. This is now the more common approach since the tester no longer has the time and the tools (such as access to machine shops) to experiment and "tinker."

The evolution continues. The dedicated individuals are still there, but the challenge has changed dramatically. No longer can test technologies be fashioned from wood, or in a machine shop, or assembled from basic electronic components. Today's test technology innovations revolve around such approaches as microchip technology, advanced sensors, and high-powered processors. These go beyond the backroom experimenter.

An example of this is the Hardened Subminiature Telemetry and Sensor System currently under development within the T&E community. Today's projectiles can no longer be adequately tested with streak cameras, pieces of cardboard (Yaw Cards), and coils of wire wrapped around a wooden frame (Velocity Coils). No longer is it adequate to simply have indications of performance at four or five points along the trajectory for today's advanced developmental projectiles. As we have been doing with missiles for decades, we now need to collect information about the behavior of an advanced projectile throughout its flight.

The Hardened Sub-miniature Telemetry and Sensor System (Figure 1) will be a complete multi-sensor and telemetry transmitter package that will be rugged enough and small enough to fit into the tracer well—about ¾ cubic inches—of a direct-fire tank ammunition round, and yet powerful enough to transmit data while in flight. This project is developing a new family of miniature sensors, transmitters, and power supplies, all ruggedized to withstand the

FIGURE 1. **Hardened Sub-miniature Telemetry and Sensor System**



pressure, temperature, and shock of the launch environment—the breach chamber of a large caliber cannon. When completed and placed into service, the hardened system will dramatically change the way we test projectiles.

But not only will it give us the information we need, it will expand our knowledge of in-flight behavior—which will greatly enhance our ability to model this behavior for simulation applications in development, testing, and training. And like many new technology developments aimed at a specific requirement, Hardened Sub-miniature Telemetry and Sensor System technologies are spawning ideas for many other applications.

This all sounds good—and it is. But it is happening only because a few dedicated individuals in the research and testing communities are working together and putting out that "extra effort," and a few far-sighted leaders who believe in them and are willing to provide financial support to make it all happen. This is a success story. Unfortunately, many more such opportunities have not garnered the combination of talent, cooperation, support, and resources for their own success stories.

Testing is Becoming Increasingly Complex

Testing has become very technologically complex and challenging. New test technologies must be pursued in the same manner that advanced systems are pursued. That is, they must be based on a detailed analysis of need, weighed against various technical and economic alternatives, from dismissing the requirement altogether to pursuing a full-blown development program. And most importantly, they must be institutionalized and adequately supported.

But isn't all of this already being done? Yes, somewhat, but there's a very important piece missing—the piece that assures the best technical and cost-effective approach. The T&E community sorely needs a Test Technology Base Program to develop the test technologies and instruments that will be needed for the new millennium weapon systems. For example, how will we measure miss distance on a space-based, high-energy laser that does not illuminate the target? How will we collect the debris from space intercepts?

The United States is placing a lot of emphasis on new and innovative technologies for tomorrow's weapon systems to make them more effective, less costly, and to amplify the power of a shrinking military force. The technologies needed to test the new wave of weapon system technologies must be equally advanced. There was a time when the rule of thumb was that a test instrument had to be 10 times more accurate than the item being tested. That was when all we were interested in was the accuracy of the measurement. Today, things are a little more complex, but the same fundamental message applies: test instruments must be adequate for their assigned task.

For years—up until about the late '70s, early '80s—we could fairly easily predict where we in the test business needed to be technologically, because changes came in traditional evolutionary steps. In many cases, our talented technical test force—of which we had much more than we have today—was able to get the job done on the spot, even if they had to hustle at the tail end of the acquisition process, because they had the basic tools and the knowledge to "wing it."

Testers are often their own worst enemies when it comes to justifying the need for new testing tools, by somehow managing to always get the job done with what they have. The question often asked by high-level management when reviewing requests for funds is: "If you don't get these funds, what are you not doing that you need to do?" This is very difficult to answer because the truth is, the tester always found a way to do "something," but that something was not always enough or necessarily adequate.

The problem is that "enough" is not well defined. There have in fact been several conferences of T&E leaders devoted to trying to answer that very question. "Enough" must never be confused with the quantity of testing, but rather with the depth and breadth of testing. One could argue that "enough" is that which just meets the requirement—and the "requirement" in turn is that which is needed for evaluation. This doesn't always work.

In promoting advanced thinking such as the Revolution in Military Affairs, Vision 2010, and others like these, one of the primary emphases has been to try and get people to rise above paralyzing paradigms, which tend to lock people into the same old way of thinking. The same is true in the test and evaluation business. The evaluator will tend not to ask for information if, in their paradigm, they don't believe it can be obtained.

The Hardened Sub-miniature Telemetry and Sensor System mentioned earlier, is a good example. Who "in their right mind" would think of asking for information about a direct fire projectile that can only be obtained by onboard instrumentation? After all, this can't be done, can it? But now that it has been shown to be possible, new thinking of all kinds is emerging. And isn't that what a technology base program is supposed to do, with "better" being the ultimate end result?

But there are other reasons as well for a test technology base program, and this can be summed up in one word—*change*. Change is a much-used word these days, but it is still appropriate and very much required by the T&E community. Let's go back to our museum and see what has changed.

Changing Definitions

The tester once had only to test "hardware"—and it was just that—"hard stuff" typically made of metal inside and out, and involving physical forces. Over the years the term hardware has evolved from "hard stuff" to electrical and electronic things like relays and vacuum tubes. These things manipulated low- and medium-frequency electrons to move and control equipment. Then "hard stuff" came to mean solid state devices that manipulated high-frequency and ultra high-frequency emissions that helped the warfighter see and think, and sometimes even to see and think on their own to do what they've been told (programmed) to do.

Changing Test Stage Involvement

The tester could no longer wait for a prototype to become available for testing, but had to get involved at an early stage of development to: (1) assist the developer in defining critical testing issues and in building-in testability, and (2) to gain an understanding of the emerging system and its technologies. Only by early involvement and understanding of the new system and its inherent technologies could the tester be in a position to react in a responsive and technologically adequate manner. Testers came to recognize that they needed appropriate and equally advanced testing tools, including the possible development of built-in test modules when appropriate.

"Enough" must never be confused with the quantity of testing, but rather with the depth and breadth of testing.

Change in Pass-or-Fail Mindset

Unfortunately, testing sometimes has the connotation of just being a "test" in a pass-or-fail context, rather than as an aid to the development process to produce the best possible system for the warfighter. As an analogy, going to a doctor to find out what's wrong (after you have failed the wellness test) as opposed to going to a doctor for preventative medicine (when you want to be sure nothing goes wrong). Finding errors during a test program should be viewed as a *good* thing. The earlier they are found the less expensive they are to fix. Whenever found, they need to be fixed to field the best possible weapon for the warfighter.

Testing as "Preventative Medicine"

The development of new weapon systems is an expensive business, but the alternative is to try to fight with obsolete and inadequate weapons. There are all kinds of risks associated with the development process: cost risks, technological risks, schedule risks, and performance risks. Testing is the "preventative medicine" that lessens that risk. We can no longer repeat the experience of the M247 Sergeant York DIVAD (Division Air Defense Gun). This was not a case of inadequacy in development. We got pretty much what we asked for in the acquisition process. The problem was that we didn't quite know what we had until we got it. Once we got it, testing determined that it was not really adequate to meet our needs.

The Right Testing Tools

We can't wait until a system is almost complete before we start testing it and the concepts embodied in it. You've heard it all before: "get in early" and stay involved during the entire development process. But we must have the right testing tools to be a real help to the developer; or otherwise, we may just be a hindrance. Imagine tracking a Global Positioning System-equipped aircraft with a vintage radar and trying to convince the developer of the aircraft that the navigation system was inadequate! Who of us would seek preventative medicine from a doctor who still used witches' brew and other weird concoctions instead of advanced radiographic equipment, CAT scans, and ultrasonics?

The Soldier's Warranty

The question is asked, "Can we afford it?" A more important question is, "Can we afford *not* to do it?" In reality, on a major weapon system development, testing represents only 2 to 3 percent of the total cost of acquisition. When put in that perspective, 2 or 3 percent is not much to ensure that we field "weapons that work." The Army likes to refer to testing as "The Soldier's Warranty," and that's not a bad concept when you think about it. Test technology is a "force multiplier" if it helps us field weapons that work and complete the intended mission every time they are used.

In a military sense, force multiplication is the coordinated application of effective weapon systems to create a combined effect that is far greater than the sum of its parts. There is a synergy in fighting a war, where each coordinated weapons application acts to multiply the force of the others. In a test and test technology sense, every technical weakness and vulnerability discovered and corrected through testing improves combat capability and effectiveness and denies the enemy exploitation opportunities.

Likewise, every reliability improvement and maintenance repair time reduction achieved through testing creates a ripple effect in the entire logistics tail. Improved reliability equates to fewer parts in the supply system, less down time for repair, fewer supply and maintenance personnel, and more combat effectiveness from each weapon system. Improved weapon design and performance derived as a result of testing mean fewer munitions expended to achieve the desired effect, fewer munitions purchased, reduced munitions storage requirements, and fewer transport sorties.

Testing does not just find out if something does or does not work, or even just how well it works. Testing also focuses on improving reliability and maintainability, reducing vulnerabilities, assuring man-machine interface compatibility and so on. It's no secret that today our defense forces are heavily dependent upon advanced technologies for success. We do not have, nor do we care to commit, the number of people required to fight a low-tech war. Trench warfare is unthinkable in today's high-tech society. Technology across the acquisition process—including test technology—provides that critical edge in technological superiority for our fighting forces.

What Can a Test Technology Base Program Do?

It can allow the art and science of testing to catch up to and advance in step with the weapon systems, which have been making technological leaps right along. It will also allow the tester to be a smarter buyer of testing tools—to get the most for the very limited funding available to the tester. But most importantly, it will help us to help the acquisition community get the best possible equipment in the hands of our military, and thus give them the best chance of success and survival.

Research, Development, Test and Evaluation (RDT&E) is a process that has been designed to systematically phase and manage various elements to achieve the desired result with minimum risk and best technical and economic approach. Funding allocations for development are structured to make this happen, and generally follow the pattern: RDT&E account 6.1 for Basic Research; 6.2 for Applied Research; 6.3 for Advanced Technology Development; and 6.4 for Full Scale Engineering Development. Today, however, test technology developments typically plunge directly into the 6.4 category for full-scale development, and hence do not enjoy the benefits of the advances that could be achieved from the other funding lines.

This was acceptable in the past, when we could rely on industry for the development of say a metric tracking radar. Companies were available that could build radars of various kinds. They had the "in-house" technology to build a particular type of radar for testing (within the state-of-the-art) at that time. But in developing a new technology system like the Hardened Sub-miniature Telemetry and Sensor System today, one cannot find builders of devices that are useful in such a new and hostile environment. The Hardened Sub-miniature Telemetry and Sensor System (Figure 1) required a leap-ahead test technology, which required the systematic progression of 6.2, 6.3, and 6.4 efforts.

How could we have, for example, acquired a wide dynamic range pressure sensor—let's say one that could measure from a few psi to 100,000 or more psi? That requires coverage over five decades of pressure differences! Does such a sensor exist? Is there a Commercial Off-the-Shelf product? Could it be developed? Could we cascade a series of existing pressure sensors, each with a more limited dynamic range, so that collectively they can measure pressures over this wide dynamic range? Or, must we develop a new family of pressure sensors, each of which can cover a more limited range?

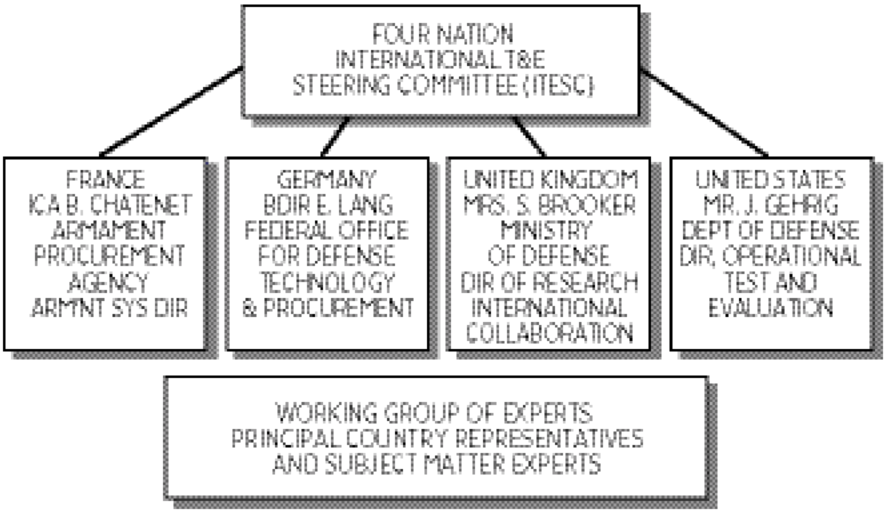
This same line of questions also applies for acceleration measurements and other sensor parameters. Still other similar lines of questions apply to the transmitter, signal conditioner, and power supply. Having answered these questions, what then is the best design configuration? These types of questions were in fact addressed for the Hardened Sub-miniature Telemetry and Sensor System.

The test community needs and has funded a preliminary Test Technology Base Program that provides funding and structure for advanced test technology acquisitions. The program will add coverage in the T&E accounts for 6.3 Advanced Technology Development-type efforts.

The Test and Evaluation/Science and Technology (T&E/S&T) Program

The T&E/S&T program was initiated in fiscal FY02 by the Director of Operational Test and Evaluation, in close coordination with the Director, Defense Research and Engineering. This program will examine emerging test requirements

FIGURE 2. **ITOP Management Structure**



derived from transformation initiatives and identify needed test technology areas. It will also leverage and employ applicable 6.2 applied research from the highly developed technology base in the DoD Service Laboratories and Test Centers, industry, and academia to accelerate the development of new test capabilities. Essentially, it will ask the questions: "How are we going to test that future system?" and then, "How can we use that technology to develop our test capability?"

The T&E/S&T program is geared to maturing test technologies and providing "feeder" technologies to test capability developers. Follow-on development of working prototypes and additional procurements would then be borne by existing T&E investment accounts. The acquisition of advanced, high-tech, complex, and costly test technologies should follow the same technical acquisition strategies followed by any weapon system. It only makes sense to do so since the process is well proven for the weapon system and could easily map over to cover the T&E systems.

In a test and test technology sense, every technical weakness and vulnerability discovered and corrected through testing improves combat capability and effectiveness and denies the enemy exploitation opportunities.

Modeling and Simulation

It is also appropriate to address Modeling and Simulation whenever considering the T&E process. One could reasonably ask why we should go through all this when Modeling and Simulation can be used instead of testing. To be sure, Modeling and Simulation is a very valuable tool for the acquisition community, but it is not something to be used instead of testing. Modeling and Simulation is in fact a valid tool *for* testing, not *instead* of testing. It can reduce the amount of physical testing of a weapon in an open-air range environment. It can also result in the better and more focused testing that can be achieved in a controlled environment in the laboratory. For these reasons, the T&E community is vigorously pursuing Modeling and Simulation.

The Boeing 777 aircraft and the Dodge Intrepid automobile are notable examples where Modeling and Simulation was used extensively and to great benefit in development. The depth and breadth of testing, however, actually increased in these cases, although a smaller number of prototypes were needed. This in turn reduced the overall amount of testing.

Testers should not focus, however, only on reducing the amount and cost of testing; rather, they should focus on reducing the overall cost of acquisition! A good marriage between Modeling and Simulation and testing certainly has the potential for reducing the cost of testing and can reduce the cost of the development process and at the same time field a superior system. If you think much about Modeling and Simulation, this result is not surprising.

Fundamentally, a model is a rendition or abstraction of the real thing, and a simulation is the exercise of that model. A model is developed from the physics and architecture of the real thing, and some of that knowledge is often the product of the testing itself. But the benefits of synergy between testing and Modeling and Simulation don't stop there. The result of exercising the model through simulation needs to be validated by physical testing to be believable. For otherwise how can we know that the simulation is realistic over the domain of interest?

Furthermore, the new information gained from the validation tests on the simulation feeds back into the model, and maybe even the system itself. Finally, the sequence repeats itself with each iteration, further expanding our knowledge and improving our model, our knowledge of the system, and the system itself. We refer to this process as model, test, fix, and model!

Since little is known about new systems, like the Hardened Sub-miniature Telemetry and Sensor System described earlier, a model of a new system is necessarily imperfect. The model is then reiteratively refined and perfected through testing until it is realistic over the domain of interest. Testing does not go away with Modeling and Simulation; in fact, a necessary link exists between physical testing and Modeling and Simulation. Testing now has the expanded role of providing the basis for the credibility of the models, and the validation of the results of simulations. Test technologies may now have to consider a broader range of test data and higher accuracies for greater model fidelity.

Testing continues to be a critical element of the acquisition process. The drivers for test technologies are advanced weapon system technologies, more complex and demanding test scenarios, and the demands for more cost-effective and credible testing. Modeling and simulation, the need for earlier involvement in weapons development, and limited available funding all plead for an aggressive test technology development program that will allow the tester to give adequate and effective support to the weapons system developer. That development program mandates a strong and structured Test Technology Base Program.

T&E Museum of the Future

What an exciting visit it will be to the T&E Museum of the Future! Once 6.2 and 6.3 funds have been applied to the T&E community for some time, a visit to the museum should be exciting indeed. What one would see is likely beyond our wildest imagination today. Just like we could not have seen what an impact the personal computer and the Internet have made on our lives, so we cannot imagine the impact today's Research and Development (R&D) would have on the T&E community.

We can only imagine seeing the advanced, low-cost, lightweight Global Positioning System equipment, with phenomenal accuracies that will be found in the museum. We can only just imagine seeing a robust data link that could support downlink of telemetry, digital video, digital audio, miss-distance measurement, target data, Time-Space Position Information data, and avionics bus data.

- Imagine sitting in the museum just such a robust data link, which could also support the uplink of commands, target control, synthetic targets, and synthetic backgrounds.
- Imagine such a robust data link that does not even operate in today's radio frequency environment, but has moved up to an uncluttered portion of the spectrum where others do not have adequate capabilities to operate and interfere.

Imagine seeing a miss-distance measurement system that provides vector information on missile and target, uses the robust data link, and computes kill probability and damage assessment in real time. Or imagine seeing the instrumentation that could support one-on-one to many-on-many tests!

We would also surely find the instrumentation for a global range in the museum. This instrumentation would have freed the developers and testers from the constraints of today's geographically constrained ranges.

Space test technologies would be available, and the means to support the test and training missions with some common instrumentation would surely be "available for viewing."

Commonality and interoperability would be assumed and visitors would be hard pressed to conceive of how anyone could have tried to "go it alone!"

Such a museum would only be our legacy if we can commit the resources to make it happen through an aggressive program of funding R&D *today* for tomorrow's Test and Evaluation!

International Cooperative Test and Evaluation

International cooperation in test and evaluation is relatively new. Several ongoing programs are demonstrating the value of a global approach and paving the way for this largely untapped area of opportunity.

Mutual Benefit

International Cooperative Test and Evaluation is the collective effort aimed at partnering, sharing, exchanging, and jointly pursuing test and evaluation areas of common interest and benefit with our foreign allies. The DOT&E manages several international cooperative test and evaluation programs aimed at resource and expertise sharing, achieving improved T&E methods and processes, and improvement in test technologies to achieve mutual benefits in cost, time, and quality. These programs have been very successful although there remains untapped potential that has yet to be fully exploited.

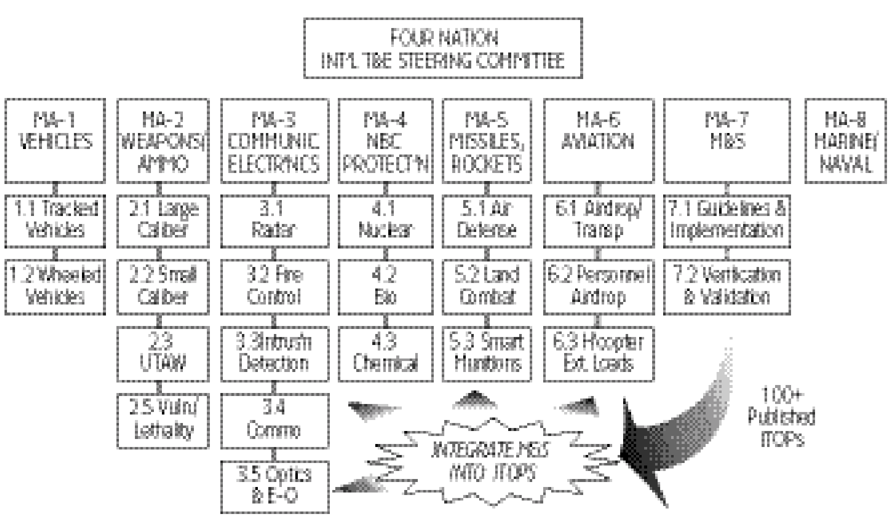
The Secretary of Defense, in a March 1997 memorandum, stated: "We already do a good job of international cooperation at the technology end of the spectrum; we need to extend this track record of success across the remainder of the spectrum…." T&E is an area that is rich in international cooperative opportunities.

Many reasons support the argument for more international cooperation, which can generally be synopsized into four categories.

No. 1—Economic

Perhaps the most obvious reason for cultivating international cooperation is to reduce cost. Cost sharing through joint effort is a clear example of economic benefit. Perhaps not so clear is where investments can be reduced or negated because of information obtained from an international partner in which case such investments do not have to be bud-

FIGURE 3. **ITOP Program Management Structure**



geted anew. A classic example is when technical research information is transferred from one country to another.

No. 2—Technological

As technology advances rapidly across the globe, it is increasingly difficult and economically impractical for any country to develop all technologies to the highest levels. Thus, countries have developed pre-eminence in particular technological fields, based on longstanding experience or country priorities. Each country has unique technologies or technical expertise to contribute to the world community where the sharing and integration of these technologies benefits everyone, resulting in a "win-win" situation.

No. 3—Operational

Operational compatibility is an issue that is also important to test and evaluation. The current trend toward coalition operations has heightened the emphasis on inter-operability and other operational issues. When people and countries work together, helpful and sometimes imperative is that they share a common understanding and do things in a common, interoperable way. One of DOT&E's international T&E programs is based on commonality, and has resulted in significant cost and time savings as well as improved test quality for all countries involved.

No. 4—Diplomacy

In a world that draws ever closer together, diplomacy or international relationships becomes increasingly important. It strengthens alliances and forms the foundation for coalition operations and other cooperative efforts. While this might appear to be above the interest of the T&E community, it does in fact have a direct bearing on test and evaluation. Cultivating good and trusting relationships is an acknowledged sound business practice. Relationships are very important when dealing internationally and can be the difference between success and failure. Perspective and cultures must be understood and appreciated to progress together effectively and grow as partners.

ITOPs [International Test Operations Procedures] are managed and directed by the International Test & Evaluation Steering Committee, composed of principal representatives from France, Germany, the United Kingdom, and the United States.

DOT&E International T&E cooperative programs align with the reasons for international cooperation just described. They are founded on sound relationships and win-win objectives. These are essential for productive and lasting success.

International Test Operations Procedures (ITOP)

The first formal international test and evaluation cooperative program is the ITOP program initiated in the early '80s. This program operates under a Memorandum of Understanding among the countries of France, Germany, the United Kingdom, and the United States relating to "Mutual Acceptance of Test and Evaluation for the Reciprocal Procurement of Defense Equipment." ITOPs document common test procedures developed by subject matter experts from the four signatory countries.

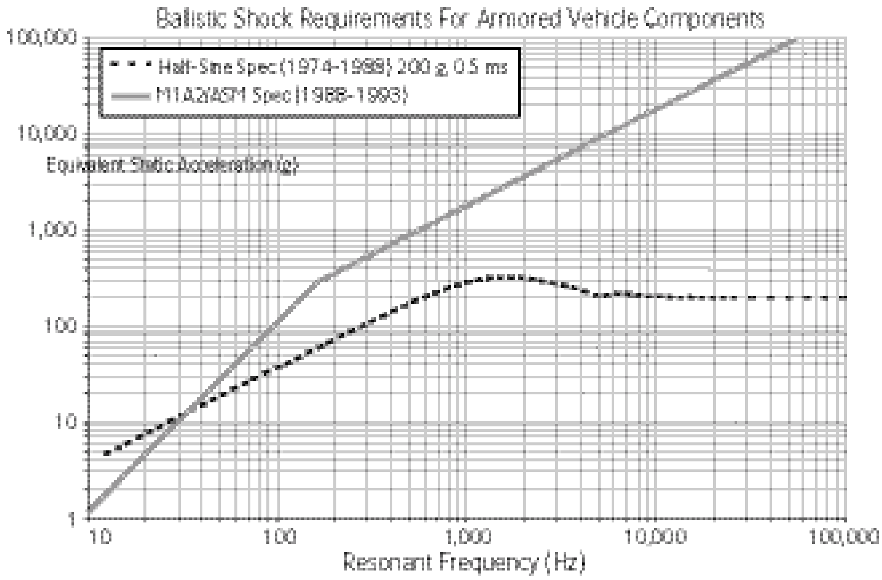
The combined efforts of these experts result in quality procedures, instilling confidence in test data produced from the application of ITOPs. Because of this confidence, each signatory country has agreed to accept ITOP-produced test data from other signatory countries, and thus minimize or negate the need for retesting when procuring military equipment from each other. Although only the four signatory nations have agreed to mutual acceptance of test data, other countries also use ITOPs and have likewise enjoyed the benefit of mutual acceptance.

ITOPs are managed and directed by the International Test & Evaluation Steering Committee composed of principal representatives from each of the four signatory countries (Figure 2). The committee meets annually and meetings are hosted rotationally by each of the four countries. Chairmanship also rotates among the four countries for a two-year tenure. In addition, the committee sets policies and governs the operation of the efforts undertaken by Working Groups of Experts.

Twenty-two Working Groups of Experts operate under eight Program Management Areas (Figure 3): Vehicles; Weapons and Ammunition; Communications-Electronics; Nuclear, Biological and Chemical Protection; Missiles and Rockets; Aviation Systems; Modeling and Simulation; and Marine/Naval Systems. Management areas continue to expand.

Over 100 ITOPs have been published to date with an additional 50 to 75 in various stages of development. Some ITOPs have transitioned into NATO "Standardization Agreements." In addition, many countries outside the four signatory countries have requested and now use ITOPs. Use of ITOPs over the years has resulted in quality testing and significant cost savings when evaluating and/or procuring foreign equipment.

FIGURE 4. **Ballistic Shock Data**



Canada-United States Test & Evaluation Program

Since the early '90s, Canada and the United States have enjoyed special arrangements for reciprocal use of each other's test facilities. Each year, Canada and the United States exchange 30-month forecasts of planned testing under the Canada-United States Test and Evaluation Program. These forecasts are reviewed by the proposed test facility or range and if testing can be accommodated, are given "Approval in Principle." This is followed by negotiations with the test facility or range and documented in a detailed "Project Arrangement."

The Canada-United States Test and Evaluation Program agreement expands each country's option to utilize unique facilities not available at home or where testing cannot be accommodated for reasons such as fully scheduled home facilities or where home facilities may be down for extended repair or maintenance. Canada has made use of unique desert test capabilities at Yuma Proving Ground, Ariz., where many deserts of the world are replicated.

Data Exchange Agreements

Data Exchange Agreements with several countries provide for the exchange of information on proving ground techniques. These Data Exchange Agreements have resulted in improvements in test processes and test technologies. Information exchanged on test technologies has saved considerable costs by avoiding the need to perform design and development work that has already been done by another country.

When the United States wanted to explore alternatives for downhill brake testing, for example, information provided by France and Germany saved considerable time and money. Downhill brake testing in the United States is typically performed on a public highway with the required downhill characteristics. Because this presented safety considerations, the question arose as to whether downhill braking could be simulated on level ground and thus performed within the confines of a proving ground.

French and German level ground test techniques for downhill braking provided the baseline for a U.S. level ground test facility and methodology, saving considerable time and money had it been necessary to undertake exploratory research and experimentation to reach this point in knowledge.

In another example, armored vehicles such as tanks were designed for many years using ballistic shock criteria developed several years ago (Figure 4). Unexpected shock damage, however, continued to occur and the solution was to over-design at the expense of higher weight (and thus reduced performance) and cost. It appeared obvious that there might be something wrong with the criteria used. The United States and Germany, through the Data Exchange Agreement, decided to examine the problem and exchanged experimental data on ballistic shock. This led to additional experiments and exchanges and ultimately resulted in the development of new ballistic shock criteria.

The work showed that the old criteria resulted in an over-design at the lower shock frequencies and an under design at the higher frequencies (Figure 4). The approach of beefing up the design to compensate for the high frequency shortfall resulted in a large over-design at the lower frequencies with the resultant increase in weight and reduced performance. This cooperative effort with Germany resulted in an estimated savings of $1 million for the United States in test technology research, and considerable savings to program managers who can now more accurately design their systems.

The Way Ahead

While the foregoing represents successes, much can and still should be done to fully exploit the potential of cooperative test and evaluation. Cooperative test and evaluation is largely still an untapped resource rich in possibilities. The R&D community has been involved in cooperative R&D for a long time to the point where it has become a natural thing to do. This is where DoD's T&E community needs to be.

The Army initiated the ITOP program as a pilot program in 1983. Most of the ITOPs therefore relate to ground systems. Air Force and Navy participation is beginning to take place but this must be accelerated and expanded. There are many areas of potential international commonality where ITOPs could provide benefits of the type already experienced with the areas currently covered by the program. Test procedures related to the release of stores from aircraft and underwater shock, for example, might be candidates for ITOPs. There are of course many more areas unique to Air

Force and Navy testing that are potential candidates for ITOP development.

With the trend toward coalition operations, safety testing could emerge as a particularly critical area where common test procedures, through an ITOP, could be a significant factor. An example is air transport by one country of munitions developed by another country. It would certainly facilitate operations if the munitions were safety tested and certified for air transport in the same way and to the same criteria used by the country providing the air transport.

Currently planned is expansion of the concept of reciprocal use of test facilities to other countries. As military equipment becomes more complex, so does the need for more advanced, complex, and costly test and evaluation capabilities. It is increasingly difficult and expensive for one nation to fulfill all of its legitimate test and evaluation requirements at ranges and facilities under its control.

One way to reduce the cost of developing the next generation of weapons—both in the United States and in allied countries—is to take full advantage of the unique test capabilities of each country. Reciprocal use of test and evaluation ranges and facilities will expand longstanding international partnerships the United States has enjoyed in the equipment acquisition process.

Reciprocal use of test and evaluation ranges and facilities will also foster interoperability. Interoperability issues of equipment from different countries that are tested at the same test and evaluation range or facility and with the same test methods and measurement standards will be easier to identify.

Experience with T&E Data Exchange Agreements has demonstrated their value. DoD and its allies can cite many examples of improvements in T&E in terms of quality, efficiency, and cost savings derived through exploitation of these agreements. That experience, however, has also shown that there still remains a large untapped potential that should be more aggressively exploited.

Relationships are very important when dealing internationally and can be the difference between success and failure. Perspective and cultures must be understood and appreciated to progress together effectively and grow as partners.

Regular and focused dialogue between Data Exchange Agreement Technical Project Officers to foster cross-familiarity and identify potential areas of exchange would benefit both sides of a Data Exchange Agreement. Knowledge of testing facilities used in other countries has resulted in adoption of new test technologies that would otherwise not have been used. Technical consultation between test and evaluation personnel of different countries has also been beneficial. With modern communications facilities, it is now possible to confer with an overseas colleague as easily as with a colleague in the next office. Of course, such dialogue is more effective if the parties know each other personally.

Relationships are extremely important in any kind of business dealings but perhaps even more so in international dealings because of cultural differences, which must first be known and appreciated.

Joint efforts in T&E such as joint development of test technology have been little exploited by the T&E community. This too is an area rich in potential. This type of international cooperative effort has long been practiced by the R&D community with good results and should be pursued by the T&E community as well. One notable example of cooperative development of test technology is the Hardened Sub-miniature Telemetry and Sensor System mentioned earlier. One of the challenges of the system is development of a family of sensors for pressure, temperature, and acceleration. The United Kingdom has offered to develop pressure sensors for the hardened system.

Operating in the T&E Global Environment—Burning Issues

Lack of Will. There are some issues that hinder operating globally in T&E. Perhaps the single most significant issue is simply the lack of will—the will to *just do it*. Some of the reasons for this lack of will are:

- International cooperation and foreign travel are discouraged because of:
  —the perception that it is too costly;
  —the argument of being too busy and unable to spare the time;
  —the perception that there is little to be gained, that we have all the answers; and
  —the perception that it takes too long to get anything done.
- The notion that international travel is just a boondoggle.
- Lack of knowledge of other countries and their capabilities.
- Lack of familiarity with international programs (don't know how to go about implementing them).
- Legal and procedural obstacles.

Training. The T&E community needs to become more familiar with international cooperation, including its benefits and procedures. Many of the courses in our military colleges already teach these concepts. This is good—but awareness and training on international cooperation needs to reach a wider range of individuals at all levels.

Knowledge of Other Countries. If we are to pursue test and evaluation in a global environment, we must first gain an understanding of the organizations, capabilities, and procedures, as well as the cultural character of other countries. As one step in this direction, DOT&E publishes an *International Test Facilities and Ranges Capability Summary.*

The latest issue of this summary is a two-volume, 800-page document detailing T&E capabilities in nine countries: Australia, Canada, France, Germany, Israel, Norway, Sweden, the United Kingdom, and the United States. This summary continues to grow with participation of additional countries. While this document has proven to be very useful, it is important to also build relationships through personal contacts and to understand cultural differences.

Common Ways of Doing Things. Working in the global environment is much easier if we have common ways of doing things—if we use the same standards and procedures and share the same sense of what's important and what's not. We already use some common standards in T&E. Military Standard 810 on Environmental Testing is a notable example. Many countries have adopted this standard in their test processes. Of course, much of what is contained in this standard is founded on international work done in NATO and other international organizations and societies. The ITOP program mentioned earlier is another contributor to common ways of doing things.

Legal and Procedural Mechanisms. International Cooperation needs appropriate structures by which we can work together. In some cases, we may need to start from the top with new legislation. This is rare but it has happened. In most cases, all we need is an international agreement of some kind such as a Memorandum of Understanding or a Data Exchange Agreement. Some tend to be scared away by the prospect of developing a formal international agreement and the perception that it is a difficult and lengthy process. It is difficult only because it is unfamiliar and the prospect of facing something unfamiliar always looms larger and more difficult than it is.

The challenge for the test and evaluation community is to pursue opportunities in the global environment that are waiting to be exploited.

Editor's Note: Gehrig and Mabanta welcome questions or comments on this article. Contact them at johngehrig@comcast.net or mabantaf@saic.com.

Defense Acquisition University and George Mason University Sign Memorandum of Understanding

In an effort to extend DAU's educational strategic partnerships and leverage learning opportunities, DAU Commandant, Army Col. Ronald C. Flom, and Dee Ann Holisky, Dean, College of Arts and Sciences, George Mason University (GMU), signed a Memorandum of Understanding (MOU) during a ceremony held at DAU Headquarters, Fort Belvoir, Va., on Aug. 8.

The signing of the MOU establishes a strategic partnership leading to a Master of Public Administration (MPA) degree. The MPA program will be available to any member of the DoD Acquisition, Technology and Logistics (AT&L) workforce who meets graduate admissions requirements. A maximum of 12 credits from DAU may be transferred to GMU and applied toward the MPA degree. All transferred DAU courses will be applied toward MPA electives. Students who have not completed the equivalent of 12 credits of graduate-level coursework through DAU will complete the remaining elective credits through GMU coursework.

This strategic partnership provides an important opportunity to meet DoD acquisition education goals and increase the skills, knowledge, and abilities of the DoD AT&L workforce.

For more information about this partnership, contact Wayne Glass, DAU Director for Strategic Partnerships, at **Wayne.Glass@dau.mil**.

Dee Ann Holisky, Dean, College of Arts and Sciences, George Mason University (left), and Army Col. Ronald C. Flom, Commandant, Defense Acquisition University, sign a Memorandum of Understanding on Aug. 8, 2002, formalizing a strategic partnership to pursue educational opportunities.

Photo by Army Sgt. Kevin Moses