AIRCRAFT SURVIVABILITY

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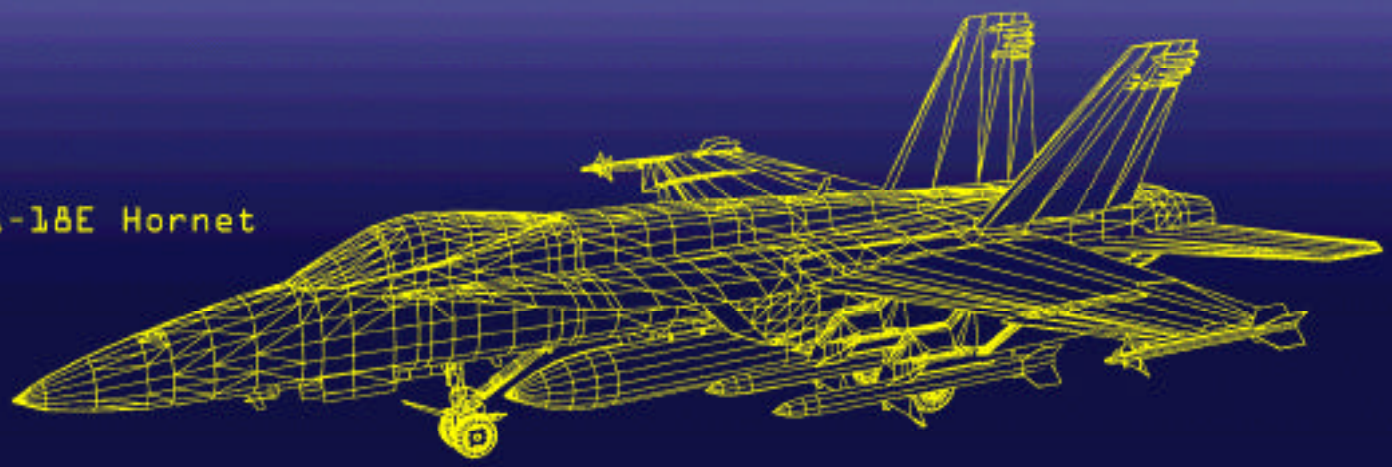
Assuring M&S Credibility for Defense Acquisition and T&E



Fall 2001

Our thoughts and prayers are with the victims and families of the September 11th terrorist attacks and those now fighting to rid the world of this evil. God speed in your quest and God bless the United States of America.

JTCG/AS

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About the cover
Heavy reliance on models and simulations has resulted in an ever-increasing emphasis on the ability to demonstrate their credibility.

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Guest Notes

Some Parting Thoughts on Survivability Modeling and Simulation

by Mr. David H. Hall

Mark Twain said that Adam, the first man, was really in a great position when it came to public speaking (or writing in a newsletter), because he knew that when he said something really good nobody else had said it before him. So it is with some trepidation that I put fingers to keyboard to try and say something noteworthy about where I think survivability models and simulations (M&S) need to go from here, at the risk of repeating what somebody else may have said better already. But after a 33-year career doing modeling, simulation, and weapons systems analysis, I do have a few things left to say. I'd really just like to talk about three things—new M&S, M&S credibility, and old M&S.

First, I'd like to say to the developers of new M&S architectures and new M&S (like JMASS and AJEM) that if you build it, they probably won't come. Just because you can get it to work, doesn't mean anybody else will use it. It may be a great innovation, but there's a fairly long transition period between building a new M&S tool and getting somebody else to use it on a regular basis. If you wonder why almost nobody is using the JMASS models yet, it's partly because analysts have yet to be convinced that it's in their best interest to spend the time and money required to switch from ESAMS, TRAP or RADGUNS. The same is true of AJEM—users have to be shown that there are capabilities in AJEM that they can't get in JSEM, SHAZAM, or COVART. And, they have to be convinced that AJEM will be a stable, useable tool that works for their application. Convincing them is going to take time and a lot of effort. So that means that the JTCG/AS and the JTCG/ME are going to have to plan support for existing tools for some significant period of time, or they risk dropping support for the tools that everyone is using before there are viable replacements. Additionally, they need to plan for more training in new M&S, like AJEM, to get people to accept and use them.

Secondly, at some point DoD is going to come to it's senses and realize that while everything it does relies on M&S, almost nobody can demonstrate that they work correctly. That's not to say that M&S have no credibility—it's just that in a lot of cases there is no documented evidence showing where a model works and where it does not. People who develop M&S go to a lot of effort to convince themselves that their model works correctly, but they almost never write down what they did so that they can convince somebody else! And the pressure of producing new software on schedule and within budget almost always guarantees that documentation, verification, and validation (V&V) fall off the table. So, new software developments are no better "V&Vd" than "legacy" tools. The JTCG/AS can best serve their DoD and industry customers by putting more funding and effort into V&V and documenting the survivability M&S being used by the community. The ECAT is a good example of what can be done (although it needs to be expanded), as are the continuing efforts by JASA to provide standard Accreditation Support Packages (ASP) for all SURVIAC models and simulations.

And lastly, at the risk of sounding like a curmudgeon, just because something is old doesn't mean it's not any good. A "legacy" tool is one that has been used and honed over the years into a thing of beauty, and a joy forever. Well, maybe not forever. But the survivability M&S that are in SURVIAC today have been improved, verified, validated, and used over many years by many users for a wide variety of applications. They're not perfect, but they're getting the job done, and they're being constantly enhanced and improved by many people. So don't be in a hurry to replace them just for the sake of getting something new or something that's supposedly easier to "maintain." You may wish later that you had left well enough alone.

And that's about it. I've enjoyed working with the JTCG/AS over the last 15 years or so, and I hope to keep seeing everybody in a new incarnation starting next year.

Since Dave is retiring in January 2002, we asked him to give us his parting thoughts and suggestions.

—Editor

Personal Thoughts to our Colleagues in the M&S Survivability Community

by Mr. James F. O'Bryon

I'm delighted that this issue of *Aircraft Survivability* has been devoted to the significant issue of modeling and simulation (M&S). Very few topics conjure up as much emotion and interest as that of M&S—its role, mission, funding, management, realism, configuration control, and future.

From the very beginning of my professional career, computers and simulations have been constant companions. My first exposure to them was in the Biophysics Department at IBM's Thomas Watson Research Center, Yorktown, New York in the early 60's, while still in undergraduate school. It was a privilege to work with the professionals there, on what was to become the world's first computer-based teaching machine.

As I recall, an old IBM 650 and 704 were somehow hardwired together with an input station. This input station consisted of a small 8 x 8 foot windowless room, equipped with a seat and a boxy vintage IBM electric typewriter, which could take commands typed in by the "students" trying out the "teaching machine." It was exciting (and, at times, exasperating) as the fledgling software was written, corrected, improved and applied to help teach student volunteers how to read and write German, take court stenography, and perform elementary statistics.

My early exposure to the practical application of M&S quickly showed me that it is, indeed a two-way street. Computers and the models that make them serve us do some things well, some things not well, and other things not at all. Computers don't get tired, bored or show other signs of emotion, although I have heard people try to attribute emotions to them on occasion. They can retrieve and manipulate data extremely well. They are also unforgiving. Use a zero instead of the letter "o," or use a comma instead of a period and they almost seem proud to tell you that you've made a mistake (again). In a word, they're a tool—not the end.

Over the past couple of decades, I have watched as the Department of Defense (DoD) has made multiple attempts to manage its growing M&S investments, by promulgating policies regarding the development and use of M&S. In 1994, a major step in this direction was the formation of the Defense Modeling and Simulation Office (DMSO) to serve as the DoD lead in assuring that our M&S plans, practices and investments are well-founded and executed. These responsibilities are found in the DoD 5000 Directives, Regulations and Instructions. The Department has also published a variety of other documents relating to M&S including the *DoD M&S Master Plan*, *Simulation-Based Acquisition*, and other similar documents.

The problem today is that, while there are regulations, directives, charters and guidelines addressing DoD M&S, few, if any, are being taken seriously or put into practice. This fact, again, was recently made abundantly clear as I asked the over 200 attendees of the M&S Conference hosted in February 2001 in Reno, Nevada by the JTCG/AS to take a piece of paper and write four sen-

tences summarizing these regulations. Only two or three would even venture a public answer.

After all has been said and done in DoD M&S, much more has been said than done. While policy and procedures are needed and have been promulgated, I see little indication that they have been much more than a wish, an intention, a desire, but certainly not a reality or even a moving force.

Another data point that brought this into focus even more was a recent M&S survey which the DDOT&E/LFT office completed and published earlier this year. We examined M&S in support of acquisition programs to try to assess the state-of-affairs for a representative cross-section of current defense acquisition programs (22 to be exact). We were able to brief every Service Acquisition Executive, the DDR&E, and the USD(AT&L) on the results. From one came the observation, "SBA. Simulation Based Acquisition? That's just a slogan; it's a bumper sticker." There were other similar comments from those briefed reflecting the unanimous diagnosis that a less than healthy state of M&S management, funding, and application presently exists in DoD.

We all know that to get a remedy, we must first admit that we're sick, and then identify what that sickness is. The survey and other testimonials provide ample proof that these directives and regulations have gone unheeded for the most part and there's much work to be done before DoD complies with its own M&S directives. Let me list a few candid comments made at the Reno M&S conference worth noting—

- OSD is such a fragmented organization that you can find any opinion you want, maybe you'll even find a good one.
- Working with military instructions is like building a sauna out of ice cubes.
- All models are wrong, some are useful.
- Everyone wants commonality of models, but they want it in their way.
- There's no such thing as validating a model. Validation is just a failed attempt to falsify a model.

You might argue with a couple of these points, but it's clear that much remains to be done.

What are some of the M&S challenges facing the Pentagon today? Let me share my own personal feelings on the subject—

- Implement those DoD directives relating to M&S already on the books.
- Organize an M&S management enterprise (e.g., consortium) within DoD to directly support the program manager acquisition community across the board with DMSO in lead and adequate resources to do the job.
- Gain early substantial funding from program managers to invest in M&S enterprise either by mandate or by major revision in PM incentive structure.
- Implement a "Microsoft-windows" type of configuration control across M&S used in support of DoD.
- Reconcile the current dichotomy in modeling supporting the training/readiness community versus the modeling supporting the materiel acquisition community.
- Make M&S deliverables a requirement for each acquisition program to the maximum extent possible.
- Stop looking at M&S as a replacement for realistic testing. T&E and M&S are partners, not competitors.
- Stop advertising that M&S will initially save money. For a period of time, in fact, it will actually cost more to address M&S shortfalls since realistic T&E and realistic M&S must both be done to address current VV&A issues.
- Expand application of M&S to also assist in experimental design.
- Build into M&S by means of comment cards, monitor screen warnings and paper output, the shortfalls and assumptions intrinsic in the M&S being used as well as information on the configuration control POC.

Having made the above-mentioned proposals for the broader M&S community, what challenges face the survivability/vulnerability/lethality/M&S communities? Let me home in on several—

- We must develop and apply an M&S architecture, in cooperation with DMSO, which permits a meaningful and workable analytical bridge between platform state (level of damage and mission degradation) and combat effectiveness.
- We must avoid using these models and simulations as promotional gimmicks.
- We must assure that the most widely used models supporting the Survivability com-

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Assuring M&S Credibility for Defense Acquisition and T&E

by Colonel W. Ernest Crain

Khanh Ngo, Modeling and Simulation Information Analysis Center (MSIAC)

Today's complex weapon systems and systems of systems cannot be developed and evaluated through hardware-only test and evaluation (T&E). The reasons are many, but really come down to a cost comparison of hardware prototypes and hardware testing in the appropriate environments. Modeling and simulation (M&S) can help reduce those costs and other risks.

The DoD Simulation Based Acquisition initiative promotes the use of simulations throughout the life cycle of every weapon system, and among all weapon system development programs. There are tremendous time and dollar savings to be had, and perhaps zero environmental impacts and safety worries if we can wring out systems and certify their performance using M&S before we ever bend metal in production. During the Army's development of the Crusader cannon artillery system, for example, the program used more than 150 simulations. None of them were developed specifically for Crusader, which is an excellent example of how simulation reuse can save time and reduce costs. Extensive use of simulations allowed the Crusader team to re-baseline the system in a matter of weeks when they had to trim more than 40 percent of its weight to meet the Army's future lighter force requirements.

However, if program managers can't locate the M&S tools they need, and if after they locate them they don't have confidence in them to provide "credible" answers, then this capability is of no value. The challenge for the M&S community in supporting the Department's acquisition process is to make M&S resources accessible and, most importantly, credible.

To appreciate the Department's changing view of the importance of M&S to the acquisition process, take a look at the current DoD 5000 series of acquisition documents and compare them to what they replaced. The use of the words modeling and simulation have gone from a mere mention in a subparagraph, to M&S being emphasized up front in concept exploration, and planned for and used throughout the life cycle of

weapon systems. Dr. Delores Etter, former Deputy Under Secretary of Defense for Science and Technology, saw an increasing appetite for M&S tools as advanced technologies, both Government and commercial, promise significant increases in M&S capabilities. She also noted that many barriers still exist in M&S (e.g., human behavior representation, 4-D presentations) and supporting technologies (e.g., software intensive systems, processing power and bandwidth), but emphasized that DoD must continue to address those issues.

The Defense Modeling and Simulation Office (DMSO), as the Department's focal point for M&S, has focused its attention in three key areas that are benefiting not only the acquisition community, but the training, analysis and experimentation communities as well.

The first area is architecture. The DMSO-developed High Level Architecture (HLA) is the accepted standard for distributed simulations in the DoD. Further, it is becoming an industry and international standard as well. It has been accepted by the North Atlantic Treaty Organization (NATO); was adopted as an international standard by the Object Management Group (OMG) in November 1998; and cleared the final hurdle to becoming an Institute of Electrical and Electronic Engineers (IEEE) standard in September 2000. The functionality of the HLA is based on the premise that no one simulation can satisfy all uses and users. It allows an individual simulation or set of simulations developed for one purpose to be used for another purpose by federating them. The collaborative environments established at the Air Force Research Laboratory at Wright Patterson AFB, Ohio, and the Army's Night Vision Laboratory at Fort Belvoir, Virginia, are good examples of using the HLA in an acquisition process. Further, the HLA complements the Test and Training Enabling Architecture (TENA) in purpose, design, development, and implementation.

Visit the VV&A Recommended Practices Guide online at http://www.msiac.dmso.mil/vva/.

The second area of DMSO emphasis is environmental representation. DMSO investments in Integrated Natural Environment (INE) projects have lowered barriers to the use of M&S. INE projects include the Master Environmental Library (MEL), a one-stop shop for discovery and ordering data sources in all environmental domains; the Synthetic Environment Data Representation and Interchange Specification (SEDRIS) that allows standard data interchange and unambiguous data representation; and the Environment Scenario Generator (ESG) that offers tailored scenario generation and just-in-time-production ordering. What are the benefits? You can build tailored, physically consistent scenarios to achieve test plan objectives. You can generate environmental conditions that otherwise would be difficult to come by, such as those in denied areas of the world, or that would require risk of injury or damage to the environment. And, you can operate at slower or faster than real time to focus on critical system and/or environmental components.

Finally, the DMSO focuses on its role in developing DoD M&S policy, especially with respect to verification, validation and accreditation (VV&A). VV&A is the critical process for gaining assurance that a selected model or simulation can produce "credible" results. With community involvement, the DMSO led the development of DoD Instruction (DoDI) 5000.61, DoD M&S Verification, Validation, and Accreditation, which established common terminology and defined high-level roles and responsibilities across the Department. The DMSO also worked with the M&S community to develop the Web-based DoD Recommended Practices Guide (RPG), which defines the underlying philosophy, principles, and methodologies recommended for use in DoD VV&A efforts. You can review the RPG online at http://www.msiac.dmso.mil/vva/. While Department-wide application of those recommended practices will help assure the

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credibility of M&S, each of the Military services and DoD Components are responsible for developing VV&A policies and guidance to suit their organizational needs.

The level of use of M&S by DoD and industry is a paradigm shift—and the paradigm continues to shift as technology offers us bigger-better-faster. M&S is a proven, cost-effective tool for getting the acquisition job done cheaper, quicker, safer and cleaner, but taking full advantage of it will require the continued commitment, cooperation, education, and evolution of the M&S and acquisition communities.

The DMSO can promote the confident use of M&S for acquisition through the establishment of standards that encourage interoperability and reuse, through the development of environmental representation resources that reduce T&E costs and risks, and through the promulgation of Departmental policies and practices that guide the development of credible models and simulations, but in the end assuring the credibility of M&S for Defense acquisition and T&E is a task that has to be worked at all levels.

Colonel W. Forrest Crain, U.S. Army, has served as the Director of the Defense Modeling and Simulation Office since March 1, 2000. He received his commission from the United States Military Academy in 1975. He is currently pursuing a doctorate in Information Technology at George Mason University. He has served in a variety of combat arms positions throughout his career. Before joining the DMSO he served as Chief of Strategic Plans for the Multi National Division (North) in Bosnia. Colonel Crain turned the directorship of the DMSO over to Navy Captain Michael G. Lilienthal on September 4 and retired from active duty on September 7.

Captain Lilienthal is now the Director of the Defense Modeling and Simulation Office (DMSO), Alexandria, Va. Captain Lilienthal is a triple "Domer" of the University of Notre Dame. He received a B.A. degree in Psychology with a minor in Physics in 1973; followed by a M.A. degree in Experimental Psychology in 1975; and a Ph.D. in Experimental Psychology in 1978. He was commissioned in 1978. Captain Lilienthal was board certified as a Professional Ergonomist (No. 462) in 1994. Dr. Lilienthal is a fellow of the Aerospace Human Factors Association and the Aerospace Medical Association. He is also a member of the Human Factors and Ergonomics Society

***Editor's Note:** This article is a recap of Colonel Crain's presentation at the February 12-15 conference "Assuring Modeling and Simulation (M&S) Credibility for Defense Acquisition and T&E" in Reno, Nevada.*

AJEM Guru Retires

Tom Wasmund from the Naval Surface Warfare Center at Dahlgren, Virginia, retired on 30 September 2001 after over 40 years of government and military service. Tom graduated from the University of Washington with a BSEE in 1959, and started his career as a Navy pilot by entering flight training later that year. He also received a BSAE and a MSAE from the Naval Postgraduate School in 1966 and 1967, respectively. Among his other contributions, Tom has been the driving force behind the development of the Advanced Joint Effectiveness Model (AJEM) that just entered service this year. He has been a long time member and chairman of various vulnerability and lethality committees for both the JTCG/AS and the JTCG for Munitions Effectiveness (JTCG/ME), and has been the AJEM Project Manager since 1993. AJEM, sponsored by both the JTCG/AS and JTCG/ME, is a lethality/vulnerability/end game model meant to account for all types of warhead and projectile kill mechanism effects against all types of air targets in a single model. Tom has been cited by the Chairmen of both organizations for his outstanding leadership and perseverance in successfully carrying this project through to the release of AJEM 1.0 in July of this year. We wish Tom the very best in his retirement.

Personal Thoughts to our Colleagues...

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munity are promptly VV&A'd down to their source codes, correcting errors where possible and publishing cautions, assumptions and shortcomings explicitly as an integral part of the M&S output.

- We must migrate to best-of-breed models and cease supporting models which do not reflect the state-of-the-art for a given application.
- We must maintain effective and current configuration control of M&S under our purview.
- We must realistically account for secondary damage mechanisms and cascading damage.
- We must migrate from empirically-based M&S to physics-based vulnerability/lethality models.
- We must fully support the program management community without losing our objectivity.
- We must educate DoD and the private sector on M&S regulations, requirements, capabilities, databases and methodologies available and formalize a forum to ensure that this occurs on a regular basis.
- We must develop meaningful risk/cost-benefit methodologies which can support wise investment decisions and survivability design trades.

Survivability and lethality M&S and testing continue to be strongly supported by the Administration. The following response to a question on June 22, 2001 from Senator Strom Thurmond by the Honorable Michael Wynne, Principal Deputy Undersecretary of Defense for Acquisition, Technology and Logistics says it well—

"Live Fire Testing is an important and integral part of the Department's weapon system test and evaluation process, providing timely and accurate assessments of system survivability, vulnerability, and munitions lethality. Live Fire Testing also provides insights into methods of reducing the vulnerability and improving the lethality of weapons and weapon platforms, assessing battle damage repair capabilities and issues, and improving the computer modeling of weapons system lethality and vulnerability. I believe strongly that Live Fire Testing should be continued."

The DoD needs to reclaim its leadership in M&S. Recall that the very first computer and simulation was built for the U.S. Army under a contract with the University of Pennsylvania for the purpose of producing ballistic tables. Furthermore, the first image generated by a computer was also performed by the Army, that of a simple line drawing of an XM-1 tank, some 30 years ago at the Ballistic Research Laboratories (now ARL) at Aberdeen Proving Ground. While the private sector community has transformed the world of computers , the ability of DoD to effectively manage its M&S has not kept pace, resulting in waste, duplication of effort, and misuse of M&S in applications for which they have not been validated.

We've come a long way from the simple teaching - machine of the early 60's and the simplistic two dimensional black and white computer drawing of an Army vehicle, and for that, we're all grateful. We've gotten to the point where our computer-generated output looks close enough to reality that we could mistake it for the real thing. And therein lies the problem. I think too many in our community have extrapolated this leading-edge computer-aided design (CAD) capability to one of assuming that the physics of vulnerability/lethality/survivability of those computer representations is equally understood. Nothing could be further from the truth. Colonel Forrest Crain, DMSO's Director recently stated that "real progress in M&S will be determined by demonstrated benefits, not policy directives or rhetoric."

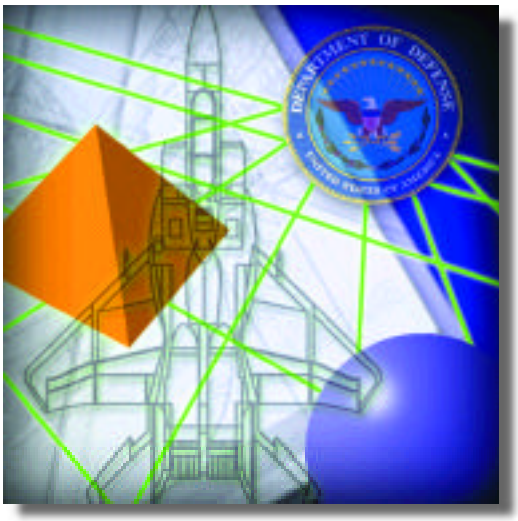
The JTCG/AS, working in close cooperation with the Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME), is uniquely positioned to provide that leadership within the survivability/vulnerability/lethality communities. I invite all readers of this publication to join us in this effort. I welcome your feedback. I may be reached at jobryon@dote.osd.mil.

Mr. O'Bryon serves as Deputy Director, Operational Test and Evaluation in the Office of the Secretary of Defense and has directed the Live Fire Test Program since 1986. He also has oversight responsibility for the JTCG/AS and JTCG/ME programs of the DoD. He is a graduate of The King's College, George Washington University and Massachusetts Institute of Technology

Modeling and Simulation in Operational Test and Evaluation

by Dr. Marion L. Williams and Dr. Frank Gay

Years ago, Clay Thomas, one of the Air Force's "wise old men," was quoted as saying "Artificial Intelligence has great potential—it always will have." Clay, known for his subtle statements, would probably have said the same thing about modeling and simulation (M&S). Over the past few years, many expectations for modeling and simulation (M&S) have outpaced capabilities. This has certainly been the case with respect to Operational Test and Evaluation (OT&E) applications. Like many Department of Defense testers, we are receiving increased pressure to reduce test costs by substituting M&S. Certainly M&S can increase the efficiency of the design and development process, create products that work better after fewer prototypes, and thus save time and money through fewer re-tests. Operational testers should be able to take advantage of these same simulations. However, with few exceptions, modeling and the integration of models into simulations are fragmented, under funded, and pretty much the exclusive domain of development contractors. The following is our view of how M&S should fit into OT&E and what we think is necessary to make this happen.



First the Basics

OT&E is defined in Title 10, U.S. Code, as "the field test, under realistic combat conditions, of any item of (or key component of) weapons, equipment, or munitions for the purpose of determining the effectiveness and suitability of the weapons, equipment, or munitions for use in combat by typical military users; and the evaluation of the results of such test." Title 10 also says that OT&E "does not include an operational assessment based exclusively on (a) computer modeling [or] (b) simulation." None of this precludes appropriate uses of M&S in support of OT&E. In fact, DoD 5000.2R stipulates that "test planning shall consider M&S," and "test results shall also be used to develop and improve models and simulations." It further states "when actual testing is not possible to support an operational assessment, such assessments may utilize computer modeling and/or hardware in the loop simulations (preferably with real operators in the loop)." DOT&E policy also permits using M&S to evaluate test results. So our formal direction is to use M&S for planning better tests and producing better evaluations of test results. Not to replace tests.

M&S may have its biggest impact in planning and predicting operational tests. During planning, simulations can help identify more profitable areas for testing, define data and instrumentation requirements, and provide a venue for running factor-screening experiments. Test predictions can significantly improve our test process by making sure that we understand what to look for and to help us recognize when events depart from

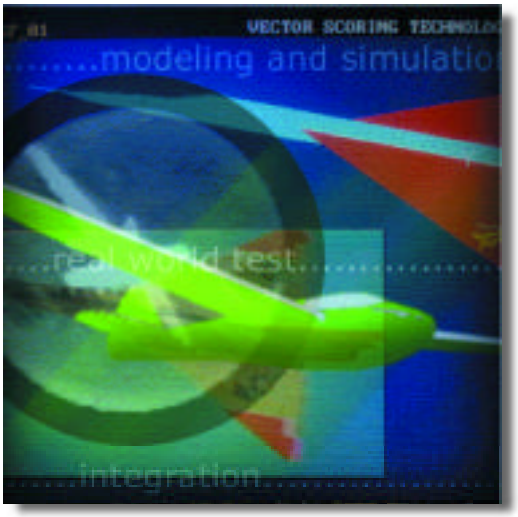
the expected. The trick is to do this at a cost that doesn't exceed benefits.

Our experience has been that simulations needed for test planning or test prediction are rarely available in a form usable by operational testers. Usually models developed to support acquisition are internal products of the developer. The models are not documented, are not a deliverable, and the results of specific studies using the models are not in a form releasable to external agencies. We have tried to develop models for our own OT&E use, or to significantly modify existing models. But the results have been very high costs ($10+ million for one program) with minimal benefits. We either started too late, or ran out of money—or both.

On a more positive note, we have had some success in using models for operational assessments. Air-to-air missile developers routinely use modeling for system design and development, and operational testers have been able to take advantage of this investment. A recent example is the AIM-9X, where the program office and contractor included the testers from the beginning, incorporating functionality for testers and faithfully including their validation requirements.

Models used to predict test results have been more valuable when there is feedback from the test into the model to correlate the results, correct model inaccuracies, or modify incorrect assumptions. But we have learned that tests must be planned with such correlation in mind. It has been very difficult to correlate models and tests after the fact. In one particular effort designed to correlate model and test results, we were never surprised when the model of the test item was used, but were always surprised when the actual test item was used. There were always factors in the test that were not accounted for in the model. Once we learned of the problem, the model could be corrected.

M&S in OT&E will become cost-effective tools only when we learn to routinely leverage on M&S investments and efforts by developers. There should be an integrated M&S plan for each acquisition program outlining the requirements for each application, and with a coordinated modeling effort. Models used by contractors for design should be made available for other applications, including OT&E. There needs to be a plan for comparing test data with model data throughout the acquisition cycle so that the model-test-model process is continuous from initial development through operational testing and employment. In many instances there



is no convenient way for this to happen except in an ad hoc manner.

Use of models in direct support of OT&E is an important topic, but largely undefined. We know that models can support testing, but our mission is to put the real system in the real environment with real operators to make sure it can accomplish its operational task. We fully understand that even a field test of a system is a simulation of the true operational environment, but it provides the only opportunity to make sure that the system works not only as designed, but accomplishes the intended mission. The truest source of OT&E data is from a real test item in a test environment. Sometimes an acceptable substitute is the real test item in a simulated environment. For example, a realistic electromagnetic environment is often impossible to create outdoors. So we use facilities such as anechoic chambers to stimulate a real test item with a dense electronic environ-

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Air Force M&S Policy

by Lt Col Gerry Smither and Lt Col Skip Langbehn

A dramatic shift has occurred in the development of Air Force Modeling and Simulation (M&S) policy. This article contrasts the old and new ways of developing policy and addresses Verification, Validation and Accreditation (VV&A) as a specific topic.

Headquarters Air Force, Directorate of Command & Control (AF/XOC) is the Air Staff organization responsible for developing Air Force M&S policy. This policy is implemented through directives and instructions. Secretary of the Air Force for Acquisition, Information Dominance Directorate (SAF/AQI) is the organization on the staff of the Secretary of the Air Force responsible for M&S policy for acquisition. Because of this tie, the two organizations work closely together.

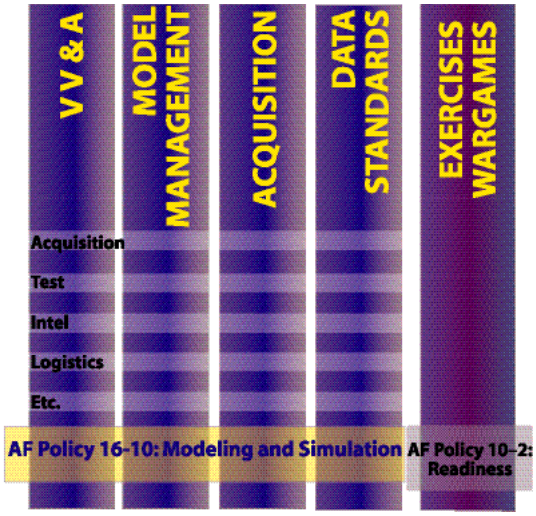

Figure 1. Air Force M&S Policy—Previous Structure

M&S Policy—The Old Way

Figure 1 depicts how Air Force M&S policy used to be structured. Air Force Policy Directive (AFPD) 16-10 provided general guidance and objectives and served as an umbrella for Air Force Instructions (AFIs) that provided specific guidance. As Figure 1 shows, however, the AFIs developed under this policy did not have a consistent theme or focus. Some AFIs were M&S-centric, such as those on VV&A, Model Management, and Data Standards while the AFI on Acquisition was functionally oriented. Extending across these AFIs were crosscutting functional areas such as acquisition, test, intelligence, and logistics. Each AFI was first drafted within AF/XOC and then coordinated across the Air Force. After years of effort, only the AFIs on VV&A and Exercises & Wargames made it through the coordination cycle successfully and were published.

Unfortunately, the AFI on VV&A was successfully coordinated and published only after it was watered down and broadened to the point where it gave only vague guidance making it practically useless. Why didn't this approach to AFIs work? Before answering this question, we need to address VV&A and its links to M&S in the decision process.

V&V—How Much Is Enough?

Models and simulations provide information as one of many inputs to a "decision-maker". Thus, models and simulations are merely tools used in a process designed to achieve a result. Figure 2 outlines this decision-making process from an M&S perspective.

An informed decision is made by the decision-maker based on alternatives presented by the trained analyst who has done a careful analysis, grounded in accredited models and simulations carefully chosen from a strong base of possibilities that have been verified and validated for that purpose. Drawing conclusions (the "decision") is the responsibility of the decision-maker. The purpose of the analysis is to provide critical insights and present a cogent summary of results to the decision-maker.

From an M&S-centric perspective, the analysis depends on accredited information provided by a suite of verified and validated models and simulations. Therefore, the experienced decision-maker is critically dependent on V&V. In reality, the decision-making process rarely works as shown in Figure 2.

Figure 3 shows what really happens. The decision-maker makes an informed decision—PERIOD!

Everything else below the line may or may not influence the decision-maker and the decision made. The tenuous chain that links M&S and V&V to the decision-maker is easily broken—with good reason.

As General Shaud, the former Chief of Staff, Supreme Headquarters Allied Powers Europe, said, "process is no substitute for careful thought." Results from M&S are simply one of many inputs to the decision-maker. This begs the question "how much V&V of the models and simulations is enough?" The M&S party line says that VV&A is all about risk reduction, not for the M&S community, but for the decision-maker. However, the reality

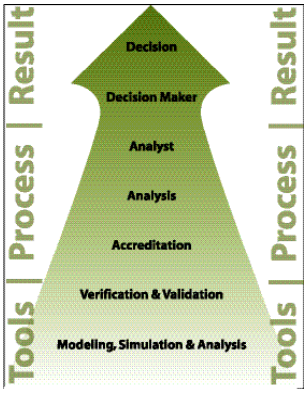

Figure 2 . Decision-Making Process—The Theory

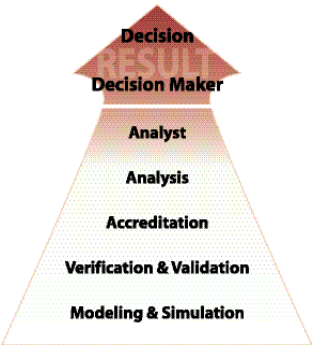

Figure 3. Decision-Making Process—The Reality

is that decisions, even bad ones, will be made regardless of the quality or quantity of V&V. When a "bad" decision happens there is an inevitable search for the guilty party. V&V won't be the reason for the bad decision, but overlooking it makes M&S an easy, obvious target. Once M&S is found guilty, the search stops.

VV&A is used to develop a clear understanding of the strengths and weaknesses of the tools being used. Unfortunately, all the V&V in the world will not stop a bad analysis, sidetrack a bad decision, or save a troubled program. Given all of this, why do we continue to focus much of our attention, much of our funding, and much of our effort on the V&V of models and simulations when V&V is, by any understanding, only a small part of the story? The answer is that it's easier to focus on the "tools and toys" rather than on the people and processes. To compound the problem, attempting to write a single policy to guide V&V policy almost guarantees a "one size fits all" mindset.

As Figure 4 illustrates, a "one-size" V&V does NOT fit all. In fact, there's a spectrum of V&V that ranges from relatively useful to practically useless. One line of the diagram indicates the relative "usefulness" of V&V, while the other line indicates the relative situational complexity. The left side of the diagram is characterized by few systems and generally one ver-

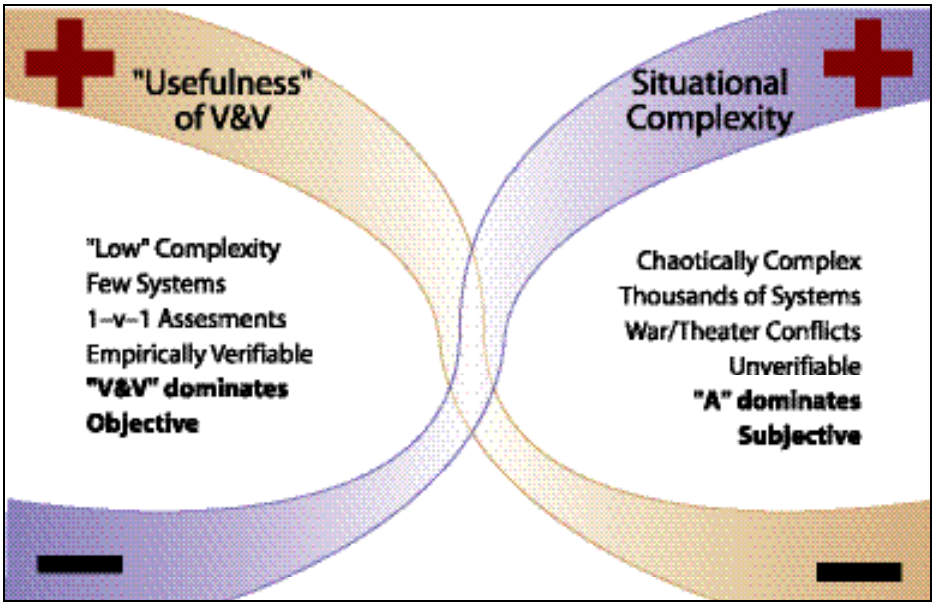

Figure 4. The Spectrum of V&V

sus one assessments that are detailed but show low situational complexity. V&V dominates in this realm and tends to be very objective and empirically verifiable. Examples can be found in the M&S done by the Test and Evaluation community where detailed engineering modeling demands rigorous V&V.

The right side of the figure represents a chaotically complex situation, characterized by thousands of systems and generally force-on-force assessments that are empirically unverifiable. In this situation, theories abound and facts are few. Accreditation dominates in this realm and V&V tends to be very subjective. Warfighting decisions fall into this category—

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David H. Hall

by Mr. Dale B. Atkinson

Dave Hall, who has been a mainstay of the JTCG/AS, has decided to retire in January 2002 and we want to take this opportunity to recognize Dave for his long service and many contributions to the JTCG/AS, JTCG/ME, SURVIAC, and the overall survivability community over many years.

Dave grew up in Lakewood, California and received a B.S. and M.A. in Mathematics from California State University in 1968 and 1972, respectively. Dave worked his way through college at Disneyland, first selling ice cream and then picking up trash. Dave met his wife, Terri, his freshman year in golf class and they were married in June 1968.

A week later, Dave went to work in the Fuze Department of the Naval Weapons Center that was originally located in Corona, California. He worked as a mathematician evaluating fuze concepts for Standard Missile, the ZUNI rocket, a non-nuclear hard point defense missile, and other related systems. In 1972, he became an operations research analyst in the Weapons Analysis Division where he wrote a major portion of the Exploratory Development Requirements Document on S&T initiatives for Navy airborne weapons systems and conducted analyses to support the identified requirements. He worked on a major project to develop and implement a methodology to evaluate advanced weapons system design concepts, tactics, and force structure that involved working on a daily basis with operational Navy pilots. He also conducted a Lanchester analysis of the Yom Kipper War that introduced him to the survivability area.

In 1977, Dave went to work for John Morrow in the Survivability and Lethality Division, and has worked in the survivability and lethality area ever since. He initially managed a project to develop a methodology for evaluating alternative survivability enhancement features for Marine Corps helicopters against air-to-air threats. In 1979 he became head of the Ordnance Systems Evaluation Branch where he supervised 10 weapons systems analysts performing design analyses of anti-air ordnance for a variety of weapons systems, including Phoenix, Standard Missile, Sparrow, AMRAAM, AIAAM, and other systems in exploratory development. Dave was introduced to the JTCG/AS when he attended a meeting of the Vulnerability Analysis Subgroup at Wright-Patterson Air Force Base. Dave also represented the Division in the JTCG/ME as well as the on The Technical Cooperation Program (TTCP) fuze and analysis working groups. TTCP is a cooperative effort with the nations of Australia, New Zealand, Canada and the United Kingdom.

In 1984 Dave became the Chief Analyst of the Survivability Division, providing technical oversight of all division projects, and is also the Branch Head of the two analysis Branches in the Division, supervising up to 30 scientists, engineers, and analysts. The Survivability Division is responsible for developing and demonstrating air vehicle survivability technology, and tracking the maturation of that technology into the fleet. The analysis branches are responsible for evaluating requirements and technologies in the disciplines of air combat survivability and anti-air missile lethality. Weapons Systems supported by Dave and his people include the F-14, F/A-18, V-22, A-12, AX, A-6, AV-8B, H-60, H-1, H-46, H-53, Tomahawk, as well as others.

Since 1987, Dave has served as the Chairman of the JTCG/AS Methodology Subgroup (now the Survivability Assessment Subgroup) coordinating the development of survivability methodology across the Services. Dave's outstanding methodology expertise and friendly and cooperative manner served him and the JTCG/AS well over the years. The Methodology Subgroup has done a lot with relatively little funding, under rapidly changing Service and OSD M&S initiatives, and changing times in the acquisition world in general.

From 1992 to 1996, he also served as the Joint Project Manager for the OSD sponsored Susceptibility Model Assessment and Range Test (SMART) project. SMART developed and demonstrated joint model and

simulation verification, validation, accreditation, and configuration management processes now being used by the Joint Strike Fighter (JSF) and many other organizations and programs. This effort resulted in the establishment of the Joint Accreditation Support Activity (JASA), which provides M&S support services to many DoD system acquisition programs, such as the JSF, the F/A-18E/F, AIM-9X, ESSM, RAM, and others. In 1997 he received the National Defense Industrial Association's Survivability Leadership Award for planning and executing the SMART project that developed "a rational cost-effective process for verifying, validating, and accrediting (VV&A) models that support acquisition decisions." Dave said that the SMART project was the most interesting major project he was involved with over the duration of his career, and he really appreciated the opportunity to work with an outstanding team of professionals, from both Government and industry. Dave also said that the JASA team that developed from the SMART project has been a joy to work with and has provided invaluable support to a number of acquisition programs.

During this time, Dave also represented the U.S. on the TTCP Panel for Weapons Evaluation where he served as the U.S. Mission Effectiveness Focus Officer and led a key technical area investigating cooperative analysis techniques for the evaluation of advanced weapons systems technology initiatives. Dave has also been the Navy JTCG/AS member of the SURVIAC Technical Coordinating Group (TCG), composed of both JTCG/AS and JTCG/ME members. The TCG provides technical oversight of SURVIAC.

During 1998 and 1999, Dave served as the Modeling and Analysis lead for the JSF Survivability Integrated Product Team (IPT) under the JSF Joint Program Office's Systems Engineering Directorate. He was responsible for coordinating survivability methodology and analysis used in support of system design and evaluating alternate technology options. Dave is also the chairman of the Naval Air Warfare Center Weapons Division (NAWCWD) Analysis Resources Science and Technology (S&T) Network. The Network coordinates analytical resources and technologies across the various sites of the Center and administrates discretionary funds for improvements in analytical capabilities for evaluating S&T initiatives.

Dave is also as a member of the NDIA Combat Survivability Division (CSD) Executive Board as well as the Chairman of their Strategic Planning Committee. Dave has taught the analysis, modeling, and simulation part of Professor Ball's survivability short course since 1985, and continues to do so. Dave has received numerous awards over the years, including being selected as a Fellow of the Naval Weapons Center in 1993 and the Michelson Laboratory Award in June 2001.

Dave is very proud of his wife and family. His wife, Terri, served as the CEO of Desert Area Resources and Training (DART), a non-profit agency that serves developmentally disabled adults and children. Terri worked there 27 years and upon leaving recently, DART announced that they are naming a new building after her. RADM Johnson, the NAWCWD Commander, also presented her with a plaque for her service to the Navy and the community. Their two children, Julie and Jason, are both grown and have successful careers of their own. Dave and Terri moved to the coast in Carlsbad, California in July of this year, where Terri has accepted a position as Director of an agency serving the homeless. Dave is commuting to China Lake until he retires and then plans to become a consultant upon his retirement.

On behalf of the JTCG/AS and the survivability community as a whole, I would like to acknowledge Dave as someone who has made a difference and express our appreciation to him for doing such an outstanding job over the years. We wish him well in his new career as a consultant.

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as the situational complexity increases, the relative importance of V&V decreases. The bottom line is that V&V, while useful, is not the key player in command decisions.

Perhaps the term "VV&A" should be recoined as "A V&V" to remind us of the spectrum of V&V that exists and the relative importance of Accreditation and Verification & Validation. As author Steven Covey reminds us in his book, *The Seven Habits of Highly Effective People*, "begin with the end in mind." Although VV&A represents the chronological order of events, this terminology generally conveys the notion that Accreditation is an after-thought and that a "one size fits all" V&V exists. For planning purposes, the Accreditation decision and process must be considered first. The key to successful V&V is a clear understanding of the decision being made, the decision-maker, and the relative importance of the information being provided

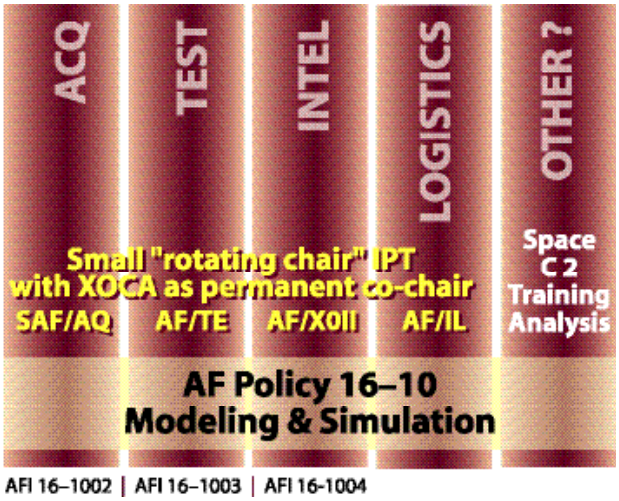

Figure 5. Air Force M&S Policy—New Structure

by the M&S. Only then can the V&V of the models and simulations be properly scoped and planned.

With this discussion of VV&A as background, we're back to our original question, "why didn't this approach to AFIs work?" Even though the current AFI on VV&A was successfully staffed and approved, it was practically useless because the guidance it provided was too broad. In a briefing to (then) Brigadier General Sandstrom of AF/XOC, one author of this paper offered the following choice "we've been almost spectacularly unsuccessful at writing, staffing, and getting coherent 'policy' out to the Air Force." Either "the civilians and military...both past and present, are unwilling, untrained, unable, uneducated, underachievers too ignorant to properly write and staff a package," or "we're going about this wrong." Fortunately, Brigadier General Sandstrom chose the latter reason and agreed with the conclusion that, "we've been trying to write broad guidance for folks who need specifics."

As a result, we came up with a new approach to develop M&S policy by using Integrated Product Teams (IPTs). By rotating Figure 1 by ninety degrees, the focus is now on the functional areas and how M&S should be used in a supporting role rather than writing M&S policy for the sake of M&S. AFPD 16-10 now acts as the umbrella for a series of functionally oriented AFIs. We formed a small, dedicated IPT with a rotating co-chair to develop the AFIs. One chairperson was drawn from the functional lead while the other co-chair is from AF/XOC. AFI 16-1002, M&S Support to Acquisition, was the first AFI developed. Our effort was chaired by SAF/AQI and co-chaired by AF/XOCA. As the focus shifts to a different functional area, a different IPT member is designated as the chairperson, but the core members of the team remain the same. This structure allows the IPT to create AFIs that are linked, address a specific functional problem, and incorporate crosscutting M&S issues. Finally, having the same IPT members has the added benefit of avoiding "stovepiped" approaches.

Without a "community" or functional area focus we lose support for M&S. Broader issues like "VV&A" and "data standards" lose meaning and support when separated from the end user. Experience shows we can either write ineffective M&S AFIs that attempt to be all things to all people or write tailored AFIs that address specific functional area needs. This AFI team is designed with cross-functional representation with, as a minimum, representatives from logistics, test & evaluation, acquisition and intelligence. The IPT drafts each AFI by identifying problems in the particular functional area being addressed that the use of M&S could help resolve.

AFI 16-1002, M&S Support to Acquisition, was published in June 2000. AFI 16-1003, M&S Support to Test and Evaluation, is now in coordination and publication is planned for the Fall timeframe of 2001. The third AFI in the series, AFI 16-1004, Threat M&S Validation, is now in final draft form and ready for the first round of

coordination. This functional approach allows M&S issues like VV&A to be addressed within the functional AFIs, allowing us to cancel the separate AFI on VV&A.

Summary

- The Air Force is taking a functional approach to the development of M&S policy.
- Good policy helps people in the field do their job better. Don't write broad guidance for folks who need specifics.
- Modeling and simulation is only a small part of the story. It's important to understand where it fits in the overall "big picture." Don't focus on the tools and toys rather than on the people and processes.
- VV&A, while useful, is not the key player in command decisions. There is no "one size fits all" when it comes to V&V, but rather a spectrum of V&V depending on the situational complexity.
- V&V should not be "the tail that wags the dog." It's important to separate the "V&V" from the "A." A more appropriate term for "VV&A" is "A V&V" to emphasize that Accreditation should determine both the scope of the M&S effort and the V&V required.

Lieutenant Colonel Gerry Smither was a co-chair of the Integrated Product Team that developed AFI 16-1002, M&S Support to Acquisition. Until recently, Lt Col Smither was the Air Force Program Element Monitor for Modeling and Simulation working in the office of the Secretary of the Air Force (Acquisition), Information Dominance Directorate SAF/AQI. This office is responsible for acquisition modeling and simulation policy within the Air Force and acquisition oversight of modeling and simulation programs. Lt Col Smither is now with the Single Integrated Air Picture (SIAP) System Engineering Task Force

Lieutenant Colonel Skip Langbehn was a co-chair of the Integrated Product Team that developed AFI 16-1002, M&S Support to Acquisition. Until recently, Lt Col Langbehn was a member of the Air Staff as Chief, Analysis Development Branch, MS&A Programs Division, Directorate of Command and Control (AF/XOC). This office is responsible for Air Force Modeling and Simulation policy and programs. Lt Col Langbehn is now with the Joint Staff in J-8/Forces Division. He may be reached at skip.langbehn@js.pentagon.mil.

Modeling and Simulation in Operational Test and Evaluation

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ment. But we don't want to generate operational test results with a model of the test item.

Operational testers are in the front of the pack in attempting to use M&S to improve testing. We want to do it where it makes sense, and where models to support those efforts are already available. We are not, however, planning to replace operational testing with simulation, to use M&S in areas where it doesn't make sense, or to use inadequate models.

Dr. Marion L. Williams is the chief scientist, Headquarters Air Force Operational Test and Evaluation Center, Kirkland Air Force Base, New Mexico. The center is responsible for testing more than 250 major programs at 20 different locations worldwide. Serving in this role since 1980, he provides technical direction and guidance to the AFOTEC commander, the headquarters staff, the AFOTEC detachments and operating locations, and various external organizations to ensure the scientific proficiency of Air Force Operational Test and Evaluation. Dr. Williams received his B.S. in Aeronautical Engineering from Texas A&M University in 1956, his M.S. in Mechanical Engineering from the University of New Mexico in 1971, and his Doctorate Degree in Industrial Engineering and Management (Operations Research), from Oklahoma State University. Dr. Williams is a Fellow of the MORS and recipient of the prestigious Vance R. Wanner Memorial Award for contributions to military operations research.

Dr. Frank B. Gray is the Deputy Technical Director, Air Force Operational Test and Evaluation Center, Kirkland Air Force Base, New Mexico. He is Responsible for technical oversight of F-22, Joint Strike Fighter, and other tests conducted by the Special Test Directorate. Dr. Gray has been involved with test and evaluation in the Air Force since 1978. He received his B.S. and M.S. in Aeronautical Engineering from Ohio State University, and his Ph.D. in Industrial Engineering and Experimental Statistics from New Mexico State University

Survivability, Lethality and Effectiveness—What's in a Word?

by Dr. Paul H. Deitz

Issues of survivability, lethality and effectiveness (S/L/E) have been around a long time. In fact it can be argued that Operations Research (OR) matured as a discipline during World War II.[1] In a field that has been subject to over 60 years of measurement, modeling, and analysis one might assume that associated terms, methods and phrases should be clear and precise to all practitioners of the art. But this is not necessarily the case. Surprised? Well then, contemplate the following questions—

- Why do all S/L/E metrics seem to fall in the range [0.0 < x < 1.0]?
- Most estimates in S/L/E are posed in terms of probabilities. What are the sources of randomness?
- Why are single (S/L/E event) outcomes usually described as probabilities?
- What dimensions, if any, are associated with S/L/E metrics?
- What field observables are comparable to the standard S/L/E model metrics?

During the onset of live-fire testing and modeling in the 1980s, the answers to these questions weren't so obvious to the ballistic vulnerability workers in the Army. The initial live-fire (LF) tests against the M113 and then the Bradley resulted in a multitude of contentious issues concerning methodologies for choosing munitions/hit points, the value (if any) of models, and the comparability of models and tests. During the period of the Abrams live fire program, some new strategies were developed.[2] At the foundation of those strategies has been an evolving attempt to systematize and structure the elements of S/L/E in order to clarify meanings, to establish clear causal (i.e., time-forward) event chains, and illuminate comparable model-test metrics.[3-5]

Figure 1 illustrates one such effort in that process. In the middle of the figure are listed six specific levels or metric classes that are typically encountered in an end-to-end weapon analysis. Level -1 embodies the characteristics of weapon detection and identification. Level 0] represents the weapon conditions at warhead launch. Level 1 represents the characteristics of a weapon at the moment it begins to interact (e.g., hit or detonate) at the target. Level 2 represents the state of the target components (i.e., killed, not-killed) after interaction with the threat. Level 3 represents the related platform capability states (e.g., ability to move, communicate, sense, engage, replenish) of the platform. Level 4 represents the utility state of the platform (e.g., ability to service usefully a particular mission).

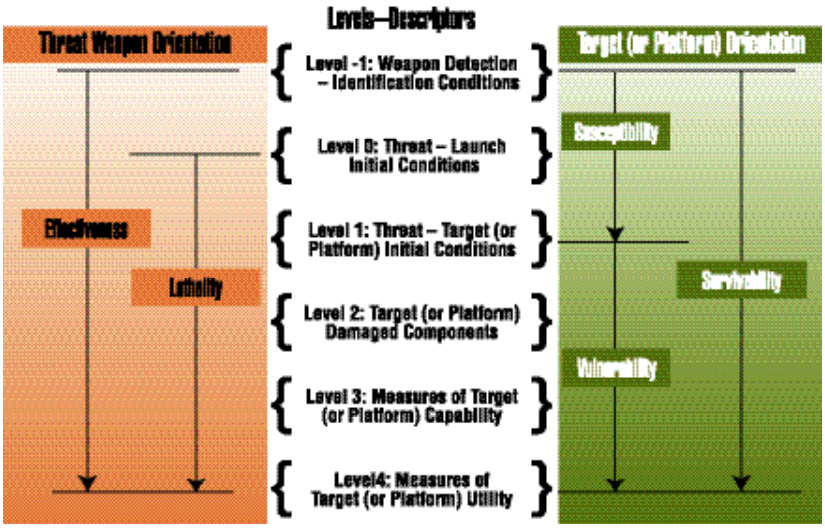

Figure 1. Levels Relevant to Survivability, Lethality, and Effectiveness. Lethality and Vulnerability are often used to pursue different agendas. Typically, (Weapon) Lethality (left side of diagram) is analyzed beginning with the weapons launch at Level 0. Thus warhead hit dispersion at the target is factored in. To estimate complete weapons Effectiveness, weapon target detection and identification must be included as well. By contrast, Vulnerability (right side of diagram) normally starts with an assumed hit at Level 1. Susceptibility covers all of the prior factors leading up to a hit. Survivability provides the overall accounting.

From the Target (or Platform) Orientation shown on the right of Figure 1, the issue of Vulnerability assumes the initiation of warhead-target interaction (Level 1) and generally proceeds through an estimate of target (or platform) utility. The key events leading up to warhead interaction with a target can be wrapped in the term Susceptibility. The processes of Susceptibility and Vulnerability when combined end-to-end can be described as Survivability.

By contrast, from the Threat-Weapon Orientation shown on the left of Figure 1, Lethality includes not only issues of target engagement (Level 1) through target utility (Level 4), but the warhead delivery as well; hence the addition of Level 0. For an overall estimate of Effectiveness, many analyses also include weapon detection-identification; hence the addition of Level –1. These levels describe a complex set of events as a sequence of physical states that occur just as one physical or engineering process ends and another begins. Thus the output of one process forms the input for the next.

To complete this paradigm, we require a set of operators to connect the physical states. In Figure 2, we repeat the description of the Levels or physical-engineering states on the left-hand side. In the center of the figure, we represent each Level by an ellipse populated by various state vectors (shown as bullets •). We use the notation $O_{n,n+1}$ to denote a mapping from Level n to Level n+1. The operator abstraction, $O_{n,n+1}$, represents a way to describe actions covered in one of the following:

- Physics-based tests, typically of the $O_{1,2}$ operator
- Engineering-based tests, typically of the $O_{2,3}$ operator
- Operational tests, that specifically focus on the $O_{3,4}$ operator
- Developmental tests, that examine any of the mappings between Level –1 and Level 3
- Mission training, that focuses on the relationships between Level 3 and Level 4
- M&S by means of which abstractions are developed to represent the physical, engineering, or operational activities represented by each of the Operators

It is this last property, that a dual is formed between actual physical, engineering, operational states and test activities (operators) on the one hand, and M&S physical, engineering, operational states and simulated operators on the other, that holds the possibility for model validation. Clearly validation is possible only if the model abstractions, as described by the Levels, and the physical measurements, gathered via experimentation, are fully equivalent. Here are a few observations about the Levels—

- However many levels one chooses to model, the mappings are generally complex and stochastic
- The metrics of Levels -1 through 3 are physically based and measurable
- The metrics associated with Level 4, Effectiveness, are generally not measurable
- The development of Probability Density Functions (PDFs) for each metric at each Level is crucial
- The results at a given level are due to all that preceded (i.e., the factorial of parameter growth problem)
- There are no state vectors at any Level described by a probability. However, PDFs can be estimated at any Level by computing multiple state vectors and observing fractional occurrences of specific outcomes.

Given this level of problem decomposition, it is easy to understand the challenges LFT brought to the M&S domain. Consider a vulnerability test in which the initial conditions have been established. This sets the conditions at Level 1, right-hand side in Figure 1. This is sometimes described as the end-game analysis. From the moment when a warhead strikes a target (or a detonation occurs in proximity), the following operator sequences must occur to result in a credible Level 4 utility estimate—

$O_{1,2}$ Mapping: Beginning with the initial threat mechanism, e.g. fragment(s), jets, blast, all relevant derivative mechanisms must be inferred as well (e.g. fire, smoke, shock). These threats must then be juxtaposed against all the target components with which they can interact. Based then on the character and magnitude of the threats and the susceptibility of each component, a decision must be made as to whether a "kill" has occurred. The difficulty of this estimate is increased when multiple damage mechanisms are present and where no single threat is capable of a kill, but significant damage aggregation can occur, none-the-less.

$O_{2,3}$ Mapping: In this step, the components judged to be killed by the O1,2 Mapping process along with those properly performing are transformed to a series of platform performance metrics. Examples might include main armament rate-of-fire, number of G's turning rate, the number of feet per minute rate-of-climb. The process can be performed a number of ways; in some cases engineering models exist for this purpose. Often fault trees are used for this estimation.

$O_{3,4}$ Mapping: This operator takes measurable performance at Level 3 and transforms Measures-of-Performance (MoPs) to Measures-of-Effectiveness (MoEs) at Level 4. This transformation, couched in mission performance, may be the most difficult to frame completely and objectively. Clearly there is a complex interplay among the possible combinations of MoPs and particular MoEs.

Most legacy V/L models have tended to blur the physical and engineering processes that begin at Level 1 and end at Level 4. The development of physical and engineering abstractions for each operator represents a complex challenge; if these transformations are prematurely combined, the chances for a credible VV&A process are greatly diminished. The collapsing of the operators between Levels 1 and 4 is an example of what can be called lumped-parameter modeling. By this kind of approximation, physical and engineering complexity is oversimplified and there is not adequate or accurate parameterization of the determining variables. Thus, key intermediate observables are not estimated and final observables are insufficient to validate model results.

Is all of this simply notional? Actually, no! The vulnerability structure illustrated in Figure 2 was used to construct the direct-fire vulnerability model SQuASH in

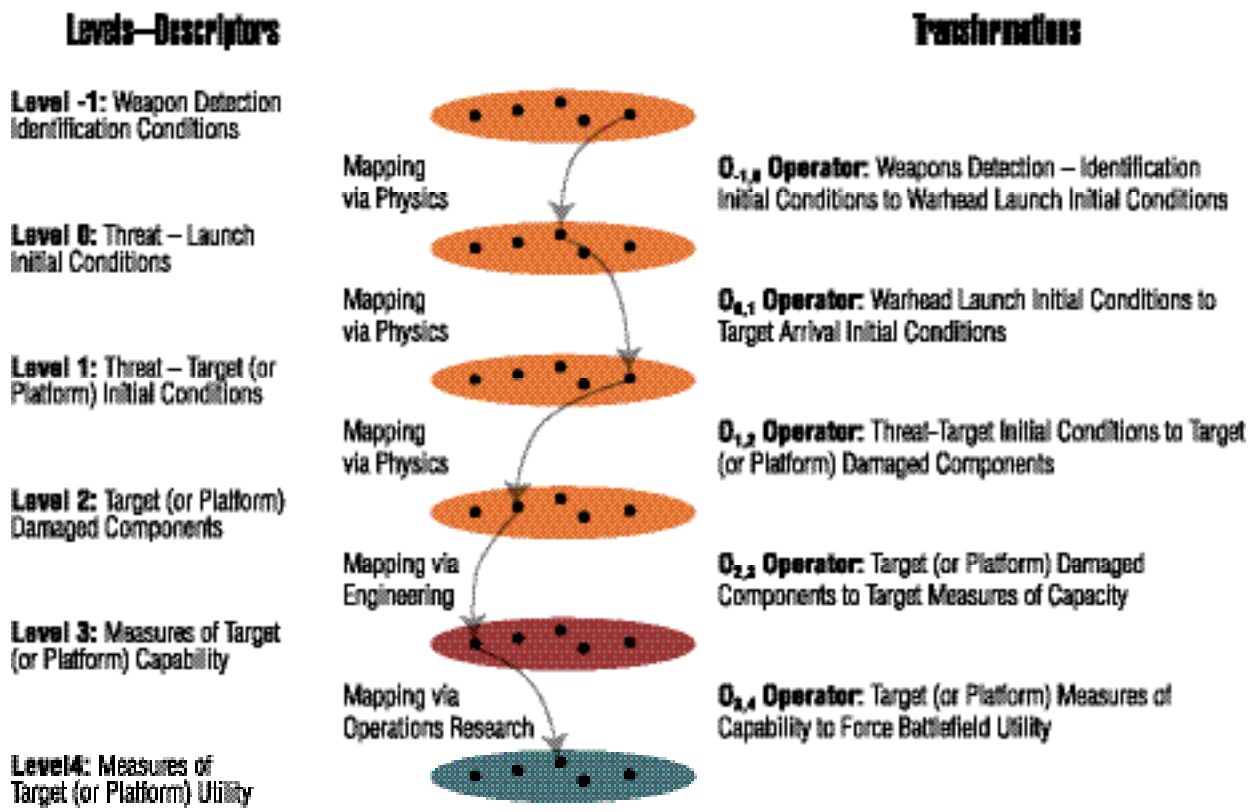

Figure 2. A Mapping Abstraction. The ellipses in the middle column represent mathematical spaces. The bullets (•) contained within the spaces represent vectors. The arrows represent mapping operators that take a vector at one Level and perform a mapping to a vector at the next lower Level. On the left, the descriptors for the various Levels are given; on the right, the actions of the various operators. Note the single connected path of arrows from Level –1 to Level 4 represents a single sample in an end-to-end connected process. As shown here, the initial conditions at Level –1 could be drawn stochastically or input deterministically. Since many of the succeeding operators ($O_{1,0}$ to $O_{3,4}$) are stochastic, the results from Level 0 through Level 4 usually represent a set of connected stochastic metrics in outcome space.

support of the Army Abrams Live-Fire program. Later the framework was used to generate a new vulnerability environment appropriate to direct-fire and indirect-fire ground and anti-air targets.[6] It was also used to improve greatly the context for the estimation of personnel casualties,[7] including a context for operational effectiveness. These ideas emerged as well in indirect-fire code to support vulnerability estimates against logistical and tactical targets.[8-10] And this same code formed the foundation for the V/L portion of the Advanced Joint Effectiveness Model (AJEM).[11,12]

Finally, in pursuit of the important DoD mandate to perform code VV&A, the model-measure dual described above has contributed to improved methods to compare intermediate and final vulnerability metrics.[13-15] One of the most important strategies to emerge has been the practice of developing probability density functions (PDFs) for each class of model metric and then comparing particular test-derived measurements against the distributions. Due to sample restrictions, single outcomes may serve only to reject model algorithms; however as sample sizes increase, confidence in model predictions can be built.

Earlier we asked, "What's in a Word?" Over the years some of the words used by the community to represent various metrics and processes have not necessarily been applied in the same way. The constructs of Figures 1 and 2 were developed to provide better precision and more informed meaning. Armed with these observations, it is possible to build more rigorous abstractions, executable codes, and credible VV&A Strategies.

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A Need for Speed

by Mr. Jon S. Ogg

Has Acquisition Reform been a success or a failure over the past decade? I will argue it has been both, depending upon one's perspective. From the vantage point of the acquisition community it is viewed, overall, as positive. Under the banner of acquisition reform we have seen some significant efficiencies in contracting, both in the business sense of the word as well as industrial base and work force. We have made progress in moving to a more streamlined business model— adopting and adapting best practices from the commercial sector. Further, we have developed long term relationships with our industry partners both in acquiring weapon systems and sustaining them while moving from an oversight to insight role in conducting our business. DoD is no longer leading in the development of key technology areas, especially electronics, but rather leveraging off of the continuous refreshment of commercial technology brought about by the boom in the rapid and seemingly endless market thirst for better, faster, cheaper. In addition, the focus or infatuation on reducing waste has driven a national "Lean" movement that is serving to propel industry, and to a lesser extent Government towards improving efficiencies and productivity. This, in turn, is driving further consolidation or contraction of both the Government and industry industrial base resulting in fewer, but more capable, production and sustainment facilities.

Another dimension to this reform movement is nearly a 50 percent reduction in the human capital involved in acquisition over the past decade. The military specifications/standards (specs/stds) crusade of the early 90s brought about by then Defense Secretary Perry, proclaimed that Government specs/stds would be the exception. This government standards reduction and the myriad of other Government streamlining initiatives has provided increased flexibility across acquisition, albeit not without some attendant collateral damage for programs that have attempted to push the reform to the limit. Yet, in the aggregate, the reform movement has had a net positive impact on the way we acquire and sustain weapon systems for our ultimate customers—the Warfighters.

As for the counterpoint, place yourself in the Warfighter's seat. Has reform placed more capable (better) systems into their hands quicker (faster) and at less cost (cheaper)? To the contrary! We actually have significantly increased the time and cost of placing new systems into their inventories in addition to driving up the cost of maintaining these systems once fielded. So, from their viewpoint, acquisition reform does not appear to have yielded the return on investment proclaimed by those charged with delivering. In fact, from a "50,000 foot view" it appears to have had the opposite effect. This point was amplified by General "Speedy" Martin, Commander, U.S. Air Forces in Europe, in his address at this year's National Aerospace Systems Technology Conference where he stated the enemy is "time." Time, is used in the context of both providing capability to the field and integrating information to enable near-real-time targeting. Our partial solution to the former is to introduce the concept of spiral development or evolutionary acquisition. In short, deliver incremental capability sooner. The concept is not new but yet another adaptation from the commercial sector, PCs being a model. Provide a rudimentary capability at a reasonable price with ample room for expansion and add capability through hardware and software over time, at an added cost. The Joint Strike Fighter is an example of this model applied to weapon system procurement. For $22 billion (TY$) and 7.5 years the Warfighter gets a basic stealthy air-mud capability. Another 3+ years and $3 billion (TY$), you get the system the Warfighter needs. Is this "better, faster, cheaper?" I submit not.

So, what is the acquisition community's mission or role? To continue our tradition of providing unparalleled technology in the form of weapon systems to our customer?—a given. Focusing on the future, our pioneering (make a difference) mission is to take the lead

in moving the acquisition community into the position of being the supplier of choice rather than default. This will entail a new look at how we provide capability while reducing cycle time and attendant costs. Our major thrust is to bring Modeling and Simulation (M&S) into the 21st century as THE enabling tool for transforming a physical model — test centric acquisition process into a virtual model-simulation centric business, under the banner of Simulation Based Acquisition (SBA), or more appropriately Simulation Enabled Acquisition (SEA). I believe we are on the verge of a revolution in the development process brought about through confluence of advancements in M&S fidelity and stakeholder acceptability, coupled with the rising costs and inability to test the systems-of-systems in a representative environment. Combine this state with the emerging revolution in air warfare with the introduction of Uninhabited Combat Air Vehicles (UCAVs), where M&S is the principal tool for deriving capability based requirements, designing, developing and verifying the system, and you have an environment ripe for change. The recent success enjoyed by the Predator in flawlessly executing the Hellfire missile integration is a shining example of the power of M&S in cutting an otherwise 12–18 month effort down to three. And it's only the beginning...a changing "SEA state" with a need for speed in delivering capability as the catalyst.

What is in the future for the Air Force in general and the acquisition community in particular? My money is on an acceleration of Unmanned Air Vehicles/ Uninhabited Combat Aerial Vehicles (UAVs/UCAVs) at the expense of conventional systems, more Science and Technology investment in key enabling technologies that complement UCAVs to include advancements in Intelligence, Surveillance, and Reconnaissance (ISR), weapons, and the next giant leap — hydrocarbon fueled hypersonic propulsion, a prerequisite for making routine access to space affordable and providing for a stand-off near real-time targeting capability (Missilier concept). Also, I see a return to the 60s/early 70s where we demonstrated the realm of the possible through flight of demos (X-), a "Back to the Future" sequel. And who is best suited to champion these movements? Those who have the focus, attitude and perseverance to make a difference. Is it not the 21st century where dreams of yesteryear are the realities of tomorrow?

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MANPADS Analysis Methodology Development

by Mr. Alex G. Kurtz and Dr. Ronald L. Hinrichsen

Man Portable Air Defense Systems (MANPADS) have become a prevalent threat to both military and civilian aircraft. In recent conflicts, it has been proven that aircraft have survived MANPADS encounters. Some MANPADS missiles also failed to detonate on or within the aircraft. The survivability/vulnerability aircraft analysis community is beginning to understand the critical issues relating to the impacts of MANPADS missiles with aircraft, however, the community still needs a validated set of analysis tools to handle this threat. In recent years a series of aggressive multi-year programs have been initiated to address these voids. These programs have incorporated parallel efforts that integrate first principle, high-fidelity, nonlinear structural analysis codes, test data, and analytical/empirical penetration equations to advance the state-of-the-art in vulnerability analysis techniques and understanding of aircraft-MANPADS encounters. This article presents a snapshot of the MANPADS methodology development projects.

The main objective of these efforts is to advance aircraft vulnerability assessment and predictive methodologies for missile encounters. Specific objectives are to—

- Apply advanced finite element/finite difference structural analysis codes to the body-on-body penetration problem and analytically predict missile velocity, missile position, penetration depth, degradation of aircraft structure, and missile kinetic energy as a function of time and
- Develop algorithms to adapt the Fast Air Target Encounter Penetration (FATEPEN) code for use in predicting MANPADS missile encounters with aircraft structures.

Figure 1 illustrates two distinct, mutually supporting parallel code development efforts. The tri-Service Advanced Joint Effectiveness Model (AJEM) uses the FATEPEN methodology to predict target penetration and damage. FATEPEN analysis algorithms are comprised of analytical/empirical engineering type, terminal ballistic penetration equations designed to provide very fast run times for production-type analysis runs. The finite element analysis (FEA) uses high fidelity physics-based structural analysis algorithms which account for the material densities and non-linearities as well as failure strengths and/or strains of both the MANPADS and target. An explicit time integration scheme is used to solve the equations of motion of the bodies as they make contact, interact, fail, and move.

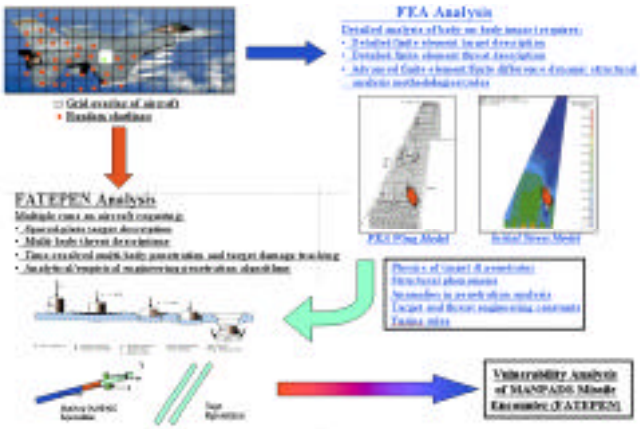

Figure 1. Interaction of MANPADS FATEPEN and Finite Element Analysis (FEA) Development Methodology

The Naval Surface Warfare Center, Dahlgren, Virginia, through its contractor Applied Research Associates of Denver, Colorado, is responsible for the FATEPEN models/algorithms. The FATEPEN models are based as much as possible on fundamental principles of mechanics together with assumptions regarding the primary loading and response mechanisms as determined by experiment or first principle code calculations. Under the current effort, new algorithms are being developed to adapt the existing penetration models to partial impact geometries and to add the capability for time resolved, multi-body, penetration and damage analysis, both of which are needed to improve body-on-body impact damage predictions.

The 46th Test Wing, Wright-Patterson AFB Ohio, through it's contractor, University of Illinois (UI) at Urbana-Champaign, is responsible for the body-on-body finite element analysis impact studies. They have built/obtained finite element and computer aided design (CAD) aircraft models and fabricated one FEA MANPADS missile. The MANPADS missile finite element model was constructed in detail and is comprised of discrete sections of an actual missile (seeker, warhead, guidance and control, and motor). The MANPADS missile model also contains detailed data on section geometries, exterior dimensions, joint construction, joint strength, component construction, material properties, mass properties, and rocket motor case strength. Figure 2 presents a collage of finite element predictions of MANPADS impacts on various targets. In each frame of the figure, the Von Mises stress contours resulting from a MANPADS impacting the target are shown.

Testing is critical to credible modeling and simulations (M&S). Joint Live Fire (JLF) is not chartered to conduct validation and verification (V&V) of the analysis codes; however, when opportunities were presented, the MANPADS analysis development programs have augmented JLF tests to extract very specific data. This took the form of camera placement/speed, additional strain gauges, additional blast gauges, and additional accelerometers specifically placed to augment recent or future analysis. Data were used to verify both missile breakup and aircraft damage. Another way the programs are conducting incremental V&V, is to run pre-test predictions for future MANPADS tests. Following the tests, the code developers and test engineers meet to discuss test/analysis results, anomalies, and data voids.

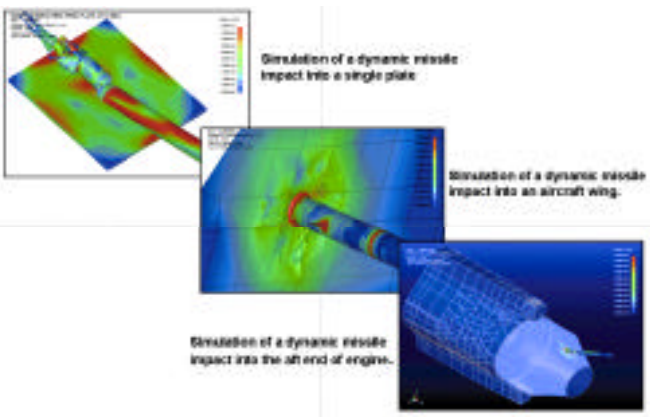

Figure 2. Collage of Finite Element Predictions of MANPADS Impacts on Various Targets

To ensure credible MANPADS modeling and simulation methodology development, 46th Test Wing, UI, NSWC, and ARA collaborate together to ensure that the simulations, multiple tests and analysis programs are completely integrated.

Although the codes lack warhead and blast algorithms, at project completion, the vulnerability analyst will be able to use FEA procedures and higher fidelity physics-based body-on-body algorithms to perform detailed pre-test predictions, conduct post-test analyses, and investigate potential vulnerability reduction techniques. He/she will also be able to use updated FATEPEN engineering algorithms to acquire initial MANPADS body-on-body aircraft vulnerability estimates, do vulnerability "production" runs, and conduct design trade-off studies.

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M&S Credibility Workshop

Assuring M&S Credibility for Defense Acquisition and T&E Survivability , Lethality and System Ef fectiveness 12–15 Febr uary 2001, Reno, Nevada

by Mr. David H. Hall

Survivability, lethality and mission effectiveness Models and Simulations (M&S) are a key element of support to acquisition program milestones. Heavy reliance on these M&S has resulted in an ever-increasing emphasis on the ability to demonstrate their credibility. At least one recent study has shown, however, that DoD and Service M&S initiatives provide for neither long-term support of these critical M&S, nor for assessment of their credibility. The Director, Operational Test and Evaluation (DOT&E) commissioned a study in 1999, conducted by Hicks & Associates Inc. (Modeling & Simulation Survey Briefing dated January 2000), on M&S use in acquisition. The study showed that while an acquisition program manager (PM) must invest early in M&S to make the best use of those M&S, a number of factors hamper his or her ability to fully benefit from that investment. The study found that—

- The Services vary in their approaches to M&S management
- Industry is the predominant developer/owner of the M&S used for acquisition
- There is often uncertainty about the "pedigree" of M&S used
- The typical PM does not view DoD-wide M&S investments as cost -or schedule - effective

As a result, the suitability and credibility of M&S used to support acquisition programs may be unknown or assumed. The DOT&E study recommended, among other actions, that OSD should direct the implementation of a process to identify and satisfy M&S requirements for acquisition programs, and review and clarify roles and functions of DoD M&S organizations.

To further explore the conclusions of the DOT&E study, the Modeling and Simulation Workshop (held in February 2001 in Reno, Nevada) identified the unique problems faced by acquisition programs using survivability and lethality M&S. The Workshop also explored potential solutions to these problems. One major conclusion recognized the need for better integration of acquisition program M&S requirements into OSD and Service policies, guidance, and initiatives.

The Workshop was constructed around presentations and panel sessions by OSD and Service decision-makers, acquisition program managers, and T&E professionals. These included DoD, Industry, academia, and the International acquisition community. The program was divided into three sessions: OSD View of M&S Use in Acquisition; Acquisition Program M&S Challenges and Perspectives; and Test and Evaluation Community M&S Challenges and Perspectives. Mr. James F. O'Bryon (Deputy Director, Operational Test and Evaluation/Live Fire Testing, Office of the Secretary of Defense) gave the keynote Address.

Briefings in the second session included representatives of Air, Sea, and Land and international acquisition programs using M&S to support their requirements. The third session presenters represented Service operational testing organizations, intelligence organizations, and representatives of test and evaluation facilities.

Each day's session ended with a panel (comprised of the day's presenters) discussion focused on Workshop objectives. The panels addressed both open mike and structured questions. On Monday afternoon, the Workshop was preceded by the JASA tutorial entitled "Essentials of Simulation Credibility."

The Workshop was specifically structured to develop a consensus and ensure that Workshop products properly reflected the views of the majority of the participants. A summary of the previous day's discussions, conclusions and observations was presented at start of each day's session. The discussion of that summary each day was aimed at developing consensus, with significant audience participation (both during and after the daily summaries). Strong minority opinions were captured

and noted. These daily summaries (including the third day's summary, which was not discussed at the Workshop) were sent to all participants via E-mail after the Workshop for review and comment. The numerous comments and change requests were summarized and incorporated, with strong minority opinions recorded in the final summary. This process guaranteed that the results and conclusions of the Workshop reflect a true consensus of opinion from the 200 plus workshop participants. In addition, post-Workshop comments reflect some comments from participants' management that were not in attendance.

Conclusions

Survivability, lethality and system effectiveness M&S are key elements of support to acquisition programs and their demonstrated credibility is essential to these programs. But DoD and Service M&S initiatives do not provide for long-term assurance and maintenance of credibility of these M&S used in acquisition. Acquisition programs and the T&E community are by and large required to forge their own paths to credible integration of M&S. The Workshop results, independent studies, and JASA's direct experience working for acquisition programs support these conclusions.

M&S and VV&A policies and technical guidance have been made available to the acquisition community through the Service M&S Offices and DMSO. The "bottom line" conclusion of the three-day workshop was that meaningful implementation of these policies is hampered by several factors that combine to lessen their potential benefits—

- Inconsistent M&S and VV&A definitions and requirements across Services
- Inconsistent standards applied to M&S software development
- Severely constrained program resources
- Policy "flexibility" that permits a minimalist approach to VV&A
- Lack of an OSD-level focal point for M&S credibility in acquisition
- Defense Acquisition Board (DAB) process that does not include any reviews of M&S credibility
- Lack of any impacts for not following policies on M&S credibility
- Confusion over responsibilities for M&S credibility generated by Acquisition Reform

In fact, the combination of factors listed above makes it quite possible for an acquisition program to comply with individual Service and DoD M&S and VV&A policies to "accredit" a simulation, and still not have a robustly evaluated, objectively credible simulation.

Put another way, "accredited" simulations are not necessarily "credible" simulations. M&S and VV&A policy compliance is a necessary, but not sufficient, condition to demonstrate the credibility of a simulation objectively and robustly. The general assumption at OSD that M&S credibility has been assured by the time the program reaches a DAB review needs to be revisited.

It was clear from the Workshop briefings and panel discussions that Service M&S Offices and DMSO do not want the role of "policing" compliance with M&S and VV&A policy, and they do not have the resources to take on such a role. The M&S credibility "buck" appears to stop at the (OT) community, which articulated the greatest caution about M&S use in acquisition of the three communities represented at the Workshop (OSD, Programs and T&E). It was observed, however, that it is too late in a program to uncover M&S problems or limitations in the OT phase of an acquisition program. Furthermore, the OT community has even more resource constraints than do the acquisition programs themselves. Thus, the OT community cannot be a wholly effective "watchdog" for M&S credibility in acquisition.

Finally, the Modeling And Simulation Test and Evaluation Reform (MASTER) concept briefed by Mr. O'Bryon showed promise of being able to address some of the technical issues brought out at the Workshop. However, there was serious concern expressed by many Workshop participants about MASTER issues, such as how to fund the effort and how to deal with acquisition program control of M&S.

Recommendations

The briefings, panel discussions and daily summaries from the Reno M&S Workshop all seem to coalesce around the conclusion that

there is no cause and effect relationship between following M&S and VV&A policy and technical guidance, and having confidence in M&S credibility for acquisition applications. It seems clear that if OSD is to reap the benefits implicit in DoD and Service M&S policies, then the VV&A "carrot" for acquisition Program Managers needs to be made bigger, and the OSD "stick" must be more effective.

In practical terms, acquisition programs need access to M&S technical support services that go beyond what the Service M&S Offices and DMSO can provide. Acquisition programs need experienced assistance with meaningful implementation of M&S and VV&A policies within the constraints of their particular risk and budget profiles. On the other hand, OSD needs to know that M&S and VV&A policies are actually having an objective impact on the credibility of M&S used in acquisition.

Some potential steps that OSD might take to make the VV&A "carrot" bigger revolve around providing acquisition programs with more practical help—

- Program-specific technical assistance geared toward meaningful implementation of VV&A policy and technical guidance, at a level consistent with application risk and program resource constraints
- Resources to develop and archive VV&A documentation for common use M&S
- Training in common, cost-effective approaches to VV&A for acquisition applications of M&S so they can do it on their own

On the other hand, a significant step to making the M&S policy "stick" big enough to attract the attention of acquisition Program Managers would be to require acquisition programs to present M&S "Accreditation Cases" for independent review well before the DAB. This would ensure that simulations that adhere to M&S and VV&A policy are, in fact, demonstrably credible for their intended use. This concept is consistent with Dr. Gansler's memo of December 2000 on "Independent Expert Reviews of Software Intensive System Acquisitions." It is also consistent with some international approaches to M&S evaluation in an Acquisition Reform environment.

On the basis of the active feedback and continuing interest in the outputs of this workshop from many of the participants, there seems to be at least prima facie evidence of the validity of these concerns at the working level. We recommend that OSD take short-term action to establish the validity and the magnitude of the issues suggested by the Workshop. It is further recommended that OSD consider long-term options for addressing both the technical and the political problems raised by these issues.

Two high-payoff follow-on actions in the near term are—

- Develop an implementation plan for MASTER
- Develop data on how acquisition programs have accredited M&S in the past.

First, since the JTCG/AS and the JTCG/ME co-sponsored the Workshop under DOT&E auspices, we recommend that these two groups spearhead the development of a concept description and implementation plan for MASTER. The goal of this effort would be to generate consensus in the acquisition community about what MASTER should look like in theory, and how it might work in practice. This would address the concern expressed by Workshop participants that MASTER "looks good on paper" but that "the devil is in the details."

Second, we recommend that a short, focused study of previous acquisition-related M&S Accreditation Reports and V&V efforts be conducted. The purpose of this effort would be to determine whether DoD and Service M&S policies were being implemented in a manner that actually provides objective evidence of M&S credibility for acquisition applications. It would also attempt to determine whether similar standards of M&S credibility were being applied across similar programs for similar types of M&S. This study would address comments from some Workshop participants that, while there may be "loopholes" in DoD and Service M&S and VV&A policies, they are not being widely used to circumvent the need for demonstrated M&S credibility in acquisition decision making. This effort would also extend the data generated by the 1999 DOT&E M&S study.

The results of both of these efforts would be briefed back to the OSD principals who participated in the Workshop and who sponsored the effort. The results would then be briefed to the larger acquisition community at the next M&S workshop, March 4–8, 2002 in Reno, Nevada. More information is on this upcoming conference is available at http://www.nawcwpns.navy.mil/~jasa/.

M&S Workshop 2002

March 4–8 • Silver Legacy • Reno, Nev ada

Like Workshop 2001, we anticipate participation from a wide spectrum of the M&S community, both Government and industry.

Workshop 2002 will be a logical sequel to the successful 2001 Workshop and will address the recommendations and conclusions of the follow-on actions presented in the article written by Mr. David Hall. The primary goal of the workshop is to enhance the way we do business in survivability, vulnerability, lethality with the employment of M&S. Reaching out across DoD for broad participation in the planning and execution of this workshop a Workshop Executive Advisory Committee (WEAC - pronounced we-ack) has been created. The WEAC is currently defining the workshop specific topics and issues in support of the primary goal with the following objectives—

- Develop consensus on problems, issues and obstacles to credible integration of M&S into acquisition programs and T&E.
- Develop suggestions for better integration of acquisition program M&S needs into OSD and Service policies, guidance and initiatives.
- Identify potential solutions, approaches and investment strategies for M&S in acquisition programs and T&E.

In order to achieve the workshop objectives, we have planned to promote more audience participation by creating working groups to define solutions to stated issues and set aside more time for panel discussions and summaries.

The WEAC currently consists of—

Simone Youngblood (DMSO)
Mike Weisenbach (JTCG/AS)
Bob Cook (USAF)
Debra Ridgeway (USA)
Frank Gray (AFOTEC)
John Haug (ATEC)
Brian Hall (OPTEVFOR)
Jim Sebolka (Wash. Inst.of Technology—in support of OSD)
Doug Fraedrich (NRL)
Hans Mair (IDA)
Tracy Sheppard (Univ. of Texas, Austin—in support of OSD)
Kathy Russell (JASA)
Ron Ketcham, Chairman (JASA)

An informational brochure and Call for Abstracts was released in October. The tentative agenda is as follows—

Monday—March 4
- Early Registration
- VV&A Tutorial
- Evening Mixer

Tuesday–Thursda y
- Daily Key Note Speakers
- Presentations
- Working Groups
- Panel Discussions
- Daily Summaries

Sponsored by the JTCG/AS in cooperation with DOT&E/LFT and coordinated by the Joint Accreditation Support Activity (JASA) and the Workshop Executive Advisory Committee (WEAC).

JTCG/AS

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http://www.nawcwpns.navy.mil/~jasa/

National Summit on U.S. Defense Policy—Acquisition, Research, Test and Evaluation

by Mr. Tracy Sheppard

The annual NDIA-sponsored National Test and Evaluation Conference was held in Long Beach, California this year. With the change in Administrations, it was appropriate that this year's event be a National Summit on U.S. Defense Policy: Acquisition, Research, Test and Evaluation. Panel sessions covered a range of topics critical to the state of defense within the Unites States and its allies. The list of speakers addressing the conference was as diverse as the topics themselves.

The conference began with five tutorial sessions covering topics such as acquisition reform, defense policy, and the use of non-lethal weapons in the Middle East. The latter tutorial was presented by Colonel Amir Ellenbogen of the Israeli Defense Forces and was a thought provoking and shocking examination of the current state of affairs in the Middle East. Needless to say, a lively discussion followed this timely and important presentation. The tutorials addressing acquisition and defense policy were given by Government and industry representatives alike and brought to light both the advances made in acquisition reform as well as the fact that there is much yet to do. And with that charge, the conference began in earnest the following morning with an address to the conference attendees by Congressman Stephen Horn (R-CA).

Congressman Horn provided a videotaped statement during which he asked the attendees to take seriously the conference objective of providing a white paper of recommendations to the Bush Administration addressing issues ranging from National Missile Defense, the state of readiness, and international cooperation and the role of the private sector. In addition to Congressman Horn, keynote presentations were given by the Conference Chairman, Mr. James O'Bryon, Deputy Director, Operational Test and Evaluation/Live Fire Testing, the Honorable Philip Coyle, former Director, Operational Test and Evaluation, Dr. Frank Fernandez, former Director of the Defense Advanced Research Projects Agency, and providing an industry perspective, Mr. George Muellner, Vice President and General Manager, Phantom Works, The Boeing Company.

The business of addressing the issues to be addressed in the White Paper began with the keynote presentations and continued to the end of the event. Panel sessions were convened to address each of the conference topics: National Missile Defense, national security, international cooperation and the global marketplace, the role of government laboratories in national defense, commercial products in national defense, defense procurement, emerging threats, and test, evaluation and acquisition. In addition to these panel sessions, a Town Hall meeting, a trademark of NDIA's Test and Evaluation conferences, provided an opportunity for session chairs and the audience to discuss candidly their thoughts, concerns and proposals for correcting the deficiencies discussed during the panel sessions. Out of this discussion emerged the key points to be discussed and addressed in the conference White Paper. Following is a partial list of those points—

- Attracting younger workers into the defense industry
- Improving business/finances of industry versus continuing cut-throat competition
- Contactor participation in operational testing for learning
- Adequacy of test funding
- A business model for Defense
- Industry investments in Research and Development
- Government review of Industry Research and Development
- Impact, or lack thereof, of recent Acquisition Reform changes
- Testing Commercial-of-the-Shelf products to military standards.

The White Paper in its entirety, once appropriately staffed through the Department leadership, will be made available to the conference attendees via the fol-

lowing Web sites: www.dote.osd.mil, www.ndia.org, and www.csa.utexas.edu.

In addition to the business of the conference, a highlight of the event was a presentation of the annual NDIA awards for outstanding achievement in Test and Evaluation. This year's recipients included—

	Military	Civilian	Contractor
Army	Capt John Eggert	Glenn McPherson	Charles Ramsdell
Navy	LCDR Michael Dodick	Luis Cortes	Robert Rosado
Air Force	Lt Col David Nelson	James Keith	Charles Triska
DoD	CDR Michael Stanton	William Colson	Dr. Anil Joglekar

The Walter W. Hollis Award for Lifetime Achievement in Defense Test and Evaluation was presented to the Honorable Philip E. Coyle, former Director, Operational Test and Evaluation. This award, first presented to Mr. Walter Hollis, Deputy Under Secretary of the Army for Operations Research, recognizes those individuals who throughout their careers, have demonstrated exceptional leadership and have made significant contributions to the Defense community.

Mr. Philip E. Coyle, III was presented the Walter W. Hollis Award for Lifetime Achievement in Defense T&E.

And thus ended another successful NDIA Test and Evaluation conference. Senior leaders from Defense and industry, as well as the hundreds of attendees representing every facet of the defense community, came together, spoke candidly, and made this event a complete success. Congressman Horn's charge to take this task seriously was met. A wealth of important and timely information came forth as a result of this conference. While only a fraction of that information is presented here, a more thorough review of the event can be obtained from a CD-ROM containing the conference proceedings. To receive a copy of the CD, please contact Ms. Debi Denney at debi_denney@iat.utexas.edu.

As indicated throughout the conference, there is much yet to do. A topic critical to the changing test and evaluation and defense acquisition process, is the role of developmental testing. This will be the theme of the 2002 NDIA National Test and Evaluation conference to be held February 25 through March 1, 2002 in Savannah, Georgia. Please join us there.

Tracy Sheppard is the Technical Director of the Washington Office of the Center for Strategic Analysis, University of Texas (UT) at Austin. Prior to joining the research faculty of UT, Tracy served for over 15 years within DoD, first as a Marine and then in positions at Aberdeen Proving Ground and within the office of the Deputy Director for OT&E/LFT in the Pentagon. Tracy received his AS and Bachelor of Electrical Engineering degrees from the Johns Hopkins University in Baltimore, Maryland.

calendar of events

NOV

5–8 — Monterey, CA
Aircraft Survivability Symposium 2001
http://www.ndia.org

26–29 — Orlando, FL
Interservice/Industry Training, Simulation and Education Conference (I/ITSEC)
Contact: bmcdanial@ndia.org

27–29 — Gaithersburg, MD
National Military Sensing Symposium—Closing the Information Loop with the Warfighter
Contact: IRIA, 734.994.1200

27–29 — Nellis AFB, NV
Brawler/ESAMs User Group Meeting
Contact: Paul Jeng, 937.421.2712

DEC

6–8 — Charlottesville, VA
BLUEMAX, ALARM, RADGUNS User Group Meeting
Contact: Paul Jeng, 937.431.2712

JAN

14–17 — Reno, NV
40th AIAA Aerospace Sciences Meeting Exhibit
http://www.aiaa.org

FEB

25–28 — Savannah, GA
National Test and Training Conference
Contact: kdouglass@ndia.org

Information for inclusion in the Calendar of Events may be sent to—

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