

The Test & Evaluation Research and Education Center at Georgia Tech

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Test & Evaluation Research and Education Center

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Recognizing an apparent lack of attention to the overall discipline of test and evaluation (T&E) at most U.S. engineering universities and technical institutes, the Georgia Institute of Technology created a center in 1995 to fill this gap. Serving among other things as an educational clearing-house and forum for T&E professionals, the Test & evaluation Research and Education Center (TEREC) has been working toward its mission of enhancing academic interest in T&E, as well as securing the future of successful T&E.

It would appear from the offerings of most engineering universities that test and evaluation (T&E) does not exist. Traditional academic disciplines are defined by subject matter such as electrical and chemical engineering rather than by system development activities such as T&E. Within the disciplines, universities emphasize the theoretical rather than the practical aspects of engineering, so that basic research gets much more attention than system development. Except for a few institutions such as the Georgia Institute of Technology (Georgia Tech), T&E has been slighted in U.S. engineering universities and technical institutes.

To increase academic interest in T&E, Georgia Tech established the Test & Evaluation Research and Education Center (TEREC) in 1995. TERC's mission is to provide a focal point where important basic issues in the T&E community are addressed; where academic and professional interests in T&E are welcomed; where novices receive instruction; and where practitioners refresh their skills. TERC's guiding vision is to assist in the creation of the future of T&E.

The vision can only be realized if perspectives from the entire T&E community are represented. For this reason, TERC seeks out T&E professionals from a broad spectrum of organizations to participate in its activities. TERC workshops, conferences, and other meetings are opportunities for the general T&E community to raise important issues and develop approaches to resolving them. TERC established the "Faculty Associates" designation to identify academic faculty having an interest in T&E and to build a community among them. The Faculty Associates from nine colleges and universities around the world repre-

sent much of the scattered academic interest in T&E and provide a pool of interested academic participants for TERC programs. The attempt to be inclusive has been successful; representatives of the 34 organizations listed in *Table 1* participated in TERC programs in 1999.

TEREC activities support its vision to advance T&E. They include research, education, and other services to the T&E community. The most useful TERC research takes advantage of its university environment to bring academic breadth and depth to bear upon basic issues. The T&E certificate documents a student's completion of a broad educational program in T&E. The planned *T&E Transactions*, a web-based, refereed journal, will distribute new T&E technical understanding to the community and archive results for future workers.

Research Programs

Exciting T&E research is concerned with improving our understanding and practice of the T&E process. One recent TERC approach to understanding the process was a study to look for evidence of complexity, perhaps even of chaos, in T&E.¹ The certain departure of tests from test plans is a truism in T&E circles. If the process is intrinsically unpredictable, current methods for planning must be adapted to account for this unpredictability. As there are several potential sources of unpredictability, identifying these sources might significantly improve the practice of T&E planning. It could be, for example, that certain kinds of planning can never be accurate if performed too early, regardless of the care of the planners or the lack of incident in the product development.

TEREC has supported the improvement of T&E through eight research projects under the sponsorship of T&E organizations within the U.S. Air Force, Army, Navy and the Office of the Secretary of Defense, as well as for the commercial organization Bell-south.Net. In keeping with its vision, TERC calls upon the expertise of individuals from many organizations when undertaking research projects. To date, New Mexico State University, the Santa Fe Institute, and Veridian-ERIM have teamed with TERC in performing sponsored research.

While TERC's research activities overall are broad, the specific research projects to date generally have focussed on two particular themes: the development of new methodology to optimize test planning and high performance computing applications to T&E. In addition to traditional research and analysis, TERC often serves as an independent evaluator of T&E methodologies and tools developed by other organizations. Sponsors have contracted with TERC to host workshops and conferences to study new technologies and ideas. In addition, TERC researchers have developed complex software systems to support the application of new methods to test planning.

T&E methodologies

Improvements in the methods and tools to support test planning are a major research activity. New product development processes such as simulation-based acquisition (SBA) and T&E approaches such as the simulation, test, and evaluation process (STEP) require new T&E planning methods. The need for more cost-effective tests also drives this interest.

One of the traditional issues in T&E is the relationship between the mission to be supported by the system under test and the test program. Methods to derive test programs from mission needs have been under development at several organizations.^{2&3} TERC researchers are constructing a software tool to support the Air Force Operational Test & Evaluation Center in its newly developed process for identifying pertinent test measures for operational impacts of systems. The tool is named MARION for Mission

Institution
Air Force Developmental Test Center
Air Force Operational Test & Evaluation Center
Air Force Space Warfare Center
Army Developmental Test Command
Army Materiel Systems Analysis Activity
Army Operational Test & Evaluation Command
Army Test and Evaluation Command
Assistant Secretary of the Army for Research, Development, and Acquisition
Canadian Department of National Defense
Chief Naval Operations (OP91)
Defense Modeling & Simulation Office
Defense Systems Management College
Franklin & Marshall College
George Mason University
Georgia Institute of Technology
Institute for Defense Analysis
JADS Joint Test Force
Johns Hopkins University
Logicon RDA
Massachusetts Institute of Technology
Naval Air Warfare Center
Naval Underwater Warfare Center
New Mexico Institute of Mining and Technology
New Mexico State University
Nichols Research
Office of the Secretary of Defense (DOT&E)
Office of the Undersecretary of Defense for Acquisition and Technology
Redstone Technical Test Center
SAIC
University of Denver
University of South Australia
Veridian ERIM International
Virginia Polytechnic Institute
412 th Test Wing

Table 1. Organizations with individuals participating in TERC activities

Analysis and Risk Impact on Operations Net-tool and is based on a strategy-to-task decomposition that considers the system's overall mission.

Once the test measures have been defined, test planners must choose methods for providing the test data. A method for selecting the optimum was developed by workers at Logicon RDA.⁴ This method quantified the benefits and resource needs of specific test options and permitted the selection of an optimum test for given resources. The operational test organizations within the services contracted with TERC to evaluate the value of this method. TERC participation included hosting a workshop on the subject so that the community could provide comment on the method.

High-performance computing applications to T&E

Advances in computing capability have permitted the proposed application of computers in new and often more extensive ways to the T&E process. For example, one of the advanced T&E applications of high performance computing could be to expand our use of virtual systems

under development for very early operational assessments. TERC activities have included the evaluation of detailed physics-based models developed by the scientific and technical laboratories such as the Department of Energy's national laboratories for T&E applications, and participation in the Department of Defense (DoD) High Performance Computing Modernization Program.

Some models that require high performance computers are currently available to predict and understand test results. A panel on the first principles models of munitions effectiveness met in a series of by-invitation workshops that met between September 1996 and February 1998. These workshops included representatives from the modeling and test communities and spanned organizations that ranged from DoD, national laboratories, commercial organizations and universities. The panel's purpose was to identify and evaluate a program of action for improving these models in their support of T&E, especially live-fire test.⁵ Table 2 contains a list of the workshop topics and their locations.

Workshop Topics	Location
Organizational meeting	Atlanta, Georgia
Blast and shock	Atlanta, Georgia
Underwater explosions	Atlanta, Georgia
Fire models	San Antonio, Texas
Hypervelocity impact modeling	Los Alamos, New Mexico
High power microwave effects modeling	Albuquerque, New Mexico
Progress updates and final meeting	Los Alamos, New Mexico

Table 2. Locations and topics of munitions effectiveness modeling workshops

Education and Training

TEREC maintains educational efforts to train newcomers to the T&E field and to maintain and extend the skills of other members of the T&E community. Most T&E professionals enter the field after graduating from undergraduate school. Generally, the needs of an employer motivate this career choice, because only the rarest students knew of T&E before beginning their careers. Consequently, TERC education and training is oriented toward post-graduate, continuing education students. Since most T&E professionals cannot leave their work for an extended period, some courses are offered by video as well as in person in Atlanta and other locations around the United States.

The TERC educational program includes a T&E certificate. In 1998, the Georgia Tech academic T&E certificate program transitioned to TERC management. Originally developed under contract to the Defense Test & Evaluation Professional Institute (DTEPI), the academic program provided graduate-level education in T&E for both the military and commercial sectors. In addition to the ability to earn a continuing education-based T&E certificate, students could combine courses with other standard courses in industrial or electrical engineering and earn the certificate in conjunction with a Master of Science degree. The academic program was founded on the assumption that many students would be in residence on campus in Atlanta. When this assumption proved unfounded, TERC assumed responsibility for the program.

The T&E certificate is now awarded upon completion of a series of short courses (Figure 1). The course series consists of two required courses and a group of electives from which one must receive six continuing education units (equivalent to 60 hours of instruction). Program participants must pass a test upon completion of each of the two required courses. Table 3 describes the course options for meeting the requirements for the T&E certificate.

In recognition of the many fine T&E courses available from other organizations, TERC will, on a case-by-case basis, substitute applicable classes from these institutions for some of the TERC short courses. The DTEPI at Point Mugu offers many courses, primarily using distance learning techniques such as compact disc-read only memory (CD-ROM) and web-based delivery.⁶ The Defense Systems Management College includes academic coursework in T&E for government personnel pursuing careers in acquisition. ITEA also sponsors numerous T&E short courses.



Figure 1. TERC short courses award CEUs applicable to the T&E certificate

Most students participating in TERC courses are not pursuing the T&E certificate. They are simply interested in the course at hand to develop a basic understanding of the field or to learn the details of specific subjects. As T&E evolves, TERC responds to new T&E community interests by offering new short courses; thus new courses are continually under development.

Program Requirements	Short Course Options
Required courses	Principles of Test & Evaluation *
	Design of Experiments *
Electives	T&E Using Modeling & Simulation
	Cost Benefit and Cost Effectiveness Analysis for the T&E Community
	High Performance Computing Applications to T&E
	Introduction to Electronic Warfare Modeling & Simulation for Test Professionals
	Economic Analysis for Technology Decisions
	Statistical Approach to Software Testing
	Project Management
	System Usability in T&E **
	Software T&E **
	Applied Regression Analysis **
	Computer Systems T&E **
	Advanced Electronic Management **
* Tested upon completion	
** Course currently under development	

Table 3. Requirements for TERC's T&E certificate

Information Exchange

Many of the other services that TEREC offers to the T&E Community can be grouped under the term "information exchange." Here, TEREC's goal is to facilitate the exchange of T&E-related information between T&E professionals.

Conferences and workshops

TEREC hosts workshops and conferences on T&E topics, making a concerted effort to deal with those topics not already being covered by other organizations or to provide an academic venue for approaching important community concerns. These workshops and conferences are often included as part of sponsored projects and typically focus on the T&E process and methods. Participants usually include representatives from a wide variety of organizations. These have included military, university and industrial organizations, and have spanned the categories of user, practitioner, and researcher.

TEREC initiated a national consideration of the importance of understanding the economic issues of T&E through two conferences. The scope of these conferences was broad and included research papers addressing economic research methods, applications of economic theories, cost measurement and other economic issues relating to T&E. The conferences also addressed the practical methods and practices for monitoring and controlling T&E costs.

This year, TEREC plans to host a workshop which will draw together a representative set from the laboratory, system development and test communities to consider methods of testing systems for information security. While this is not a new issue, it is receiving new emphasis with the spreading awareness of both system vulnerabilities and the low costs of entry for potential adversaries and criminals. These themes were sounded in 1999 at the Annual ITEA International Symposium in September and at the October Georgia Tech Conference on Information Warfare held in Colorado Springs. At that last conference, a parallel session produced a list of prioritized issues in computer network defense that named T&E as one of the most critical problems.

T&E Transactions

Finally, to elaborate on an aforementioned topic, TEREC's newest proposal to facilitate information exchange is the publication of a refereed T&E journal. The purpose of the journal, tentatively entitled *T&E Transactions*, is to encourage T&E professional technical communication and to document and archive technical advances in the field. The publication will serve a function that is different from any established T&E publication such as the *ITEA Journal*. A survey of TEREC Faculty Associates found broad support for the journal in addition to producing several volunteers

for editors and referees. It is not intended at the present time to charge a subscription fee for the journal, so funding sources are needed and are being pursued. To control costs, the plan is to take advantage of Internet technologies, developing an electronic journal to be published on TEREC's web server.

For further information, visit the TEREC web site at <http://www.terec.gatech.edu> or write to TEREC, Georgia Institute of Technology, Atlanta, Georgia 30332-0840. Telephone (404) 894-7311; Facsimile (404) 894-8636. E-mail: terec@gatech.edu

Dr. Sam Blankenship, the director of TEREC, is in charge of identifying and coordinating TEREC activities. He has directed several T&E research programs, including developing test methodologies for command and control systems and smart weapon systems, developing software for T&E applications, and reviewing test plans and practices. He has organized workshops and conferences in various areas, and has developed and taught graduate, undergraduate, and continuing education courses in a variety of T&E areas. Dr. Blankenship currently serves as the ITEA Southeast Regional Vice President.

Dana Stocks is the director of education and training for TEREC, directing the T&E certificate program and coordinating TEREC short courses. At the 1999 ITEA Symposium held in Atlanta, Georgia, Ms. Stocks chaired a panel on the impacts of information technology on development of the T&E professional. She has been heavily involved in modeling and simulation as it applies to T&E and has developed and taught short courses on this subject. She has been a Research Scientist at Georgia Tech since 1990.

Endnotes

¹ Nancy David, James Crutchfield, and Samuel Blankenship, "Is T&E Chaotic?," Presented at Second Conference on the Economics of T&E, November 1999, Atlanta, Georgia.

² James Przybysz, "Scope/Cost Process," Presented at Second Conference on the Economics of T&E, November 1999, Atlanta, Georgia.

³ Martha Nelson, "Unified Framework for T&E Planning," Panel Session at the Second Conference on the Economics of T&E, November 1999, Atlanta, Georgia.

⁴ Cyrus Staniec and Lambert Sebastiani, "An Optimization Approach to Integrate M&S and T&E in Weapon System Development," Presented at Test Plan Optimization Methodology Workshop, January 1999, Atlanta, Georgia.

⁵ Summarized under Workshops on the TEREC Web site: <http://www.terec.gatech.edu>

⁶ Jim Engel, "Institute's Efforts Strengthen the T&E Process," *The ITEA Journal of Test and Evaluation*, Vol. XX, No.2. June/July 1999, 55.