The
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"Human Factors and Performance T&E"

Featured Facility

Horizontal Accelerator Test Facility, Naval Air Systems Command, Patuxent River, Maryland

Special Feature

Annual Directory of ITEA Corporate Member Capabilities, 2004

TECHNICAL PAPER ABSTRACTS:

Human Performance and Protection Modernization

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Air Combat Command, Langley Air Force Base, Virginia

Technological advancements in modern aircraft have vaulted the U.S. Air Force forward in terms ofcombat capabilities,while concurrently creating challenges in human systems integration requiring novel solutions to accommodate the trade-offs between human safety, protection and performance.

Human Systems Integration Test and Evaluation at the Air Force Flight Test Center

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This paper discusses test and evaluation (T&E) of U.S. Air Force aircraft and associated weapons systems at the Air Force Flight Test Center, Edwards Air Force Base, California. Emphasis in T&E is on human engineering, including controls and displays, ergonomics and workstation layout, environment (lighting, temperature, vibration, noise), usability, maintainability, operator workload and situational awareness, as well as on health and environmental engineering. This paper describes the techniques and methodologies used (mostly subjective questionnaires) and the limitations of the "experiment" in terms of experimental control, sample size, reliability and other factors. The data cannot often be generalized to the operator/maintainer population at large, but can illuminate trends or possible operational deficiencies. An example of a human systems integration test, including lessons learned in an Air Force aircraft, is also presented.

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Making it Safe: Wounded Personnel Deserve the Best Equipment

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Today, there is a high probability that the U.S. Air Force will evacuate battlefield casualties from the local treatment centers in Iraq to medical facilities in Germany or the United States aboard Air Force aircraft. The evacuations will take place using the latest medical technology available and will help save the lives of many fighting men and women. The Air Force's Air Mobility Command will execute its mission by safely evacuating and transporting the wounded aboard available aircraft. The medical crews are highly trained and dedicated, and the medical devices that are used on these flights must be as dependable as the crews that use them. The equipment must withstand forces and one-of-a-kind uses not normally encountered in medical facilities on the ground. The Air Force Research Laboratory performs testing to assure users that medical devices will meet the rigors of high-altitude flight and survive the operating environment. This paper addresses the mission and operation of the Aeromedical Test Branch and its impact on the aeromedical evacuation mission.

MANPRINT Challenges of Testing and Evaluating Future Combat Systems

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The size, scope and complexity of the Army's Future Combat Systems program present many challenges to Manpower and Personnel Integration (MANPRINT) test and evaluation (T&E). This paper considers two related challenges and provides some insights into how to meet these challenges. The first challenge is to sufficiently address the large number of soldier-performance-related design and operational requirements. The second challenge is to adequately support the numerous and diverse test events planned at the system and system-of–systems levels that require MANPRINT T&E.

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Assessing Complex Team Performance in a Sustained Operations Environment

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This paper reports on lessons learned from the methodology and preliminary findings focused on the research of individual and team command, control,communications,computers,information, surveillance and reconnaissance (C4ISR) decision making, coordination and performance under fatigued conditions over time. The methodology and instruments utilized are discussed, as well as issues such as scenario equivalence and fidelity. A sample of the results is provided, indicating both individual and team-level effects of fatigue on performance. The discussion is focused on measurement and modeling of complex team behaviors and some of the difficulties involved.

Performance Assessment Models and Tools for Complex Tasks

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Assessment models support the design of quality performance assessments. Assessment tools are being developed to enable easy and effective application of the models. Based on representations of assessment design knowledge and domain knowledge in ontologies, the tools provide guidance to assessment designers and, through constraint processing, check the completeness and accuracy of designs. With the addition of Bayesian networks, the tools can also enable individualized instruction by identifying knowledge gaps and prescribing instruction to fill the gaps. This paper describes the technical approach to developing the tools, as well as discusses applications of ontologies and Bayesian networks for assessment authoring and individualized instruction.

Establishing Valid Expressions of Measurement Uncertainty in Flight Test Instrumentation

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Measurement discipline is the effective application of measurement science principles to instrumentation devices (sensors, conditioners, encoders) to create and maintain a trusted measurement result. This paper proposes methods and actions that the test instrumentation community should pursue to achieve effective, valid expressions of measurement.

PRESIDENT'S CORNER

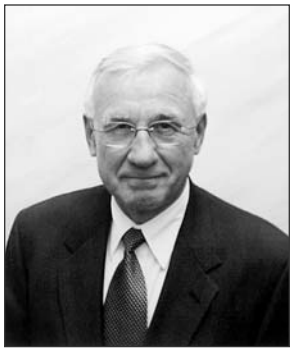
The central theme of this edition of *The ITEA Journal of Test and Evaluation* focuses on human factors and performance test and evaluation. This marks somewhat of a departure from the past, wherein the themes have focused more on scientific processes, methodologies and system technology-related articles. This is an important milestone, and I applaud the ITEA Publications Committee for showcasing human factors and for the outstanding authors who have contributed interesting and thought-provoking articles.

It is hard to know where to begin in choosing a favorite article; all of them recognize the importance of the human element and how it plays in the successful outcome of testing and evaluating a system. No matter how well a system is designed, the system's full potential is not realized until the human aspect is taken into consideration. I know many of you understand this phenomenon when you confront the many, many features that go unused within your current computer applications—all great products—but you wonder if the human element was considered when the software was designed.

I also recall an operational test of a family of military vehicles some years ago wherein the systems were supposed to be designed to fit the standard physical profile of soldiers representing the fifth to ninety-fifth percentile. The system's manufacturer quickly realized it had a problem when the Service offered one soldier for test that barely fell within the fifth percentile for height. No matter how close the seat was adjusted forward, the soldier could not reach the pedals to operate the vehicle. Eventually, a set of blocks had to be added to extend the pedals to continue with the test.

What does this human factor discussion have to do with ITEA and its membership? The message is very clear: We must avoid becoming fixated on systems alone, at the expense of the human element, if we want to be successful in our Association endeavors. If we neglect the human aspect of what ITEA is all about, we will quickly discover we have a well-designed system that no one comprehends or chooses to support. The good news is that ITEA understands this pitfall and has been extremely successful in avoiding it. We can boast example after example of dedicated volunteers successfully supporting this Association's chapters, committees, Regional Vice Presidents and Board of Directors.

It is the human aspect of this organization that allows ITEA to prosper and grow. For example, Reta Morgan Reynolds, an active member of ITEA's Francis Scott Key Chapter, provided exemplary support to the Publications Committee by helping to solicit theme-related articles for this edition of *The ITEA Journal.* Reynolds, a human systems integration operations research analyst with the Future Force Office, Virtual Proving Ground Team, U.S. Army Aberdeen Test Center, Maryland, is an excellent example of ITEA members who regularly draw upon their volunteer spirit and professional expertise to benefit the Association.



Gary L. Bridgewater

Another example of a human success story is the ongoing work of the Regional Vice Presidents (Daniel J. Pierre; Gregory D. Lamberth; Scott P. Foisy; Stu Burley and his successor, Richard L. Minero; and newly appointed acting Regional Vice President Robert A. Vargo), under the able leadership of Roger A. Offerdahl, chairman of Chapter and Individual Membership Development. This group has been working very hard to identify, encourage and assist in the start-up of new chapters or in the revitalization of lagging chapters to keep the membership growing. As a result of their hard work, ITEA has several promising new chapters that will soon be on the books.

This can-do attitude by ITEA members is also evident in the outstanding work that Chapter President Michael T. McFalls and his team from the Rocket City Chapter, in conjunction with the Volunteer Chapter, are doing in support of the 2004 Annual ITEA International Symposium. These chapters conceived the excellent idea of teaming together to combine the ITEA Symposium with the Army T&E Days symposium in Huntsville, Alabama. This year's symposium, to be held August 30-September 2, 2004, will greatly increase the breadth of the program, the exhibits and the prospect for a record attendance.

These are but a few of the human element success stories going on across the Association daily. ITEA depends on the people of this organization and the cadre of active volunteers to ensure that the work of the Association moves forward. Because without this integral human element, ITEA would have no chance for success.

I would also like to point out that this edition of *The ITEA Journal* is the Association's annual salute to its corporate members and an acknowledgement of their outstanding support to the Association. Please take the time to read through the corporate section and discover what each of these companies brings to the test and evaluation community, and continue to refer to this directory as a resource year-round. The corporate members are a vital part of ITEA at all levels: from the grass roots, to the chapters, to the international arena.

Gary Bridgewater

Information Operations: Assessing the Human Element in System Performance

Dr. Hendrick W. "Henk" Ruck

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Today the United States faces new enemies not foreseen when its operational systems were in research and development years ago. We face new challenges of developing and implementing systems more quickly, of making those systems more precise and effective, and of performing the tests and evaluations to validate performance expectations. Along with these challenges comes the overwhelming necessity for information superiority. As explained in new draft Air Force Doctrine Document 2-5, "The aim of information superiority is to have greater situational awareness and control over the adversary. Effective use of information operations (IO) leads to information superiority." Future doctrine indicates IO is the linchpin holding our air and space operations together. And the critical measure of our success in IO will be the success of the decisions our commanders make.

Dr. Hendrick W. "Henk" Ruck

What is IO? Air Force doctrine-in-development goes beyond a delineation of information warfare (IW) ("attack" and "defend") and information-in-warfare ("gain" and "exploit") of the past doctrine. Emphasis is now on network warfare operations, influence operations, electronic warfare operations and integrated control enablers, such as predictive battlespace awareness and intelligence, surveillance and reconnaissance. Joint doctrine is evolving as well, and there is a new emphasis from the Secretary of Defense on streamlining the services' IO doctrine. But no matter how you slice it, IO has a uniquely human bottom line. A person, and that person's gray matter, are required for information to have any significance in decision-making. Critical information can surely be passed from machine to machine to hasten its dissemination. But when was the last time a machine was held accountable for a major mishap? It is always a human who either failed to understand, act or control. More often than not, it is the human who is able to create success in the face of the fog of war and in against-all-odds types of situations.

Today, I see reflections of a growing awareness across the Department of Defense. As systems become more complex, we have an ever-greater mandate to consider the human element in how we will operate and control our new technological marvels. Blaming human error for failures is becoming recognizably lame. A broader understanding is taking shape, however, that we have to design within systems a capability to be controlled; to actually think about how to provide people with insight into an appropriately calibrated trust of the automation. For the better part of 50 years, government laboratories have been dedicated to research in this area, which in turn, has led to methods for test and evaluation of the human element in system performance.

The Air Force Research Laboratory's (AFRL's) Human Effectiveness Directorate is conducting research focused on integrating the human element into complex systems design. Because information operations has particularly human attributes and implications, we have designated IO as a major emphasis area, and we have designed and implemented a staff office to tune and sharpen the IO programs to meet critical future requirements. As our scientists

and engineers have traveled the world interviewing Air Force people in IW flights and have engaged with IO Center warfighters in San Antonio, Texas, we have catalogued a broad range of needs for applying human factors research and conducting the right evaluations of human performance. Clearly, IO is an emerging and "forming" area of warfare, and much work still needs to be done.

One area being addressed is visualization, or how to present information to the IW operator. A huge problem with IW is in the ability to understand what effect an action has—battle damage assessment. This is known as the "smoking hole" problem in IW—the lack of a conventional weapon's smoking hole to determine effects. To address this problem, we are researching and developing an Information Warfare Combat Assessment Tool (IWCAT) to monitor and evaluate the effectiveness of IW actions. The effort is based on extensive interviews with IW flights to understand their processes, decision requirements and system-level constraints.

If we do our job right, this tool will correlate IW missions with commanders' objectives and offer rapid situational awareness of the missions and their effectiveness. Tool operators will be able to see the current status and history of each indicator, make assessments and view individual intelligence reports.In effect,it will provide what our customers are calling an IW campaign dashboard, enabling visualization of the overall effect that IO is bringing to the fight, particularly the connection between the mission and the objective.The IW flights have told us that it is important to them to manage the time lags in IW missions and to see when, not just where, operations will occur. They also need to deconflict and synchronize IW missions with one another. We are attempting to provide these capabilities. Evaluations of just how well this system accomplishes these goals will be critical to the program. It is just one of several areas we are researching toward supporting IW operators in performing their mission.

On another note, a role the Human Effectiveness Directorate would like to play more of in the future is the "honest broker" in major system-of-systems demonstrations and exercises. Included is a role of "expert advisor" to the test and evaluation community. Centers and users we have talked to need teams of people who possess tools for measuring situational awareness and decision effectiveness. This is particularly significant as new paradigms for publish/subscribe and other aspects of network-centric warfare are spirally instantiated and evaluated. Our people on the sharp end of the spear are putting their lives on the line to do the mission. We who guide science and technology development have a responsibility to look beyond seemingly revolutionary technology.

Too often, we become enamored with technology, bandwidths, architectures and tools at the expense of losing sight of how a system's interface looks, feels and helps a human do the mission. In human effectiveness, we have been developing and refining methods for embedded measurements of decision effectiveness and situational awareness. We are developing methods and processes for projecting and teasing out future systems requirements. We would like to deepen our support to the IO community by playing an independent assessor role for government customers who are themselves trying to make sense of the alphabet soup of architectures and tools being developed and evaluated.

As we look to the future, we will continue to meet the demands and the necessity for information superiority. Faced with increasingly automated systems, we see a parallel increase in the number of catastrophic incidents involving humans who do not understand where their automation is going or what it is doing. We all have faced frustration at simply trying to move Microsoft's friendly paper clip out of the way of our ongoing work. And Microsoft Word is not really all that complex. Imagine, for instance, trying to facilitate a combat search and rescue mission while dealing with multiple non-integrated software "tools" whose designers had failed to consider the time pressures or environmental constraints under which their systems would be used.

The human link is both the weakest and the strongest—it is often unreliable and exploitable—but it also offers the greatest strength and resilience, capable of overcoming shortfalls of ill-designed hardware, software and weapon systems. We need to make sure we invest in this link with advocacy and processes to support our people, who are—without a doubt—the greatest treasure we have. o

Dr. Hendrick W. "Henk" Ruck is director, Human Effectiveness Directorate, Air Force Research Laboratory (AFRL), Wright-Patterson Air Force Base (AFB), Ohio. The directorate is a 1,000-person research and development organization with facilities at Wright-Patterson

AFB; Brooks City-Base, Texas; and Mesa Research Site, Arizona. The directorate's mission encompasses basic and applied research through advanced development in areas that include training methods; system interface design criteria; physiological, psychological and physical effects of combat environments; individual and team performance; and personnel protection. The technologies under development include those that support aircrew training simulators; life support equipment; crew escape systems; visual and auditory displays; biotechnology; logistics support systems; and computer-aided tools for designing and evaluating crew stations and other human-centered systems. Dr. Ruck entered the U.S. Air Force in 1972 as an ROTC program scholarship graduate of Stevens Institute of Technology, Hoboken, New Jersey. His civilian career began at the Air Force Occupational Measurement Center in 1975, and since then, he has worked at several laboratories, the Air Force Inspection and Safety Center and the White House. He began military service with the Air Force Reserve in 1975 and retired in the rank of colonel in 2001. His career included duty with the Office of the Secretary of Defense, Headquarters Air Force Materiel Command, the Armed Forces Staff College, Ballistic Missile Office and Air Force laboratories. He managed an AFRL division that researched advanced human interfaces, and later worked as the associate director for AFRL's plans and programs. Dr. Ruck, known for his scientific contributions in the field of industrial and organizational psychology, was appointed to the Senior Executive Service in May 1999. He became director of the Washington office, AFRL, and associate deputy assistant secretary of the Air Force for Science, Technology and Engineering, Washington, D.C., in 2001.

Acknowledgment

The author gives special thanks to Lt Col Cynthia Dominguez, USAF, chief, Information Operations and Special Programs, Human Effectiveness Directorate, Wright-Patterson Air Force Base, Ohio, for her contributions to this commentary.

Using Remote Psychophysiological Monitoring for Human Performance T&E

The burgeoning complexity of evolving programs—Future Combat Systems and the Stryker Brigades for the Army; Joint Strike Fighter and unmanned combat aerial vehicles for the Air Force; and the DDX destroyer program for the Navy—necessitates an intelligent and unified approach to testing the demands placed on individuals with regard to cognitive overload, distributed decision making and situational awareness. Though each of the armed services faces its own contextual challenges in this regard, many of the baseline parameters involved are the same.

A lack of available objective data has been a major limiting factor in the advancement and acceptance of human systems integration testing and evaluation. Limitations in computational power and fieldable hardware have been the major impediments to the collection of such data.

New and emerging technologies offer the opportunity to transform such testing. Advances in processing power—memory devices that are both compact and durable—along with improved sensors, make collection and analysis of objective human systems data a realistic goal. The task at hand is to harness and integrate advances made by various military, academic, industrial and medical research endeavors. Using such a "cross-pollination" approach presents opportunities for much-needed progress to take place in test and evaluation work that is relevant to human systems.

One such technology is remote psychophysical monitoring, based on 20 years of National Aeronautics and Space Administration (NASA) research to enhance individual astronaut performance. BioSentient Corporation's ambulatory system, MobileMe, and its analysis station, SentientMonitor, are designed to collect, measure and analyze multiple autonomic nervous system (ANS) parameters of *multiple* individuals simultaneously in real-time, real-life situations. This capability may prove very helpful in accurately assessing the psychophysiological status and assisting in the evaluation and enhancement of human performance in operational environments.

The systems consist of a garment (which may be worn under clothing) that houses the sensor harness; and an electronics pack (worn around the waist) containing physiologic data gathering and analysis modules that include resident and removable memory, wireless communications and power source. The standard ambulatory unit is currently configured to measure, display and transmit five ANS parameters: heart rate (derived from an electrocardiogram trace that is collected and stored); respiratory rate; finger blood volume pulse; finger temperature; and skin conductance.

Comprehensive autonomic testing usually requires a whole laboratory full of equipment and requires a person not only to be attached by wires, but also to remain stationary. The BioSentient system allows wireless collection of integrated data from multiple ANS parameters using minimal equipment, with little or no restrictions on activities.

The ambulatory system is supported by a portable central monitoring facility that receives data from the ambulatory system(s) wirelessly and/or via the Internet, and it can simultaneously measure, receive, analyze and manipulate the data of up to 30 wearers, all integrated onto one display. It calculates several heart rate variability spectra in real time and allows for two- and three-dimensional graphic comparisons of parameters.

The behavior of teams and individual team members is influenced by their psychophysiology. Monitoring and characterizing the ANS responses of more than one person simultaneously in real time will help in understanding three factors: team

Ambulatory, multi-parameter, real-time autonomic nervous system (ANS) monitoring facilitates the assessment and optimization of human performance during operational activities. Equipment pictured is BioSentient Corporation's ambulatory system that simultaneously measures, analyzes and displays multiple indicators of ANS function from multiple wearers. MobileMe, worn by the test subject at left (with components shown at lower right), collects, processes, stores, displays to the wearer and sends data wirelessly to a remote portable monitoring station (two panels, top right) that can concurrently monitor, analyze, store and integrate the data of up to 30 individuals in real-time.

dynamics, the characterization of human interface in physiological terms and patterns of synchronicity/congruence between team members.

How this psychophysiological and other data correlate to human performance parameters such as stress, cognition and situational awareness levels as they pertain to the test and evaluation of systems is being investigated by the Joint Warfighter Test and Training Capability (JWTTC). Currently, the Human Systems Integration Test and Evaluation Working Group, comprising representatives from Department of Defense test ranges/agencies, as well as academia, research centers and battle labs, is identifying the common baseline requirements needed for such measurements.

With these requirements in hand, the JWTTC objective is to develop capabilities to perform system-level tests and assessments, and system-of-systems test and evaluation, where human systems integration test and evaluation can be performed in an objective, quantifiable manner, in an operationally realistic environment. o

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This article was contributed by authors Mae Jemison, president and founder of BioSentient Corporation and a former National Aeronautics and Space Administration (NASA) astronaut; Raj Mandavilli, vice president, product and business development, BioSentient Corporation; Dr. Sheila Wang, fellow, Emotion and Behavior Lab, National Institute of Aging, National Institutes of Health; and Reta Morgan Reynolds, human systems integration operations research analyst, U.S. Army Aberdeen Test Center, Future Force Office, Virtual Proving Ground Team.