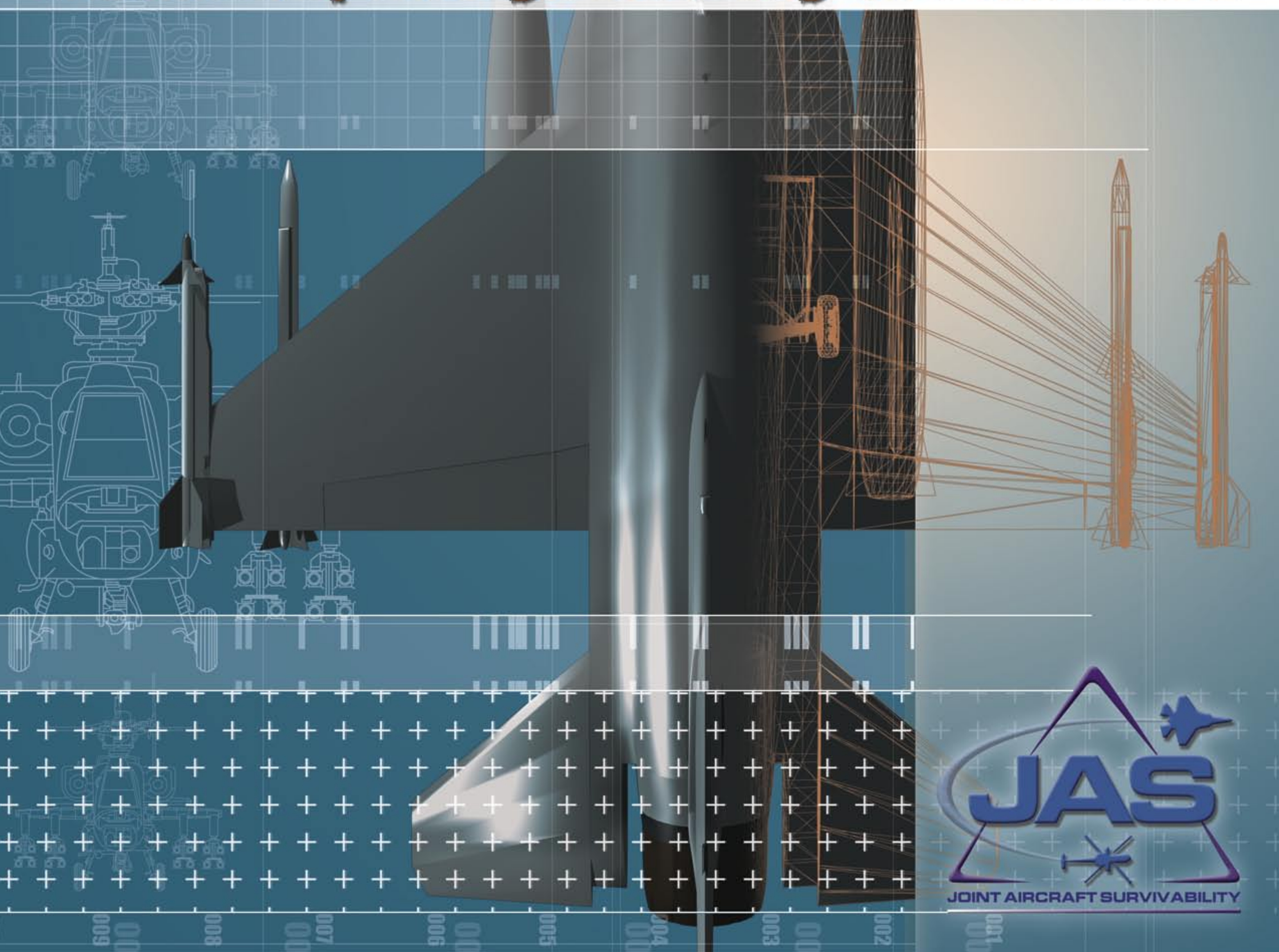
AIRCRAFT SURVIVABILITY

Published by the Joint Aircraft Survivability Program Office

Fall 2004

Survivability through Modeling and Simulation



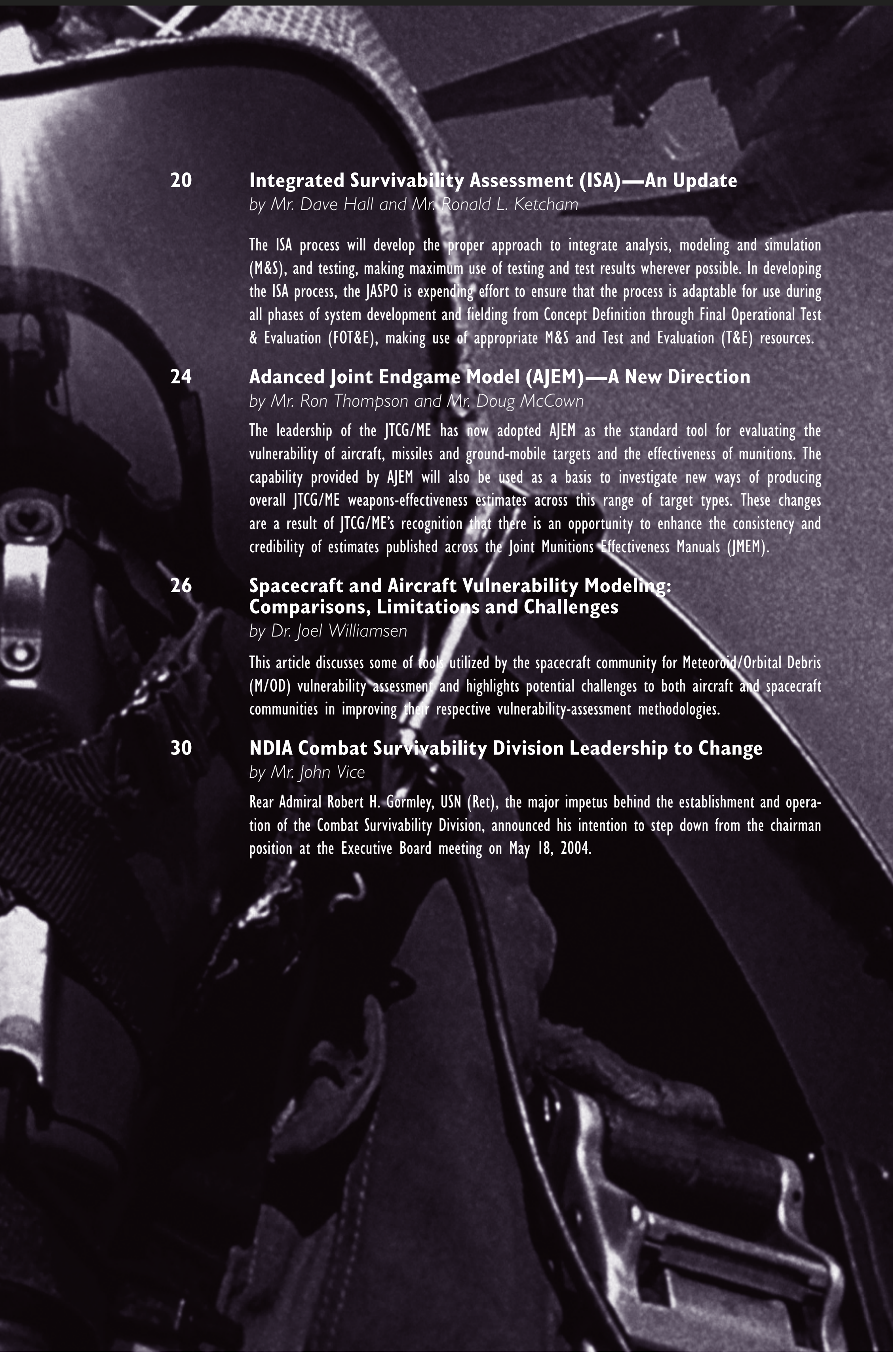
Aircraft Survivability is published three times a year by the Joint Aircraft Survivability Program (JASPO). The JASPO is chartered by the Joint Aeronautical Commanders Group.

JAS Program Office
200 12th Street South
Crystal Gateway #4,
Suite 1103
Arlington, VA 22202
Phone: 703.607.3509
DSN: 327.3509
http://jas.jcs.mil

Views and comments are welcome and may be addressed to the Editor—
Joseph Jolley
Phone: 703.607.3509 x12
E-mail: jasnewsletter@jcs.mil

Assistant Editor—
Dale B. Atkinson
E-mail: jasnewsletter@jcs.mil

Table of Contents



Mailing list additions, deletions, changes, and calendar items may be directed to—

SURVIAC

SURVIAC Satellite Office
3190 Fairview Park Drive
Falls Church, VA 22042
Fax: 703.289.5179

Creative Director
Christina P. McNemar
Phone: 703.289.5464
mcnemar_christina@bah.com

Art Director
K. Ahnie Senft

Assistant Art Director
Bryn Farrar

Newsletter Design—
Maria Candelaria

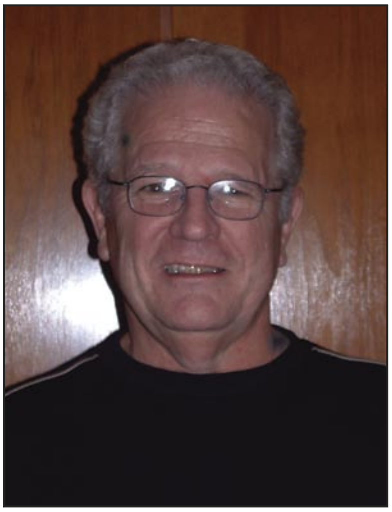
Illustrations—
Dustin Hurt

Cover Design—
Holly Shipley

Distribution Statement A:
Approved for public release;
distribution unlimited.

News Notes

■ *by Mr. Joseph Jolley*



Mr. Richard A. "Tim" Horton retires

Mr. Tim Horton, a stalwart in survivability discipline, retired on August 31, 2004. Mr. Horton served in a number of leadership positions in survivability throughout his long and varied career. From his enlistment in the Army in 1961 to his last position as Head of four Divisions at the Naval Air Warfare Center, Weapons Division, at China Lake, he was a leader and inspiration to those in the aircraft community. Mr. Horton's career began in the infantry. He made several rapid and successful transitions, first to helicopter crew chief, then to Officer Candidate School and a commission, and then to flight school where he was rated in both fixed-wing and rotary-wing aircraft. Based on his personal experiences with survivability from two combat tours in Vietnam, Mr. Horton sought out a position in which he could do something to help improve the survivability of our combat aircraft and became the first Executive Director of the Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS) in 1979. He was instrumental in forming the Survivability/Vulnerability Information Analysis Center (SURVIAC) and the Joint Live Fire (JLF) program, both of which are still paying survivability dividends today. As Head of the Survivability Division at China Lake, he was responsible for improving processes and facilities, including a major new test facility that will include a nine-engine airflow capability, and has been a driving force behind survivability enhancements to all Navy and Marine Corps aircraft and weapons systems. He also served as the Navy Principal Member and Chairman of the Joint Aircraft Survivability Program Office (JASPO) Principal Members Steering Group, which is chartered under the Joint Aeronautical Commanders Group (JACG), and funded by DOT&E/LFT&E. At the recent JASPO Principal Members Steering group meeting in San Diego, California, on August 3–5, 2004, Mr. Horton was presented a letter from Vice Admiral Massenberg, the JACG Chairman; a letter from Larry Miller, the Deputy Director of Operational Test & Evaluation/Live Fire Test; and the extremely nice JASPO engraved glass plaque for his outstanding service to the survivability community and the U.S. Department of Defense (DoD). The JASPO wishes Mr. Horton the best.

Congradulations to Dr. Peter Disimile

Dr. Peter Disimile, a Staff Scientist at the Safety and Survivability Flight at Wright-Patterson Air Force Base, Dayton, Ohio, has had two papers selected for the Fourth Triennial International Aircraft Fire and Cabin Safety Research Conference held in Lisbon, Portugal, November 15–18, 2004. The conference is jointly sponsored by all the major aviation safety organizations around the world, including the U.S. Federal Aviation Administration (FAA), Joint Aviation Authorities of Europe (JAA), Transport Canada Civil Aviation (TCAA), Civil Aviation Bureau of Japan (JCAB), Civil Aviation Safety Authority of Australia (CASA), Centro Technico Aerospacial of Brazil (CTA), and the Aviation Register of Russia (IAC). The papers selected are entitled "Heat Transfer Effects in Close Proximity of a Short Pyrotechnic Event" and "Surface Ignition on a Heated Horizontal Plate." Dr. Disimile is a valued member of the Fuel System Committee of the JASPO Vulnerability Reduction Subgroup and is a leader in the fire-and explosion-protection area. Congratulations, Dr. Disimile!

Mr. Darnell Marbury joins JASPO

The JASPO welcomes Mr. Darnell Marbury as the newest member of the JASPO staff. Mr. Marbury joined the staff on July 6, 2004, and serves as the Executive Support Analyst. Prior to joining the JASPO, Mr. Marbury provided technical service and support for senior executive members of the Naval Aviation Systems Team in the Naval Air Systems Command's Washington Liaison Office in Crystal City, Virginia. Mr. Marbury is a welcome addition and has quickly become a valued member of the JASPO staff. In his off duty time, Mr. Marbury works as promotional manager and Webmaster for several bands in the Maryland area.

OSD UAV Roadmap Survivability update

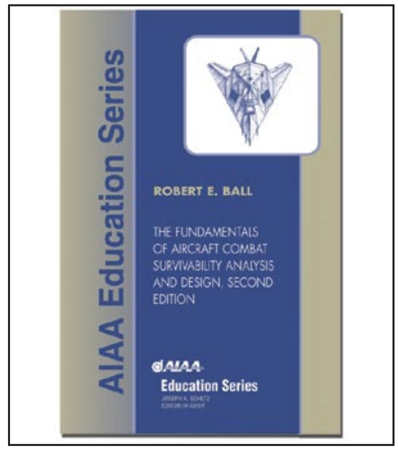
The JASPO is working with OSD/AT&L to update the survivability discussion in the forthcoming revision to the OSD UAV Roadmap. Drawing heavily on the expertise of the aircraft survivability community and the resources brought together at the National Defense Industrial Association (NDIA) Unmanned Aerial Vehicle (UAV) Survivability Workshop hosted by IDA in April, the JASPO drafted a six-page paper to introduce the broader UAV community to combat survivability. This paper provides background on aircraft survivability, UAV survivability in combat, survivability as a design discipline, threats and survivability design features by UAV class, and links to resources in the aircraft-survivability community. The paper was well received by AT&L and will be incorporated into the platform annex of the roadmap, which is scheduled for release in the Fall 2004.

Ms. Robin Finley fills new key role for the JASPO

U.S. Navy photo by 3rd Class Yesenia Rosas

Recognizing the need to improve the overall financial management and execution of Joint Aircraft Survivability Program Office (JASPO) funds, Ms. Robin Finley joined the Joint Aircraft Survivability Program Office (JASPO) in April 2004 as its full-time Business Financial Manager (BFM). This is the first time the JASPO has had dedicated BFM support at NAVAIR, Patuxent River, Maryland, where JASPO funding documents are processed. Ms. Finley comes to the JASPO with over 23 years experience in financial management and customer service. Before joining the JASPO, she supported the AV–8B and other Navy programs. Ms. Finley is doing an outstanding job. In the short time she has been on board, significant improvements in coordination, oversight, and control of JASPO funding documents have been realized as a direct result of her efforts. We welcome Ms. Finley to the JASPO team.

JASPO sponsors Aircraft Survivability Short Course



The Joint Aircraft Survivability Program Office (JASPO) and the Survivability Vulnerability Information Analysis Center (SURVIAC) will conduct a three-day Aircraft Combat Survivability Short Course in early summer 2005. The course is unclassified, and the location and exact date are to be determined. This orientation course is for engineers and others who would like to learn more about the aircraft combat survivability discipline. Check our Web site at http://jas.jcs.mil for the latest information on the exact date and location and course fee.

M&S Introduction

by Mr. Ronald L. Ketcham

Modeling and Simulation (M&S) has played a key role in defining aircraft requirements, in designing aircraft, and in testing aircraft characteristics related to survivability. In recent years, the Joint Aircraft Survivability Program Office (JASPO) has begun to take a stronger leadership role in managing the M&S tools used throughout the Joint Survivability Community (JSC). These tools are collectively referred to as the JASPO M&S tool set, which includes such standards as Enhanced Surface-To-Air Missile Simulation (ESAMS), Radar Directed Gun System Simulation (RADGUNS), Computation of Vulnerable Areas and Repair Times (COVART), Fast Shotline Generator (FASTGEN), Advanced Low Altitude Radar Model (ALARM), and many others. This issue of *Aircraft Survivability* is primarily focused on the recent activities and future plans that the JASPO has for these tools.

There are many reasons that make the JASPO the logical choice for playing this role in the management of the JASPO M&S Toolset:

- The JASPO is the representative of the aircraft survivability technical community. This group is comprised of the users of the JASPO M&S Toolset.

- The JASPO has a primary function of providing coordination of activities within this community. The JASPO is charged with bringing the JSC together periodically to identify their requirements and ensure that these requirements are addressed in the management of the JASPO M&S Toolset through the activities of the Survivability Assessment Subgroup.

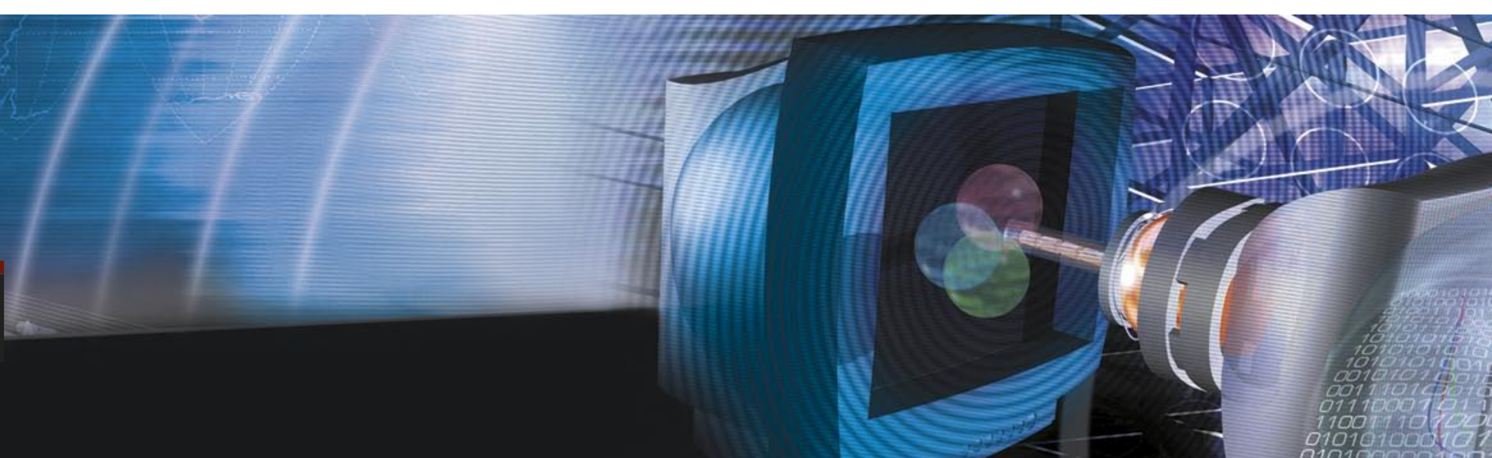
- The JASPO has the connections and liaisons throughout the community required to provide this leadership.

- The JASPO's goal is to promote user driven requirements as opposed to other organizations that would mandate from above, without the direct knowledge and understanding of user's requirements, or the direct contacts within the user community to obtain them.

- The JASPO has much of the required infrastructure to execute this role. The Survivability Assessment Subgroup meets routinely to identify, prioritize, and fund projects that maintain and advance our M&S capabilities. The JASPO sponsors the annual Joint Model User's Meeting (JMUM) and individual User Groups to facilitate user dialogs. The JASPO funds SURVIAC for model management, distribution, and configuration management support. The JASPO created and charters the Joint Accreditation Support Activity (JASA) for VV&A related support.

This issue highlights some recent efforts by the JASPO to maintain and support the JASPO M&S Toolset.

Mr. Kevin Crosthwaite, the Director of SURVIAC, has written an article detailing the state of the current JASPO M&S toolset in SURVIAC (see page 12). He also describes the array of the JASPO's funded activities that SURVIAC does to support model managers, developers, and users.



Mr. Dave Hall has written an update on the continuing effort to develop and execute an Integrated Survivability Assessment (ISA) process for the Director of Operational Test & Evaluation (DOT&E) (see page 20). The benefits of ISA go beyond the DOT&E application. This JASPO-funded project has begun to define a process that will permit survivability analysts and the testing community to integrate and compare the benefits obtained from both susceptibility-and vulnerability-reduction techniques. Dave also discusses a second JASPO effort to use the U.S. Navy's Multi-Mission Maritime Aircraft (MMA) to demonstrate this process.

Ms. Marti Hoppus and Mr. Dave Hall have written an article detailing the role JASA plays in supporting the JSC (see page 15). As one of the major elements of the JASPO, JASA contributes to the achievement of DOT&E's goal to increase the credibility of M&S used in acquisition, with emphasis on M&S used in support of test and evaluation. Currently, JASA provides Verification, Validation, and Accreditation (VV&A) support to Service, Joint Service, Department of Homeland Defense, and international programs.

In addition to articles detailing JASPO's current projects and services, I have included an article detailing our future vision for the JASPO M&S Toolset (see page 8). The Survivability Assessment Subgroup Strategic Plan defines our strategic goals and defines a high-level process for reaching them. This plan states that the JSC should own and direct the management of its government-developed and-supported M&S for the benefit of all users. It is the role of JASPO to ensure these interests are clearly defined and promoted.

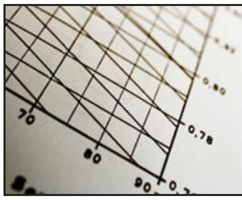
This issue also highlights two M&S efforts outside of the JASPO domain.

Mr. Ron Thompson and Mr. Doug McCown document a new direction for the Advanced Joint Endgame Model (AJEM) (see page 24). The JTCG/ME has now adopted AJEM as the standard tool for evaluating the vulnerability of aircraft, missiles, and ground-mobile targets and for the effectiveness of munitions. "The capability provided by AJEM will also be used as a basis to investigate new ways of producing overall JTCG/ME weapons-effectiveness estimates across this range of target types. These changes are a result of JTCG/ME's recognition that there is an opportunity to enhance the consistency and credibility of estimates published across the Joint Munitions Effectiveness Manuals (JMEM)."

Mr. Joel Williamsen presents an interesting article discussing the use of M&S in analyzing spacecraft vulnerability (see page 26). The article discusses some of tools used by the spacecraft community for the vulnerability assessment of meteoroid/orbital debris (M/OD) and highlights potential challenges for both aircraft and spacecraft communities in improving their respective vulnerability assessment methodologies.

As you can easily see from this M&S issue of *Aircraft Survivability*, there is a lot going on to enhance the M&S tools we use. If you are a user of these tools, I encourage you to become involved in this process. Make sure your interests are represented in our future planning. If you want to talk about these activities and the role you should be playing, do not hesitate to call or send me an E-mail. ■

Mr. Ronald L. Ketcham is the Chairman for the Survivability Assessment Subgroup under JASPO. He may be reached at 760.939.2363, DSN 437.2363 or by E-mail at ronald.ketcham@navy.mil.



The Survivability Assessment Subgroup Strategic Plan

■ *by Mr. Ronald L. Ketcham*

The Survivability Assessment Subgroup, formerly known as the Methodology Subgroup, is one of the three subgroups of the Joint Aircraft Survivability Program Office (JASPO). Each year we allocate between two to three million dollars for projects intended to maintain and improve the JASPO Modeling and Simulation (M&S) Toolset. In FY04, we funded the Survivability/Vulnerability Information Analysis Center (SURVIAC) to sponsor JMUM (Joint Model User's Meeting) and other model-management support activities. We funded enhancements to the Advanced Low Altitude Radar Model (ALARM) and the Fire Prediction Model (FPM). We also funded the continued development of an Integrated Survivability Assessment (ISA) process and many other projects. We have just completed the selection process for a similar set of efforts to be conducted in FY05. While these efforts have addressed real user needs and clearly fit within our program objectives, we have made little progress in promoting larger and longer-term strategic initiatives. This strategic plan is aimed at addressing this shortcoming.

This does not look like the typical strategic plan that defines detailed objectives, schedules, and investments. As will be shown, this plan recognizes that the probability of the success of our efforts will depend not only on our objectives and resources but also on the processes used to define these goals and to execute plans. JASPO is recognized as the technical coordinating group for leading and representing the aircraft survivability community throughout the Air Force, Army, and Navy. We do not specify goals or mandate policies to the technical community. We work with the Joint Survivability Community (JSC) to facilitate establishment of their requirements. This strategic plan is designed to work with the Subject Matter Experts (SMEs), software developers, and users of our M&S Toolset and with the customers who use the results produced by these tools. From them, we seek the requirements for our next generation of M&S capabilities. This bottom-up relationship is fundamental to whether this plan will succeed.

One key question to address is model-management *ownership*. Who owns the models and what are the implications of ownership? There is no official U.S. Department of Defense (DoD) policy or guidance on the issue. JASPO takes the position that the M&S employed by the broad community of aircraft-survivability users should be owned by those users. These models were developed and paid for by U.S. tax dollars and should not be owned by, or support the interests of, any single government entity. This would result in the inefficient employment of government resources. The user community must direct and control the development of their JASPO M&S Toolset. It will be JASPO's role to facilitate and ensure this control—not to replace it.

Clearly stated, the Joint Survivability Community (JSC) should own and direct the management of their government-developed and-supported M&S for the benefit of all users. JASPO's role is to ensure these interests are clearly defined and promoted. This strategic plan is aimed at defining this process as much as defining goals and milestones.

Mission

The mission of Survivability Assessment Subgroup is to *establish* an *accepted* joint-service *methodology* for conducting air-weapon system-survivability analysis using a *capable, flexible, and efficient* computational environment based on a set of credible modeling components. As mission statements go, we feel this one is pretty good. It has remained a consistent framework for directing projects funded by the subgroup over the past decade. This mission statement reflects the primary objectives of this strategic plan. Because of this, it is worth looking at some of the words of this mission statement in more detail.

Methodology—This refers to the combination of processes and tools that are used in aircraft-survivability analysis. *Tools*, as applied here, refers mainly to the JASPO M&S Toolset, a set of government-owned and-managed M&S tools that are used throughout the JSC. Most of these models are now in SURVIAC or plan to be in the future.

Establish—A key function of the subgroup membership is to define, maintain, and promulgate these methodologies throughout the DoD. Standardized methods enhance cost savings, credibility, and usability of results.

Accepted—The methodologies established by the Survivability Assessment subgroup must be adopted by consensus of the broad joint community of SMEs of aircraft survivability-analysis methods. While we do not want to suppress innovation, new methodologies should be tested and should undergo extensive community peer review.

Capable, Flexible, and Efficient—The JASPO M&S Toolset must have the capabilities our users need. They must also have the flexibility to address a broad and dynamic warfare environment that our air platforms must endure. Finally, to be of value to the acquisition and test communities that rely on our results, we must be able to provide answers in a timely manner.

Credible—The JASPO M&S Toolset must provide accurate answers. We must always obtain and document the evidence that supports the credible application of these methods to specific uses.

Strategic goals

This mission statement resulted in three Joint Strategic Objectives (JSOs) that have been presented at subgroup meetings over the past few years. These objectives have therefore been vetted by the JSC as represented by the JASPO. Over time, these JSOs have been expanded into the strategic goals listed below.

> ***Goal 1:***
> ***The Survivability Assessment Subgroup, working with the JSC, will develop, document, and implement an ISA Methodology.***

An ISA will provide—

- New capabilities to the processes and tools that we will use to analyze trade-offs for incorporating different susceptibility and vulnerability alternatives;
- A capability for a combined assessment for Operational Test and Evaluation (OT&E) and Live Fire Test and Evaluation (LFT&E);
- The ability to routinely identify and address the weaknesses of our processes and tools;
- More integration between M&S and testing to enhance the capabilities and credibility of both;
- A better integration of output flow from engineering, to engagement, to mission-level tools to enhance the effectiveness, efficiency, and credibility of our complete range of M&S tools; and
- A framework to identify and promote professional standards throughout the community of survivability analysts.

Where should an aircraft designer invest—susceptibility or reduction vulnerability? Our current methodologies do not effectively support this decision-making process. The development of an ISA methodology is intended to address that shortfall and much more.

We have already taken a small but significant step toward addressing this goal with the recent publication of *Integrated Survivability Assessment (ISA) For Survivability Operational Test and Evaluation (OT&E) And Live Fire Test and Evaluation (LFT&E)* (JASPO-03-M-006). This is a detailed plan for providing for the capability of a combined assessment for OT&E and LFT&E and gives us an ISA framework to expand to meet the other ISA goals specified.

> ***Goal 2:***
> ***The Survivability Assessment Subgroup, working with the JSC, will define requirements and will develop and promote the transition to new M&S capabilities for use by the JSC.***

The Survivability Assessment Subgroup will work—

- *Within* the SMEs of the JSC to identify and rank the existing deficiencies of our current M&S Toolset, which could result in enhancing one of our current tools or creating an altogether new tool; and
- *With* our M&S developers and users to develop software coding standards and architectures that will make our M&S more flexible in addressing new requirements.

The warfare and threat environments our aircraft must endure are constantly changing and putting new demands on the capabilities of the JASPO M&S Toolset. We do what we can to meet new M&S requirements incrementally in the annual JASPO-funded program. However, at current funding levels, we have been falling further and further behind. The intent of this goal is to develop approaches and plans to address our M&S shortfalls, not just to identify current capability deficiencies but to also define programming standards, architectures, and interfaces that will make our programs more extensible and manageable in a highly dynamic environment.

> ***Goal 3:***
> ***The Survivability Assessment Subgroup will advance the employment of management practices that will promote, maintain, and document the capabilities, accuracy, and usability of M&S tools employed by the JSC in an affordable manner.***

The Survivability Assessment Subgroup will—

- Promote the establishment of Configuration Control Boards (CCBs) with representatives of all stakeholders to ensure M&S is managed for the entire user community;
- Seek to ensure that all members of the JASPO M&S Toolset have adequate and affordable Configuration Management (CM);
- Seek to ensure user groups meet periodically to promote broad, cross-community reviews of

- the technical methods and management of the JASPO M&S Toolset;
- Seek to ensure all models have adequate model-manager support for all models in the JASPO M&S Toolset; and
- Seek to ensure that all members of the JASPO M&S Toolset have adequate evidence of credibility in the form of documented Verification and Validation (V&V).
- Seek to ensure that user communities have adequate documentation, user support, and training for all members of the JASPO M&S Toolset.

All these factors impact the capability, accuracy, and usability of the M&S in the JASPO Toolset: The Joint Accreditation Support Activity (JASA) has documented that these three M&S elements directly link to the credibility of the results of a model or simulation.

Most problems with the existing M&S Toolset result from insufficient investment in the infrastructure of model management. It is not the intention of the JASPO to directly manage specific M&S. Instead, the JASPO will influence—and in some areas control—*how* models are managed. The JASPO will seek to ensure all JSC M&S is controlled by representatives of the entire user community and are managed in such a way as to enhance and maintain model credibility for the entire user base.

Approach

The process by which this plan is refined and executed is even more important to success in meeting our specified goals than the rate of investment. Currently, the JASPO invests between $2–3 million a year on projects related to M&S. While this level of funding is inadequate in achieving our strategic goals in a reasonable period of time, we can make some progress. However, there are numerous examples of M&S efforts that have had tens, and in some cases even hundreds, of millions of dollars expended with no apparent success achieved. No matter how much is invested, the wrong approach to the project may result in total failure.

This issue is best understood by first looking at two extreme approaches on opposite ends of a management spectrum. First, consider the approach by which the JASPO or the Survivability Assessment Subgroup would author a detailed strategic vision and plan and then mandate these goals as policies that members of the JSC would be required to follow. Mandates rarely, if ever, work in these situations. If mandates were successful, then all our developers would be programming today in *Ada*—a software language once mandated by the DoD. All of our applications would be HLA compliant—another DoD mandate. And by "all applications," I mean the Joint Modeling and Simulation System (JMASS) as the architecture that was once mandated to replace much of the M&S in the JASPO toolset. All of these mandates failed. A primary reason they failed is because those making the mandates did not fully understand the user-community requirements. Equally important is that users did not see themselves as the "owners" of the mandated systems. This allowed obstacles like rice bowls and the "not invented here" syndrome to prevent widespread acceptance or even adherence to these mandates. Finally, and most importantly, these mandates did not come from the same sources of funding that sponsored M&S development or analyses. This is a clear example of the golden rule that states, "he who has the gold, rules."

A total laissez-faire or "hands-off" environment represents the other end of the spectrum. This is the system that, for the most part, we operate in today. Much of the time, there is little or no coordination between our independent M&S developers and users. Everybody does it his or her own way. As a result, we end up with multiple architectures and applications that overlap in function. These M&S tools are often non-compatible and make it difficult for users to compare results. One of the worst examples today is the existence of three separate vulnerability frameworks that are currently supported within the DoD. The oldest are the Computation of Vulnerable Repair Time (COVART) and the Fast Shotline Generator (FASTGEN) programs, which are the current JASPO vulnerability frameworks in SURVIAC. Second is the Army framework AJEM/MUVES. AJEM was intended to be a joint framework, but the development effort failed to adequately take into account non-Army requirements and issues. Finally, the Air Force recently developed a third architecture currently referred to as the "Endgame Framework." This effort made little if any attempt to address the requirements of, or get the support of, the broad community. Some may make the argument that these three tools are the sign of a robust M&S Toolset for the user community. I argue that supporting three frameworks is an ongoing waste of very limited resources. Even if the capabilities of these frameworks could be shared without some extra integration cost, which would not be the case, we would still be continuously expending limited resources on managing three separate programs.

JASPO has chosen a middle ground between these two extremes to manage the strategic-planning and execution process. The Survivability Assessment Subgroup will seek to bring the technical community together to manage the JASPO M&S Toolset and strategic plan. The high-level goals specified above have been vetted by the JSC. Detailed goals will be defined and owned by the SMEs of the JSC. We have already begun this process in a few areas, such as the recently published ISA report mentioned above and an M&S Countermeasures draft Strategic Plan set for review in FY05.

Admttedly, bringing the JSC together to reach consensus in establishing our detailed goals may be extremely difficult at times. However, we will seek to develop a variety of tools to provide incentives for separate organizations within the JSC to work for common goals. The

Survivability Assessment Subgroup seeks to establish partners in this process with organizations such as the Air Force Studies and Analysis Agency (AFSAA), which manages the Air Force M&S toolkit; the Defense Modeling and Simulation Office (DMSO); and individual service M&S offices. Getting acceptance of our strategic goals by these groups may help us to bring together the JSC together.

Another key tool available to the JASPO is limiting funding to projects that fall within the confines of our JSC-established strategic initiatives. We have had some recent successes in this area. For example, there are currently two versions of the model Enhanced Surface-to-Air Missile Simulation (ESAMS) in wide use throughout the JSC. The JASPO has funded a project to merge these two versions into a single baseline that all users seem willing to adopt. This will reduce ESAMS' management costs and allow us to focus our V&V efforts on the single code.

The following clearly summarizes our approach to developing and executing our M&S Strategic Plan—

- The Survivability Assessment Subgroup has developed the three general strategic goals with the consensus of the JSC.
- The Survivability Assessment Subgroup will continue to use the Joint Model User's Meeting (JMUM), user-group meetings, subgroup meetings, and other community events and working groups to reach out to the JSC and seek consensus on detailed definitions of these goals. Users best understand their needs and will control our direction.
- The Survivability Assessment Subgroup will dedicate all resources that the JASPO now invests in M&S to projects that fall within the strategic plan. Also, any additional funds the JASPO may receive in the future for M&S would be expended only on projects that address the JSC requirements defined in the strategic plan. In this event the golden rule will become an asset instead of an obstacle.

The execution of the Survivability Assessment Subgroup strategic plan will be broken down into three phases—

1. **Foundational**—The purpose of this phase is to build the organizational infrastructure required to complete the detailed descriptions of the strategic goals. This requires the Survivability Assessment Subgroup to broaden the active participation of the JSC at the level of subgroups' and user-groups' activities. We also seek during this phase to convert model-centered user groups into domain centered user groups.

2. **Transitional**—This phase will be the step at which detailed strategic goals will be translated into detailed future project requirements. For example, if one strategic goal were to develop software-coding or modularization standards for any future development efforts, these standards would be developed during this phase. These standards must also receive the acceptance of the appropriate SMEs in the JSC.

3. **Implementation**—Once the JSC develops detailed strategic objectives and defines implementation requirements, the Survivability Assessment Subgroup will seek projects to implement these requirements.

At this time, there is no way to define a schedule, largely because there are two big unknowns. We need first to get detailed goals and requirements established, and then we need to seek additional funding. The current level of funding is inadequate to maintain the current JASPO M&S Toolset. It certainly cannot help us to meet future requirements in a timely fashion. We will make it a priority to seek this additional funding. However, whatever level of funding we have, that funding will be utilized to support the execution of our strategic initiatives. ■

Mr. Ronald L. Ketcham is the Chairman for the Survivability Assessment Subgroup under JASPO. He may be reached at 760.939.2363, DSN 437.2363 or by E-mail at ronald.ketcham@navy.mil.

Survivability/Vulnerability Information Analysis Center (SURVIAC) Modeling Support

by Mr. Kevin Crosthwaite

The Survivability/Vulnerability Information Analysis Center (SURVIAC) is a centralized information resource for all aspects of non-nuclear survivability, lethality, and mission-effectiveness activities. SURVIAC provides information resources and analytical services to support scientists, engineers, analysts, and program managers engaged in designing and improving weapons systems for the warfighter. It is essential to make efficient use of credible models and simulations to support acquisition, test and evaluation, and warfighter operations. Thus an important part of SURVIAC operations is distributing selected computer models to U.S. Government organizations and their contractors. SURVIAC's analysts provide additional value-added support on these models by responding to requests and can carry out in-depth analysis for special studies and tasks. SURVIAC also maintains a network of experts in Government, industry, and academia to draw upon to answer technical questions and support special studies.

The models in the repository have not been developed by SURVIAC but typically are products of other Government agencies such as the Joint Aircraft Survivability Program Office (JASPO). The JASPO computer models entered into SURVIAC have been specifically designated by these Government agencies as standard methodologies for wide use within organizations of the U.S. Department of Defense (DoD). SURVIAC works closely with the JASPO as a key aspect of their overall corporate view of model development, support, and credibility. With JASPO's support, SURVIAC provides the DoD community with comprehensive survivability- and lethality-modeling services as described below.

Model information

SURVIAC provides a range of model information to help users solve their problems. We can discuss key aspects of a user's problem and then offer informed advice on selection of models to address his or her issues. SURVIAC maintains models that address engagement functions such as detection, track, launch and guidance, and endgame analysis. If users have modeling questions on subject areas beyond the survivability and lethality domain, such as logistics or cost, then SURVIAC will refer users to MSIAC, the Modeling & Simulation Information Analysis Center (MSIAC), and, conversely, MSIAC refers requests in the survivability and lethality domain to SURVIAC.

Model distribution

SURVIAC actually holds and distributes the approved model version with documentation and sample unclassified data sets. Various other modeling agencies and service Modeling and Simulation Resource Repositories (MSRRs) refer requestors to SURVIAC to obtain the models. SURVIAC requires the proper software-release documentation to ensure that all users are authorized DoD agencies or their contractors. SURVIAC's analysts provide installation advice for a variety of user hardware configurations and develop and provide sample cases and results for new users. SURVIAC maintains a database of all users for each model. This enables it to notify users about updates, new versions, or workshops involving their specific model.

Expert advice

To maximize responsiveness to users and provide specialized model knowledge, SURVIAC provides a technical Point of Contact for each model. This allows SURVIAC to provide users with guidance in areas such as model application, algorithms, and limitations. We can assist users to exercise model options, understand results, and develop or obtain data sets. We maintain contact with each of the respective model managers, but we are able to shield them from routine user questions.

Training

SURVIAC hosts model workshops to train community members on the application of specific models. Workshop attendees receive group instruction on multiple facets of the model in question. SURVIAC also provides individual hands-on training either at SURVIAC or at the requester's location, as arranged and funded separately.

Configuration Management (CR) support

SURVIAC collects Software Change Requests (SCRs) from the users as they encounter bugs or designs for new capabilities. SURVIAC coordinates action on these SCRs with the Government model managers and Configuration Control Board and supports beta testing.

Updates

The Center alerts users to changes, including pending improvements and error conditions. SURVIAC also receives and verifies model versions and model changes and then distributes the updated versions.

User meetings

SURVIAC hosts informal model-user meetings to provide forums for technical interchange. Users meet to discuss individual problems, work-arounds or fixes, and sample results.

SURVIAC provides information and distribution support for a selected set of the JASPO models, Table 1 (see below). The specific JASPO models in the table receive the full range of support as provided for by the JASPO.

Model entry into the SURVIAC model repository

In addition to continually updating versions of current models, the acquisition of new models is important to SURVIAC's ability to remain responsive to user-community needs. SURVIAC has established procedures to incorporate new models. A copy of the SURVIAC model-entry procedures is available on request from SURVIAC.

Briefly, a new model requires Government review and approval before it can be incorporated into SURVIAC. The JASPO Survivability Assessment Subgroup is a key organization in the model-entry process. This group evaluates candidate model readiness for SURVIAC. Standards have been established for various criteria to determine if a model is ready to be incorporated into SURVIAC's holdings. Generally the model should—

- Meet a significant assessment need of the JASPO or the Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME);
- Have established acceptance in the assessment community;
- Contain validated mathematical models and algorithms;
- Produce authoritative and useful results;
- Use methodology commonly specific to procurement documents;
- Include accurate, detailed, and current documentation;
- Contain accurate, detailed, and quality databases;
- Be written in generally acceptable coding language;
- Use portable code with machine-peculiar features minimized;
- Have a stable configuration;
- Possess a sponsoring government agency;
- Adhere to software standards;
- Interface easily with other models; and
- Produce results compatible with other models.

Table 1. Models in distribution (*=JASPO models)

AIRADE	Airborne Radar Detection
ALARM*	Advanced Low Altitude Radar Model
BLUEMAX IV*	Aircraft Flight Path Generator
BRAWLER*	Air Combat Model
BRL-CAD	Target Geometric Description Program
COVART*	Computation of Vulnerable Areas/ Repair Times Program
DIME	Digital Integrated Modeling Environment
ESAMS*	Enhanced Surface-to-Air Missile Engagement Model
FASTGEN*	Target Geometric Description Program Fast Shotline Generator
FATEPEN	Fast Air Target Encounter Penetration Program
IVIEW	Graphical User Interface for Output
JSEM	Joint Service Endgame Model
LELAWS	Laser Threat Model
MIL AASPEM II (MIL II)*	Man-In-the-Loop Air-to-Air System Performance Evaluation
RADGUNS*	Radar Directed Gun System Simulation
TRACES	Terrain/Rotorcraft Air Combat Evaluation Simulation
TRAP	Trajectory Analysis Program

When a model has been evaluated, an assessment form is completed and submitted to the SURVIAC Technical Coordinating Group (TCG). The TCG is a government review group that provides oversight guidance to SURVIAC. The final decision for incorporating a candidate model into SURVIAC rests with the TCG.

How to acquire modeling services

Model requesters can contact SURVIAC by telephone, letter, e-mail, fax, or visit. Each request should specify the computer and operating systems on which the model will execute as well as the desired media—CD, tape, *etc*. All requesters will receive a Memorandum of Agreement (MOA), which must be completed and returned to SURVIAC and be on file before any software can be released. Copies of the MOA are available on the SURVIAC Web site. This statement must be signed by the requester and, for contractors, also by the contractor's Government contracting agent to certify need-to-know. A charge of $500 will be made to all non-government

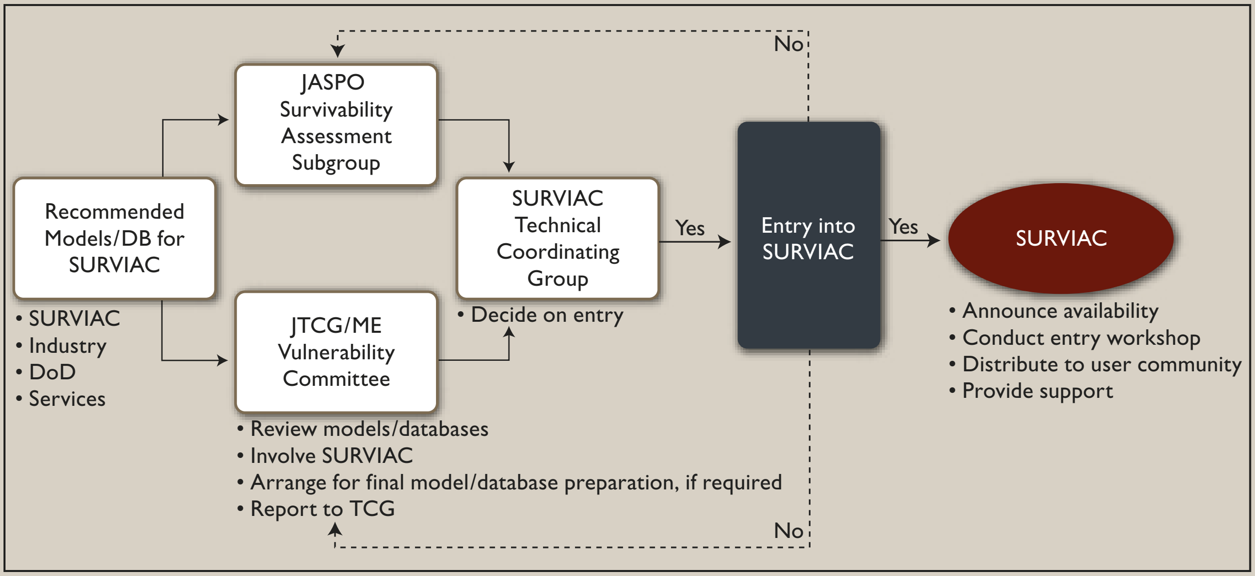


Figure 1. Process of new model entry into SURVIAC

users for each model requested. Documentation is included on the same CD as the model. If hard copies of the documents are desired, nominal documentation copying costs are additional to the basic charge. Models and documentation are made available to government agencies free of charge.

Information on model workshops can also be obtained by contacting SURVIAC. SURVIAC will notify all registered users about meetings or workshops pertaining to their specific model. Model workshop fees vary based on the resources required for workshop preparation and conduct. These fees typically include the cost of the model and documentation. User group meetings are informal and have only a nominal charge for administration expenses.

For frequent users, the SURVIAC subscription plan can provide a substantial savings over the individual purchase price of models and modeling services. The basic subscription plan includes the price of one model/documentation set and allows half-price attendance for up to two persons per organization for each workshop. The SURVIAC subscription option is a cost-effective way for an organization to build its analysis capabilities.

To obtain SURVIAC models or services or to learn more about them, call SURVIAC at 937.255.4840, or DSN 785.4840, or address your written request to—

46 OG/OGM/OL-AC/SURVIAC
2700 D Street, Building 1661
Wright-Patterson Air Force Base, Ohio 45433–7605
E-mail: surviacmodels@bah.com
URL: http://iac.dtic.mil/surviac

Looking toward the future

SURVIAC continually works to stay aware of current developments in the modeling and simulation communities. We aggressively pursue new versions and enhancements to current models. We work to bring valuable new models to the attention of our Government sponsors. Most importantly, we attempt to stay abreast of major new programs affecting modeling and simulation. Some examples of these projects are the Joint Accreditation Support Activity (JASA). JASA has made major strides in improving model credibility and has defined and is testing procedures for enhancing model validity, verification, and CM. SURVIAC stores in the repository the JASA reports that have been prepared on models. As new modeling tools come to fruition, SURVIAC will be ready to incorporate their results for the betterment of modeling and simulation. ■

Mr. Kevin Crosthwaite is Director of the Survivability/Vulnerability Information Analysis Center (SURVIAC). He has worked on several technical analysis and test programss involving a wide variety of weapons systems. Mr. Crosthwaite has a Masters in nuclear physics from Ohio State and is a licensed professional enginneer. He serves on the NDIA Combat Survivability Executive board on the AIAA Survivability Technical Committee. He may be reached at 937.255.4840, DSN 785.480, or via E-mail at crosthwaithe_kevin@bah.com.

Joint Accreditation Support Activity (JASA)

■ *by Ms. Marti Hoppus and Mr. Dave Hall*

The Joint Accreditation Support Activity (JASA) is chartered under the Joint Aeronautical Commanders Group (JACG). JASA operates under the JACG's Joint Aircraft Survivability Program Office (JASPO) to provide support for the verification, validation, and accreditation (VV&A)[1] of the Models and Simulations (M&S) used by acquisition programs across the Services. As one of the four major elements of the JASPO, JASA contributes to the goal of the Director of Operational Test & Evaluation (DOT&E) to increase the credibility of M&S used in acquisition, with emphasis on M&S used in support of test and evaluation. Currently, JASA provides VV&A support to Service, Joint Service, Department of Homeland Defense, and international programs.

JASA is composed of a government/contractor team of experienced analysts and software engineers. Within the government, JASA is an Externally Directed Team (EDT) located in the Aircraft Survivability Division (now Code 4.9.6) at the Naval Air (NAVAIR) Weapons Division, China Lake, California. Led by the JASA Director, Michelle Kilikauskas, JASA has both a dedicated staff and a team of experts who are matrixed into the JASA organization, as customer tasking requires. SURVICE Engineering Company's Ridgecrest Area Office leads the contractor support team, supplemented as required by other team members. JASA is a wholly customer-funded organization. Current customers include the JASPO, joint and other U.S. Department of Defense (DoD) activities, and international defense customers.

The fundamental goal of the JASA team is to decrease risk in acquisition by applying proven VV&A principles in a cost-effective way to establish and document the credibility[2] of M&S used in the acquisition process. We continually sharpen our skills by working with a variety of model developers and model users in government across the Services, in industry, and in academia. We pass on the lessons learned and the benefit of that experience to all our clients. In fact, one of our core values is "Learn from the best, teach the rest."

JASA's role

While other agencies such as the Defense Modeling and Simulation Office (DMSO), individual Service M&S agencies, the DoD itself, and the North Atlantic Treaty Organization (NATO) set policy and guidance on M&S credibility and VV&A, JASA provides practical help and support to simulation developers, acquisition programs, and other customers in implementing those policies in a cost-effective way.

JASA does not accredit models and simulations; the users accredit their M&S. However, JASA does assist M&S developers in fulfilling their responsibilities by helping them establish disciplined M&S development and management approaches that generate and document evidence of capability and credibility and by helping them make that evidence available to potential accreditors of the M&S in easy-to-use, cost-effective ways. JASA assists M&S development teams in preparing accreditation cases for their customers and also assists those customers in evaluating the accreditation cases prepared and submitted by the M&S proponents. Our motto is "Credible Models for Credible Answers." We direct our efforts at helping to demonstrate whether M&S are suitable for the intended use.

JASA's services fall into three general categories: accreditation support, in which we help develop and implement cost-effective VV&A programs for a variety of customers; training/knowledge sharing on practical VV&A principles, techniques, and lessons learned; and influencing VV&A policy and practice by participating in U.S. and international groups who develop those policies.

Accreditation support

JASA follows the general approach illustrated in Figure 1 (see page 18). for supporting acquisition programs and their need to accredit the M&S used in support of program milestones. The first and possibly the hardest step is to articulate in detail the intended use of the M&S for the application at hand (What questions are to be answered using M&S outputs—and how?). The next step is to develop M&S and accreditation-information requirements based on that intended use statement (What will the M&S need to do, how accurately will it perform, and what information will the accreditor need to see in order to make a decision whether to accept it?). Once those requirements are established, JASA can help the program develop a cost-effective VV&A plan to gather that information. Once the plan is executed, we help build an "accreditation case" for the M&S, which provides a logical set of claims and evidence for showing why the M&S

continued on page 18

Ronald M. Dexter

Young Engineers in Survivability

By Mr. James B. Foulk

The Joint Aircraft Survivability Program Office (JASPO) is pleased to recognize Mr. Ronald M. Dexter as our next Young Engineer in Survivability. Currently the Manager of the SURVICE Engineering Company's Dayton Operation, Ron is an exceptionally bright and enthusiastic young engineer whose efforts to develop and apply technology to maximize combat aircraft survivability and to train others in the craft have significantly enhanced numerous rotary-and fixed-wing programs and the survivability discipline as a whole.

Ron grew up in the country near a small town in northern Michigan and attended college at Western Michigan University, where he received a Bachelor of Science in Aircraft Engineering in 1988. After graduation, he accepted a position at Sikorsky Aircraft in Stratford, Conneticut, working as a Junior Stress Analyst in the Loads and Criteria Group. During his first year at Sikorsky, Ron developed structural and component flight loads for the MH–60K and HH–60J helicopters, performed dynamic finite-element analysis on components for the Presidential VH–60 helicopter, and performed load testing on and supported the redesign of the UH–60 windshield-wiper system.

Ron's survivability career began in 1989, working on the RAH–66 Comanche (then named the LH) helicopter. He performed the initial vulnerability assessments to support the early design trade studies and technical proposal that helped the Boeing-Sikorsky team win the down-select award. Early on, Ron demonstrated a keen enthusiasm for the vulnerability-assessment process and took the initiative to learn the analytical codes for developing computerized target models and conducting shotline interrogation of those models to determine vulnerable areas at the component, subsystem, and total system levels. His ability to quickly understand the survivability codes led to several pioneering efforts in computer-based ballistic vulnerability assessment methods at Sikorsky using Government-developed, *e.g.*, Ballistic Research Laboratory-Computer Aided Design (BRL-CAD) and Computation of Vulnerable Repair Time (COVART), and in-house-developed codes. Many of these methods were employed extensively throughout the RAH–66 program, and they are still in use at Sikorsky today.

The conversion of CAD geometry also became a passion of Ron's in these early days, and he has continued to strive to minimize creation of new target geometry that has already been created by the design engineers. In 1992, he developed scripts and programming methods that use a faceted approach to convert geometry data in the Computer Aided Three Dimensional Interactive Application (CATIA) format into both BRL-CAD and Fast Shotline Generator (FASTGEN) formats. It was also during this time in Ron's career that his role in the Sikorsky survivability group began to change as he was given the opportunity to lead projects supporting advanced design efforts. In addition, Ron began working on H–60 vulnerability-assessment projects in conjunction with the Army Research Laboratory (ARL) (then known as the Ballistic Research Laboratory or BRL). Coordinating closely with ARL analysts, he helped develop and refine the Damage Modes and Effects Analysis (DMEA), Probability of Component Dysfunction Given a Hit (P_{cdlh}), and Probability of Kill Given Damage (P_{kld}) methodologies to better account for the complex flight regimes unique to helicopter operations. He also helped develop assessment methods to accurately account for rotorcraft performance and handling by working directly with the Sikorsky design groups and then processing the data for integration within the COVART fault-tree methodologies through the use of P_{kld}s. This process required changing the traditional DMEA from a system-failure process to a functional-loss methodology, and it is now considered the standard for highly detailed rotorcraft analysis in which design support is a necessity, not just a desire.

While working for Sikorsky, Ron also generated numerous target-description models, including those for the UH–60L, SH–60R, HH–60H, and RAH–66 aircraft and for numerous in-house conceptual-design aircraft. He also performed many vulnerability studies on conceptual, development, and current production aircraft. Working in conjunction with product-development teams, weight analysts, financial analysts, and component suppliers, he directed and/or performed technical and cost-effectiveness trade studies at the component and system levels. He also performed cost, weight, and vulnerability-trade studies to evaluate potential vulnerability-reduction features for the developing RAH–66, for the SH–60B Seahawk armed-helo program, for three in-house Medium Lift Replacement (MLR) helicopter concepts, and for several conceptual/preliminary design studies.

In 1994, Ron was promoted to Senior Engineer and soon thereafter became lead for Sikorsky's Ballistic Vulnerability Group. In this role, he provided management and technical solutions for all Sikorsky helicopters, including conceptual, current-production, and out-of-production models. He also led Independent Research and Development (IR&D). In addition, Ron became involved with the data collection and damage analysis of H–60 aircraft hit by small arms and Rocket-Propelled Grenades (RPGs) in Somalia, and he supported enhancement studies for rotorcraft armor kits during the conflict. Furthermore, he led and/or performed numerous vulnerability assessment and design support efforts for aircraft such as the UH–60A/L, MH–60S, SH–60B, HH–60H, HH–60J, MH–60K, CH–53E, RAH–66, S–76, VH–3D, VH–60, and S/H–92.

In the summer of 1998, Ron left Sikorsky and Connecticut and returned to the Midwest to establish and manage SURVICE Engineering's first regional operation, located in Dayton, Ohio. He was tasked with working closely with the nearby Survivability/Vulnerability Information Analysis Center (SURVIAC) and with supporting the Air Force at Wright-Patterson Air Force Base (AFB), aircraft manufacturers, and Government agencies outside the region. Under Ron's technical and managerial leadership, the Dayton office grew in the six years following its inception and provided guidance for the company's establishment of other regional operations and for training new engineers in the field of survivability.

Since joining SURVICE, Ron has continued his passion to improve vulnerability-assessment codes, tools, and processes. His coordination with SURVICE, Sikorsky, and Boeing Helicopter engineers to enhance geometry-conversion processes and efficiently convert CATIA and Pro/ENGINEER data into ballistic-modeling software not only resulted in the first complete rotorcraft geometry model developed from conversion methods but it also helped establish a process that is becoming the standard for ballistic-geometry modeling. Moreover, Ron's efforts have led to enhancements in numerous vulnerability codes and models, including BRL–CAD, FASTGEN, COVART, the Tri-Service Advanced Joint Effectiveness Model (AJEM), the Tri-Service Fire Prediction Model (FPM), and the new Tri-Service Fire Ignition Module (IGNITE).

Ron has also continued to lead vulnerability-assessment and design-support efforts for many rotary-and fixed-wing platforms, including the RAH–66, S/H–92, CH–53E, B–2, A–10, C–5, MiG–29, and other foreign systems. As manager and/or lead engineer, he provides technical support in target vulnerability, design-trade studies, vulnerable-area computations, target-damage assessments, aircraft attrition, weapon lethality, and consumables analyses for a host of government and commercial customers. These customers include the Air Armament Center Modeling Simulation and Analysis Division (AAC/ENM), the National Air and Space Intelligence Center (NASIC), the Aeronautical Systems Center Modeling and Simulation Division (ASC/ENM), the 46th Test Wing at Wright-Patterson AFB, the Naval Air Warfare Center Weapons Division (NAWCWD), Sikorsky, Boeing, and SURVIAC.

The list of documents that Ron has either authored or co-authored includes over 40 technical reports, memorandums, and papers on the vulnerability assessment and/or live-fire testing of various U.S. and foreign aircraft and on the verification and validation of various vulnerability-assessment codes. In 2003, Ron's paper entitled "WINFIRE/Fire Prediction Model (FPM)" was awarded the Best Poster Paper at the NDIA Aircraft Combat Survivability Division Symposium held at the Naval Postgraduate School in Monterey, California. The paper discussed recent FPM progress and accomplishments, including efforts led by Ron to verify and validate the model and apply it to the C–5 Live Fire Test & Evaluation program.

Finally, Ron has been an active participant in numerous engineering organizations throughout his career. Beginning in his college days, he led a student chapter of the Society of Automotive Engineers (SAE)—an organization in which he is still a member—and helped the group win a first-place display award at the 1988 SAE International Congress and Exposition. He is also a Board Member of the National Defense Industrial Association (NDIA) Combat Survivability Division, serving as the Poster/Exhibit Chairman at the organization's annual Combat Survivability Symposium since 1999 and as a member of the Education Committee since 2001. Ron has served as Secretary of the American Institute of Aeronautics and Astronautics (AIAA) Survivability Technical Committee (STC) for the past two years and is currently the STC Chairman-Elect and a member of the STC Liaison Subcommittee and the Modeling and Simulation Working Group. Recently Ron was nominated and approved as an Associate Fellow at AIAA. He is also a member of the American Helicopter Society.

Ron is married to a caring wife, Kelly, and is father to two energetic boys, Matthew and Daniel. His passions outside work include coaching his sons' baseball teams, camping, fishing, hiking, biking, and just about any outdoor activity. His indoor passion is woodworking where he designs and builds furniture. It is with great pleasure that the JASPO presents Ronald M. Dexter as the latest Young Engineer in Survivability. ■

Mr. Jim Foulk is the founder and president of the SURVICE Engineering Company in Belcamp, Maryland. A survivability pioneer and leader in Government and industry for over 40 years, he was a founding member of the NDIA Combat Survivability Division and was one of the original visionaries for the DoD-sponsored SURVIAC. He may be reached at jimf@survice.com.

Mr. Ronald M. Dexter accepting an award for his WINFIRE/Fire Prediction Model paper from Dr. Mike Mikel.

continued from page 15

does or does not meet the requirements. Finally, JASA can help the accreditor review the accreditation case and any residual risks before he or she makes a decision to accept the M&S, reject it, or accept it with restrictions and/or workarounds.

JASA's role in providing VV&A support services to customers varies from simply consulting to acting as formal Accreditation Agent for the program. JASA is currently Accreditation Agent to the Joint Effects Model (JEM) program, providing a full spectrum of services related to acceptance of the model by the Services. JASA has served as Accreditation Support Agent (which entails slightly less responsibility than Accreditation Agent) for the Joint Common Missile (JCM) Program, Rolling Airframe Missile (RAM), Evolved SEASPARROW Missile (ESSM), and Joint Strike Fighter (JSF). **We have participated as Accreditation Support Team member for the MK 48 Mod 6 ADCAP Torpedo, the Coast Guard Deepwater Program, AIM–9X, and F/A–18E/F.** We have provided consulting services for a number of other programs and facilities not necessarily tied to a single program (such as the Threat Signal Processor in the Loop facility at China Lake). JASA also provides accreditation support to Operational Test Agencies (OTA) on a wide variety of programs.

Training

JASA provides a number of opportunities for customer training, ranging from materials on our Web site[3] to on-site training courses. We offer four basic courses on applied VV&A, all of which address VV&A policy, basic concepts, implementation, and lessons learned, but the emphasis and level of detail vary according to the target audience. Customized on-site training can also be arranged to focus on your specific needs. An early version of the tutorials is available on our Web site.

- **VV&A Overview for Program Managers**—A two-hour course geared toward answering the question, "What is VV&A, and how does it affect my acquisition program?"
- **VV&A Overview for Industry**—A two-hour course (the first half-hour of which is an overview for management) geared toward answering the question, "How can I demonstrate the credibility of my M&S to customers without breaking the bank?"
- **VV&A 101 for Model Developers**—A half-day course geared toward the question, "What is VV&A, and what do accreditors want from you?"
- **VV&A 101 for Testers**—A two-day course developed initially for the Commander, Operational Test & Evaluation Force (COMOPTEVFOR) in Norfolk, Virginia, which answers the question, "How might M&S be part of an effective operational test strategy, and what's involved in getting M&S accredited for use in Operational Test & Evaluation (OT&E)?"

Other training and knowledge-sharing opportunities that JASA offers include papers and briefings presented on a wide variety of applied VV&A topics; public release papers are listed on our Web site, and "for official use only" papers may be obtained by appropriate agencies and DoD contractors on request from the JASA office.

We have just recently developed a VV&A Case Study, adapted from our recent efforts, which resulted in accreditation of a suite of M&S by COMOPTEVFOR for use in Operations/Operational Evaluation (OPEVAL). This Case Study has been developed as a detailed example of how to establish the credibility of M&S for use in Test & Evaluation (T&E), but it applies

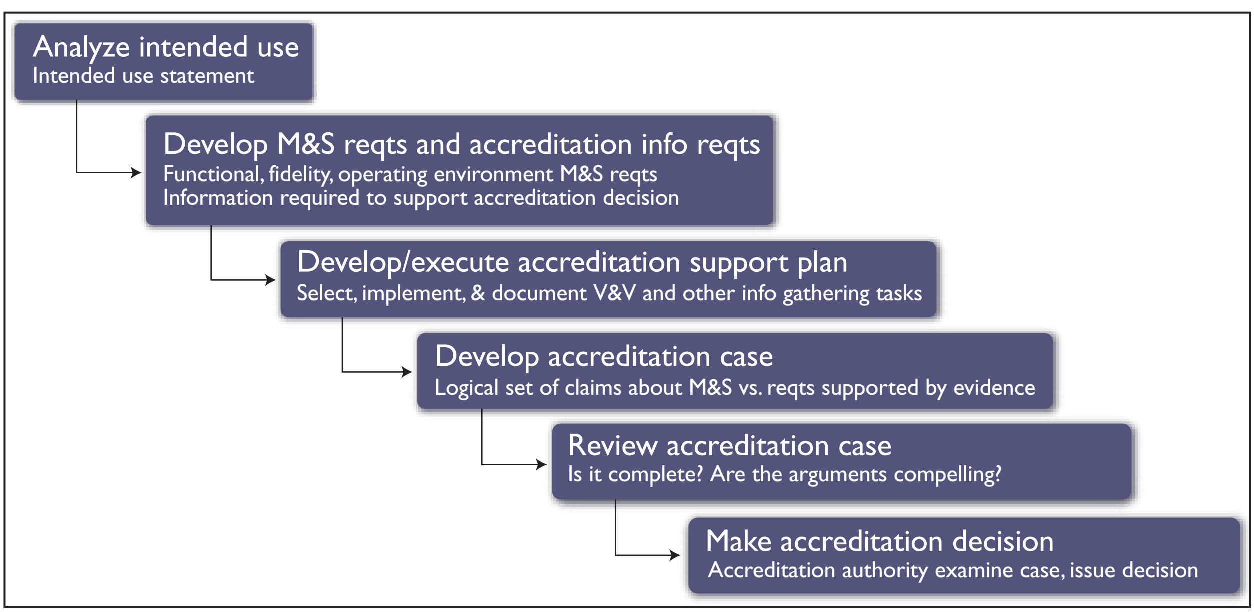


Figure 1. Steps to an accreditation decision

equally well as an example of M&S use in any phase of the acquisition process. The Case Study contains examples of documents used throughout the process—

- Intended Use Letter with M&S Requirements
- Accreditation Support Plan
- Test Data Analysis Peer Review Briefings
- Certification Report
- Certification Summary Briefing
- Certification Letter from the Program Manager to Operational Test & Evaluation Force (OPTEVFOR)
- Accreditation Letter from COMOPTEVFOR

This case study will be available soon to help train the community in how to plan and execute a VV&A program. We are interested in feedback to make these documents more useful to the acquisition community.

Policy and practice

JASA has participated in a number of national and international forums for developing VV&A policy and practice. We were part of the team that wrote the DMSO VV&A Recommended Practices Guide and participated on the DMSO data VV&C Tiger Team and the Technical Support Team. We have collaborated with the Joint Technical Coordinating Group on Munitions Effectiveness (JTCG/ME) on their VV&A process, and we have participated in the International Test and Evaluation Steering Committee (ITESC) Working Group of Experts (WGE) on V&V. Recently we led the DMSO team that developed a number of templates for VV&A reporting for legacy and federated M&S.

We are also actively researching and documenting information on the capability, accuracy, and usability of the M&S tools supported by the JASPO and distributed by the Survivability/Vulnerability Information Analysis Center (SURVIAC). Since 1997, JASA has been developing Accreditation Support Packages (ASPs) for the JASPO-supported M&S in SURVIAC. The ASPs summarize and document information useful to a potential user and accreditor and are available as part of the package of documentation provided with those M&Ss.

Recently, JASA has updated the format for the ASP documents to combine the previous three-volume set into a single volume. This volume also adds information not previously contained in the original format, including expanded sections for data credibility, software quality, and model management. The new ASP Specification[4] will be published as a JASPO document during FY04.

JASA's goal

Our goal is to set the standard in VV&A practice and implementing DOD VV&A policies in a cost-effective, efficient manner. We want JASA to set the *de facto* standard for best practice in accreditation support and to raise the bar in developing meaningful accreditation cases. We help programs fulfill their responsibilities and adhere to policy by generating evidence of credibility as a normal product of M&S development and provide that evidence of M&S capability, accuracy, and usability to accreditors in a meaningful and cost-effective way.

Within the worldwide M&S community, JASA "learns from the best and is an example and practical help to the rest." ■

Ms. Marti L. Hoppus, an M&S VV&A Support Analyst for the Naval Air Warfare Center Weapons Division, Survivability Division, JASA, has over 11 years of experience in the VV&A) of weapons systems in the DoD acquisition process. She has served as a VV&A analyst in support of a number of Navy and Joint weapons-systems developments including Sidewinder, F/A–18, JSF, and others. She was a "charter" member of the Susceptibility Model Assessment and Range Test (SMART) project, which developed and demonstrated Joint model and simulation VV&A and configuration-management processes for DoD. She is currently providing VV&A assessment support to the Commander, Operational Test and Evaluation for the JEM Program and to the Surface Electronic Warfare Improvement Program and is involved in survivability and lethality analysis and technical contract monitoring. Ms. Hoppus has a Bachelor of Arts in Business Administration.

Mr. David H. Hall is the Manager of SURVICE Engineering Company's Ridgecrest Area Operation, under contract to the NAVAIR Survivability Division for analysis support services. SURVICE provides the Navy with analyses of air weapon systems, test and analysis support services, and simulation and software support including model VV&A. Before his retirement from the Government in January 2002, he was the Chief Analyst of the NAWCWD Survivability Division, head of the Survivability Analysis Branches, Chairman of the Survivability Methodology Subgroup for JASPO, and interim JASA Director. From 1992–1996, he was also the Joint Project Manager of the SMART project, which developed and demonstrated Joint M&S VV&A and configuration-management processes for DoD. Mr. Hall has Bachelor of Science and Master degrees in mathematics from California State University at Long Beach, California.

Footnotes

1. Verification is loosely defined as determining how well M&S software meets the specification. (Did you build the model right?); Validation determines how well the M&S matches the real world from the perspective of its intended use. (Did you build the right model?); And accreditation is a decision by the responsible authority to accept the model based on V&V results and other factors. (Did your customer accept it?)
2. We define M&S "credibility" as being composedcomprised of three basic elements: "capability," "accuracy," and "usability."
3. http://www.nawcwpns.navy.mil/~jasa/
4. JASPO–03–M–002, Accreditation Support Package Specification.

Integrated Survivability Assessment (ISA)

An Update

■ *by Mr. Dave Hall*

Put yourself in the position of the Director of Operational Test and Evaluation (DOT&E) for a minute. You have to report to Congress on the survivability of a new air-weapons system that's about to go into the fleet. You have data from flyby tests over several threat radars, you may have a few actual live firings of threat missiles against drones carrying a new electronic-warfare suite, and you'll have some ballistic live-fire tests of a few threat penetrators against subsystems of the new air vehicle. What do you say to Congress? How can you gather all that information into one coherent story to tell about the aircraft's survivability in the future?

Early in 2002, the (DOT&E) tasked the Joint Aircraft Survivability Program Office (JASPO) with developing an Integrated Survivability Assessment (ISA) process to help them answer that question. This process is to be used in combining survivability Operational Test and Evaluation (OT&E) and Live Fire Test and Evaluation (LFT&E) assessments to provide an overall survivability assessment of a system under test. The ISA process will develop the proper approach to integrate analysis, modeling and simulation (M&S), and testing, making maximum use of testing and test results wherever possible. In developing the ISA process, the JASPO is expending effort to ensure that the process is adaptable for use during all phases of system development and fielding from Concept Definition through Final Operational Test & Evaluation (FOT&E), making use of appropriate M&S and Test and Evaluation (T&E) resources. This process can be a tool for requirements offices, program analysts, system developers, testers (DT and OT), and potentially for tactics development to enhance system survivability.

In response to the DOT&E direction, the JASPO instituted a project called "Integrated Survivability Assessment (M–7–02)." Under FY02 funding, that project (and a redirected, related FY01 project) first developed a "checklist" of survivability features and objectives that should be evaluated for any air-vehicle system. Second, a hierarchy of survivability metrics was developed for survivability evaluations in OT&E and LFT&E; these metrics would be the means to evaluate the checklist. Third, an outline ISA process was described for how those metrics could be measured today, making use of existing (JASPO) M&S and tri-service test-range assets. Fourth, to demonstrate the concept, three examples of different types of air-weapons-system acquisition programs were notionally measured using the ISA process outline. Based on the results of the notional examples, deficiencies were identified in the ISA process, the types of data available to the process, and the M&S available to support the process.

During FY03–FY05, the JASPO is investigating in more detail the current capabilities of test ranges and the M&S to support the process and will be coordinating with the Service OT&E agencies on the overall approach. In FY04, JASPO also began to execute the ISA process for a representative acquisition program requiring an integrated survivability OT&E and LFT&E program (the Multi-Mission Maritime Aircraft-MMA).

By "Integrated Survivability," we mean *all* factors that affect the ability of a vehicle to successfully operate in its tactical environment. A definition of Integrated Survivability Assessment was offered by the JASPO (then the Joint Technical Coordinating Group on Aircraft Survivability) at a workshop it sponsored on the subject in Albuquerque, New Mexico, in 1997—

"*Definition–Integrated Survivability Assessment*: A consistent process that combines, into an integrated whole, *all*[1] of the component parts of the standard survivability equation (Ps = 1 - Pk) for—

- Development of realistic, achievable, affordable, and sustainable survivability design requirements based on operational requirements and effectiveness goals;
- Measurement, through a combination of analytical and test methods, in both a scientific and operational context, and consistent with the development phase, of the effectiveness and military worth of approaches to increasing survivability; and
- Evaluation, tradeoff, and selection and incorporation of operationally effective approaches to survivability that are consistent with operational requirements."

The ISA process must take into account the effects of all the elements of survivability illustrated in the following figure to fully evaluate the survivability of a system under test. ISA evaluates the relative contributions of a wide variety of survivability elements, including signatures, countermeasures, and vulnerabilities, to various types of threat-weapons systems. This assessment must be accomplished not only for a single threat engagement, but, to be truly meaningful, it must be accomplished as part of an assessment of mission performance. To survive and perform its mission, then, the ISA process must evaluate the ability of the air-weapon system to operate in a hostile multi-threat environment, using its own native assets as well as off-board assets.

Since the assessment must be done in a mission context, it is important to identify specific mission-threat scenarios, or vignettes, within which to evaluate the system under test. Ideally, these same vignettes will be used throughout the acquisition of the system, from requirements to fielding. Consistent use of these vignettes across the development of the system allows DOT&E and the Operational Test Agency (OTA) to measure the progress of the system's development as it nears LFT&E and OT&E milestones. This process should minimize "surprises" as the system goes into OT&E and should maximize the utility of previous DT&E results to support OT&E planning.

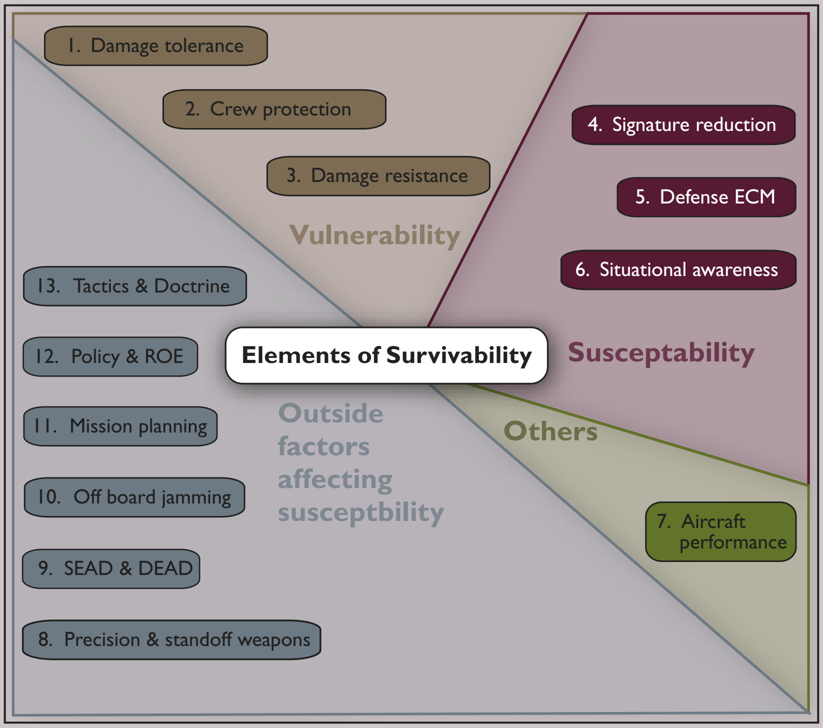


Figure 1. Generalized ISA process

A generalized diagram of the ISA process is shown in Figure 2 (see page 22). Under the constraints and guidance for the specific assessment being accomplished, an analysis is conducted of the missions and scenarios in which the System Under Test (SUT) is expected to operate, the characteristics of the SUT, and program documents describing the system and proposed OT&E and LFT&E. This analysis results in a set of vignettes against which the SUT will be assessed, and these vignettes will form the basis of the conditions under which the SUT will be tested.

Data from previous DT&E and LFT&E, any initial OT&E testing already accomplished, and the program documents will be assessed to determine what is required for M&S to support the ISA. Information on existing M&S, vulnerability data, and susceptibility data will determine which M&S are best suited to the program and any M&S improvements required to support the OT&E and LFT&E.

Once all this "up-front" work is accomplished, the tests and any supporting M&S analyses are conducted and evaluated. These analyses then provide values for the survivability metrics chosen under the ISA to measure the survivability of the SUT.

As Figure 2 shows, the key elements of the ISA process are the "up-front" analysis and planning: creating the vignettes, developing them into the Test & Evaluation Master Plan (TEMP) and test plans, identifying supporting M&S requirements, and evaluating existing M&S and data to determine what is required to adequately support the ISA.

This planning and analysis requires a detailed, in-depth understanding of all aspects of survivability from both analysis and testing perspectives. Especially important is an understanding of the credibility of any supporting M&S tools and the capabilities and limitations of test-range facilities.

Figure 3 (see on page 23) illustrates the usual relative roles of OT&E, M&S, and LFT&E for a survivability assessment. The usual operational tests of survivability deal with threat-system detection, acquisition, tracking, and launch capabilities against the aircraft system under test. Threat-weapons systems are never live-fired against the actual SUT, with the possible exception of relatively inexpensive unmanned air systems.

Live-fire testing, for survivability, is almost exclusively related to the vulnerability of the SUT to impact by a threat weapon whether ballistic, laser, high-power microwave, *etc*. Thus the LFT&E portion of a survivability test deals only with the probability of killing the SUT given a hit by a weapon's damage mechanism.

M&S is the "glue" that holds the ISA together. Weapon-system guidance, intercept, fuzing, and hit are all simulated in one fashion or another, either *via* digital simulation of the threat-weapon's performance, or hardware-in-the-loop simulations, or manned simulators of the SUT, or a combination of the above. Thus M&S bring together the various elements of the "kill chain" leading up to a successful (or unsuccessful) kill of the SUT by the threat-weapon system. The fact that M&S is so critical to resolution of OT&E and LFT&E issues makes the credibility of the M&S extremely important to the OTA and the program.

This equation (see Figure 3 on page 23) illustrates the relationship for engagement-level simulations (one threat, one air vehicle). For mission-level assessment, in which there are multiple integrated threat systems and multiple cooperating air assets, the role of M&S becomes even more critical. Limitations on airspace, threat assets, supporting air assets, *etc*. make it even more difficult to fully evaluate mission-level survivability without the use of supporting M&S.

Having said that, it is instructive to pause and consider what the role of M&S should be in OT&E and LFT&E. By statute, M&S cannot replace testing. Thus M&S *supports* test planning, test analysis, and the resolution of Critical Operational Issues (COI). In support of test planning, M&S is used to help answer the questions: "What tests should we conduct?" "What data should we collect, with what fidelity and frequency?" "What do we think will happen when we conduct the test?" In support of test analysis, it helps answer the questions: "Why'd that happen instead?" "What should we do about it?" And M&S provides the "So what?" answer for COI—that is, if a certain test produces a particular result, often that result cannot be directly related to the real issue of the test. Many times that test result must be "massaged" through a simulation to really identify whether the result shows that the system is survivable. The point is that the use of M&S in OT&E and LFT&E should be from these perspectives.

Under the JASPO, ISA is funding a study that was initiated in FY03 of test-range requirements to support ISA. This study was facilitated by an assessment of the sensitivity of M&S results to varying inputs, which identified not only M&S requirements but test-range data-accuracy requirements as well. Based on these preliminary requirements, an assessment of test-range capabilities was initiated for one test range. Tasking for FY04 includes an expansion of the test-range data-requirements analysis and an expansion of the test-range capabilities assessment to other test ranges. The goal for FY04 is to complete the analysis for three test ranges, one from each Service (Army, Navy, Air Force), and to identify any improvements in test-range capabilities that will be required to meet ISA requirements. Some effort may be required in FY05 to complete the test-range capabilities assessment for all three of the test ranges.

In addition to the basic ISA development project, the JASPO is funding a separate ISA demonstration project in cooperation with the MMA program. JASPO-funded efforts will develop a focused ISA plan for MMA and develop and coordinate the development of a survivability checklist, metrics, and vignettes for MMA. The JASPO effort will also begin to develop the database requirements for the MMA ISA assessment.

To obtain wider understanding and support for the ISA process development, a series of briefings will be presented to the Service OT&E agencies, and parallel funding sources will also be sought to shorten the timeline required for full development of the ISA process.

FY05 plans call for completion of the test-range data-requirements development and the expansion of the range-capabilities survey to

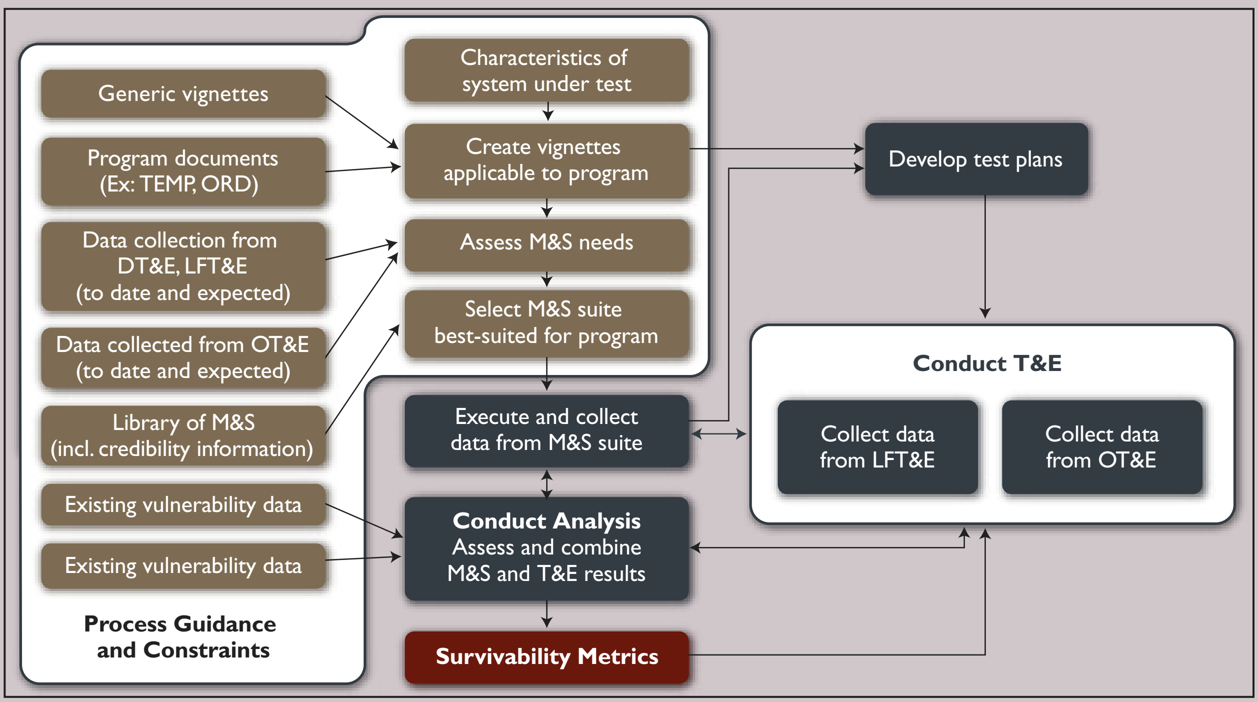


Figure 2. Usual relative roles of OT&E, M&S, and LFT&E for survivability assessment

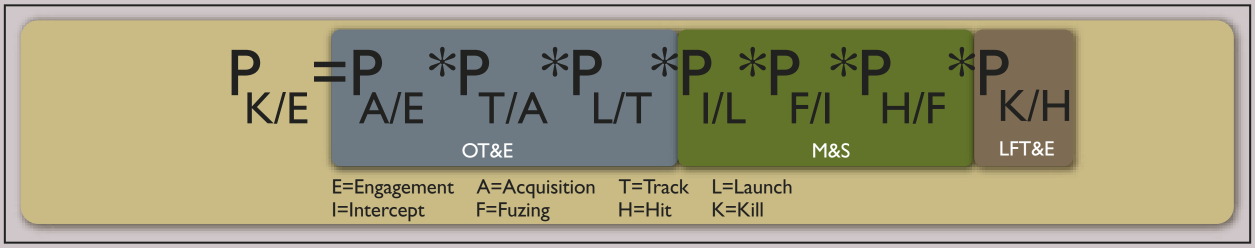


Figure 3. Relationship for engagement-level simulations

include training-range facilities. The ISA process, using mission-level metrics for survivability assessment, will require coordination between test and training ranges to fully evaluate the survivability of integrated air platforms and systems. This will necessitate enhancements to the current state of instrumentation at training-range facilities, and the ISA data requirements and training range assessment against those requirements will specify those needed enhancements in detail.

The ISA process definition will expand in FY05 to include development of handbooks and training materials. These will include instructions on how to include ISA in development of the TEMP and other test-planning documents.

The MMA demonstration will be continued in FY05 and beyond to exercise the ISA process. Required databases will be developed for the vignettes chosen in cooperation with the program office, OT&E organization, and LFT&E. The test and training-range assessment will be expanded to include any additional specific requirements for MMA survivability testing.

The ISA process development appears to be feasible, at least in concept. However, a real demonstration of the concept for MMA (or of any other acquisition program) will determine the worth of pursuing the process further to make it applicable to any type of future system. And we know of a number of deficiencies in both M&S and T&E range capabilities that we are already beginning to address.

To really make the ISA process work and be worthwhile, the OTA's and the facilities that produce the test data must become intimately involved. Early involvement by the OTA in developing metrics and vignettes for each program and the use of consistent metrics and vignettes throughout the life of the program are essential to making an ISA meaningful. In addition, since the ISA process requirements will highlight improvements that need to be made in test-range facilities and instrumentation, involvement of test-range personnel in developing these requirements should help facilitate and support funding for range improvements.

Since the ultimate measure of a system under test is its ability to survive and perform its mission, and if we are to test mission survivability on an open-air range, the use of training-range facilities is likely to be an integral part of the ISA process. This will require improvements to instrumentation and threat-system availability for these ranges and an expansion of their role beyond training.

There have been a number of agencies involved in developing and reviewing the ISA process. The DOT&E and the JASPO have funded the project and provided guidance and a critical review of the results. SURVICE Engineering Company has led the effort by developing and documenting the concept and process and provided briefings to a number of interested parties. Copies of the ISA Process Description[2] and Test Range Capabilities analysis documents[3,4] may be requested through the JASPO Survivability Assessment Subgroup Chairman, Mr. Ron Ketcham. He may be reached at Ronald.Ketcham@navy.mil. ■

References
1. *All* is taken to mean component, subsystem, and system design and performance characteristics, active and passive defense measures, and the additive influence of support assets.
2. Hall, David H., "Integrated Survivability Assessment (ISA) for Survivability Operational Test and Evaluation (OT&E) and Live Fire Test and Evaluation (LFT&E)," SURVICE Engineering Company for the Joint Aircraft Survivability Program Office, JASPO 03-M-006, China Lake, CA, October 2003.
3. Simecka, Karl, "Test Range Capabilities to Support Missile Miss Distance Measurement," SURVICE Engineering Company for the Joint Aircraft Survivability Program Office, JASPO 03-M-001, China Lake, CA, January 2003.
4. Simecka, Karl and Saitz, Dorothy, "Test Range Requirements And Capabilities For Integrated Survivability Assessment (ISA)," SURVICE Engineering Company for the Joint Aircraft Survivability Program Office, JASPO 04-M-001, China Lake, CA, February 2004.

Mr. David H. Hall is the Manager of SURVICE Engineering Company's Ridgecrest Area Operation, under contract to the NAWCWD Survivability Division for analysis support services. SURVICE provides the Navy with analyses of air weapon systems, test and analysis support services, and simulation and software support including model VV&A. Before his retirement from the Government in January 2002, he was the Chief Analyst of the NAWCWD Survivability Division, head of the Survivability Analysis Branches, Chairman of the Survivability Methodology Subgroup for JASPO, and interim JASA Director. From 1992–1996, he was also the Joint Project Manager of the SMART project, which developed and demonstrated Joint M&S VV&A and configuration-management processes for DoD. Mr. Hall has Bachelor of Science and Master degrees in mathematics from California State University at Long Beach, California.

Advanced Joint Endgame Model (AJEM)

A New Direction

■ *by Mr. Doug McCown and Mr. Ron Thompson*

In the early 1990s, members of the Anti-Air Working Group of the Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME/AA) community envisioned a new anti-air effectiveness model. In 1993, Mr. Bruce Nofrey (now retired) of the Naval Air Warfare Center at Pt. Mugu, California, noted that the Defense Modeling and Simulation Office (DMSO) was seeding the development of Modeling and Simulation (M&S) tools. Mr. Nofrey enlisted the help of several people within the anti-air community to draft requirements to present to DMSO. The DMSO review identified the Modular UNIX-based Vulnerability Estimation Suite (MUVES), an environment developed by the Army Research Laboratory, as already being precisely the tool that this group was seeking. It turns out that it wasn't—at least not yet. Hence, there was a long delay between the vision of 1993 and the action of 1997. During that time, Mr. Tom Wasmund (also now retired) of the Naval Surface Weapons Center in Dahlgren, Virginia, navigated many obstacles to rally fiscal support to jointly develop the Advanced Joint Effectiveness Model (AJEM), which was based on MUVES. In 1997, the Software Requirements Specification was published for AJEM. Since 2000, there have been annual releases of AJEM, which are available through www.ajem.com. Since 2001, Mr. Doug McCown has been the AJEM model manager. He has focused on moving AJEM to support the needs of the Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME).

New vector

AJEM started off as a concept for a new anti-air effectiveness tool. The leadership of the JTCG/ME has now adopted AJEM as the standard tool for evaluating the vulnerability of aircraft, missiles and ground-mobile targets and the effectiveness of munitions. The capability provided by AJEM will also be used as a basis to investigate new ways of producing overall JTCG/ME weapons-effectiveness estimates across this range of target types. These changes are a result of JTCG/ME's recognition that there is an opportunity to enhance the consistency and credibility of estimates published across the Joint Munitions Effectiveness Manuals (JMEM).

Previously, these manuals were truly "manuals." They are now electronic documents and fast-running software tools for the operational user. These products are created primarily for the tacticians and weaponeers of the operational community. These primary users are concerned with anti-air, air-to-surface, and surface-to-surface tactics and weapon-usage choices. This course change was required because the current and historical processes for developing effectiveness data for JTCG/ME applications in the air-to-surface and surface-to-surface communities called for the intermediate step of supplying target-vulnerability data. While AJEM could bypass the target-vulnerability-data step, using AJEM in that way would have created a severe discontinuity in the JTCG/ME target databases, because the operational tools on which the manuals are based depend on integrating vulnerability data with weapon-delivery-accuracy data. Storage requirements and runtime constraints currently prohibit AJEM from being useful as an operational tool.

AJEM's role for the air-to-surface and surface-to-surface JTCG/ME community is to provide the target-vulnerability data required by these existing operational tools. To insure AJEM could be used for the target-vulnerability data-generation role, a feasibility study was completed in 2003. This study affirmed that AJEM contained all the algorithms necessary to be the standard tool for developing JTCG/ME vulnerability data.

Consistency

The JTCG/ME further recognized that to produce consistent vulnerability data required one of two things. Either a single source for data production or a single process must be used to produce all vulnerability data. A single source is clearly an impractical business solution for many reasons. This meant the JTCG/ME must concentrate on standardizing the methodology used by government and contractor vulnerability experts throughout the Army, Air Force, and Navy into a single, agreed-on process. By identifying AJEM as the tool that will be used, efforts could be concentrated on choosing the appropriate algorithms within AJEM, the data input choices to drive those algorithms, and the resulting output from this process. A group was formed to assemble an AJEM Standard Usage Guide. This guidance, to be completed at the end of the calendar year, is intended for use in JTCG/ME production analysis for FY05 and is to be reviewed and updated annually. By using this guidance, the JTCG/ME will insure that vulnerability data produced in FY05 is consistent, regardless of who executes the data development.

An additional effort to insure consistency is the development of articulated AJEM and MUVES Configuration Control Boards (CCBs). The MUVES model manager, Mr. Russell Dibelka, and the AJEM model manager, Mr. Doug McCown, are the points of articulation between the control boards *because they are members on each other's CCBs*. This structure insures connectivity and communication between the Control Boards. The MUVES CCB has instituted a structured way to review, approve, and test software modifications. The MUVES CCB has chosen to use the pre-existing AJEM Software Change Request (SCR) database on the AJEM Web site to track and rank MUVES change requests. This process has greatly improved communication between the JTCG/ME and the AJEM/MUVES community. Additionally, as MUVES improvements are made, ultimately resulting in MUVES 3, which is to provide Real-Time Interactive Vulnerability Analysis (RIVA), the MUVES CCB will help facilitate a smooth transition of MUVES 3 into AJEM.

To further aid consistency, the next release of AJEM will contain the most recent version (Version 3.2.2) of the fragment and projectile penentration estimation tool called Fast Air Target PENetration (FATEPEN). Efforts have been under way with the FATEPEN model manager, Mr. David Dickinson of the Naval Surface Weapons Center in Dahlgren, to improve the interface between AJEM and FATEPEN. Mr. Dickinson has also been working with a Penetration Working Group, sponsored by JTCG/ME, to identify how to appropriately use FATEPEN within AJEM. To aid in communication, Mr. Ron Thompson, who sits on the AJEM CCB, is a participant in the Penetration Working Group.

Credibility

Although consistency is necessary and adequate for some applications, credibility (*i.e.*, comparability with observable test results as might be conducted in the Joint Live Fire Program) is the goal. During FY03, the AJEM Accreditation Support Package (ASP) was completed. The ASP documented the state of AJEM verification and validation. This document, which will be distributed with AJEM and will be available on the AJEM Web site, is a key reference document for the accreditation of AJEM by the JTCG/ME. In FY04, a Model Review Committee (MRC) was established to review the AJEM ASP against JTCG/ME requirements and make a recommendation on AJEM accreditation. The MRC is made up of three members of the JTCG/ME community. Mr. Del Hanson of the Army Materiel Systems Analysis Activity (AMSAA) is the chairman of the MRC. He will be presenting the findings of the MRC to the working group chairman of the JTCG/ME in September FY04. AJEM has the support of several accreditations of the MUVES code for Army-specific applications. These are documented in the ASP, but ultimately the validity of an accreditation is limited to the specific application for which it is being accredited. Many applications for which the Army accredited MUVES are directly applicable to AJEM accreditation for JTCG/ME purposes. A key application of the findings of the MRC will be to guide ongoing improvements to AJEM for use in JTCG/ME production of consistent and credible Joint Munitions Effectiveness Manuals (JMEMs).

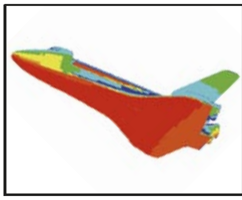
Summary

AJEM development has been focused on specific requirements of the JTCG/ME community. By doing so, however, AJEM may also have widespread utility across the target-vulnerability, aircraft-survivability, and weapon-lethality community. AJEM offers the hope of changing the process by which weapon-system effectiveness can be evaluated in the future. First, AJEM establishes a base for data consistency and credibility. Second, AJEM is constructed to produce both vulnerability and effectiveness data. This will enable new and alternative products to be developed, based on effectiveness data, in which a two-step process is deemed too coarse.

AJEM 2.2 will be released before the end of the calendar year in preparation for FY05 JTCG/ME target-vulnerability and weapons-effectiveness data-generation tasks. This new release incorporates production-analysis enhancements and includes MUVES 2.3 and FATEPEN 3.2.2. To further support FY05 production, an AJEM production-analysis support infrastructure is in place to insure that those obstacles are overcome quickly, efficiently, and accurately. ■

Mr. McCown became AJEM model manager in November 2001. He received his Bachelor of Science. in Systems Science from the University of West Florida. He has been involved in the JTCG/ME for 15 years. He has over 20 years of experience in vulnerability, lethality, testing, technology development, and weapons system development. Most of this work has been for air-to-air weapon systems. He was the principal maintainer of the missile lethality code, Shazam, at Eglin Air Force Base, and delivered Wright-Patterson its first copy in 1986. Between September 2002 and August 2003, he spent ten months at the JTCG/ME program office to help align JTCG/ME goals with AJEM development. He is currently the branch chief for the Concepts Analysis Branch at Eglin Air Force Base. He may be reached at 850.882.9585, or by E-mail at mccown@eglin.af.mil.

Mr. Ronald A. Thompson has been a member of the Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME) Program Office at Aberdeen Proving Ground, Maryland, since September 2001. He is Technical Manager for Air to Surface and Methodology development programs. Prior work at the Army Materiel Systems Analysis Activity (AMSAA) and with the General Electric Company has been in ground combat vehicle system development, Antiarmor system analysis, methodology development, test and evaluation, Live Fire Test and Manufactoring Management. Mr. Thompson has a Bachelor of Science degree in Mechanical Engineering from the University of Maryland and is a Registered Professional Engineer. He holds a Masters degree in Technical Management from the Johns Hopkins University and is a member of the Army Acquisition Corp.



Spacecraft and Aircraft Vulnerability Modeling:

Comparisons, Limitations, and Challenges

■ *by Dr. Joel Williamsen*

Over the last 30 years, computer-based methodologies for determining the vulnerability of aircraft and spacecraft to kinetic threats have developed over similar but independent paths. This independence in development history offers vulnerability analysts of both stripes a unique opportunity to view the features within their own models from a fresh perspective—that of their colleagues in a closely related field—and to speculate on the possibilities for model improvements that might result from this comparison. This article discusses some of tools utilized by the spacecraft community for Meteoroid/Orbital Debris (M/OD) vulnerability assessment and highlights potential challenges to both aircraft and spacecraft communities in improving their respective vulnerability-assessment methodologies.

Spacecraft-vulnerability modeling

NASA developed the *BUMPER Computer Model* in 1986 in response to a critical need: the development of Space Station Freedom, and its expected 10-year orbital exposure to meteoroids (naturally occurring ice-and-rock particles in orbit around the Sun) and orbital debris (man-made space junk). As the responsibility for the Freedom Station was handed from the Reagan to Bush to Clinton administrations, it added international partners (even Russian elements) and morphed into the International Space Station (ISS), nearly doubling in size and length of mission. In the same time period, the predicted orbital-debris environment grew by a factor of six. Clearly, a precise method for predicting the vulnerability of ISS to critical failure (station or crew loss) from M/OD was needed. The solution was a Fortran-based program that relies on four basic computer inputs (subroutines or models) to compute the probability of critical M/OD failure—

- A *Finite-Element Surface Model* of the spacecraft, generated with a commercial product called IDEAS. The IDEAS model provides a framework to describe the spatial relationships of the external spacecraft components (primarily, the pressurized areas of the ISS), the orientation of these components to the velocity and zenith directions, and the association of a Property Identifier (PID) with each large group of external "cells" in the geometry model. Each of these PIDs is related to an individual shielding-material configuration.

- The *GEOMETRY Subroutine* generates the M/OD environment flux on the finite-element model of the Space Shuttle based on diameter distributions, threat directions, and velocity distributions from the M/OD models (described earlier) for the orbital parameters of a specific mission (altitude, inclination, orientation of the spacecraft, *etc.*). It also considers the "shadowing" (or blocking) of some M/OD threat directions for those external elements of the Space Shuttle that might be provided by nearby spacecraft (such as the Space Shuttle) or by its own exterior elements (*e.g.*, the shadowing provided by the solar arrays). As part of this operation, the subroutine divides the M/OD environment into discrete increments of velocity, direction, and diameter ranges and calculates the flux (number of particles within this increment that impact the spacecraft) for each surface element. It also calculates the area of each finite element exposed to the incoming flux from each incremental combination of direction and velocity.

- The *RESPONSE Subroutine* calculates the critical particle diameters that cause critical failure for each incremental combination of velocity and direction for each surface PID based on the ballistic-limit or hole-size relationships described in the previous section.

- The *SHIELD Subroutine* compares each incremental diameter range being considered by *GEOMETRY* to the critical diameter being computed by *RESPONSE*. If the incremental diameter exceeds the critical diameter required for failure, the flux for that incremental diameter range is added to all other penetrating flux conditions to determine the overall number of critical penetrations for each spacecraft exterior element.

Once the penetrating flux is calculated for each exterior element, it is combined with the exposed area of each element and the time of exposure to calculate the probability of critical failure using the following equation—

$P=1 - e^{-(FAT)}$, where
P=Probability of one or more impacts by particle size "d" or larger
F=Flux from NASA model of particle size "d" or larger (per m^2 per year)
A=Exposed surface area of spacecraft (m^2)
T=Exposure time on orbit (years)

This equation illustrates the general rule for spacecraft vulnerability from the M/OD threat: *the larger a spacecraft and the longer time it spends on orbit, the higher the likelihood that a sufficiently large M/OD particle will collide with it and disable it.*

Figure 2 and Figure 3 (see page 28) consist of graphical outputs from the BUMPER program showing the relative likelihood of impact by M/OD particles on a typical shuttle model.

The plots verify the predominance of "front" and "side" impacts from the orbital-debris environment in low-Earth orbit (shown in Figure 4 on page 29). Note that few orbital-debris impacts can occur on the tile sections of the orbiter "belly" if the orbiter is flying in the "engine first" flight mode; however, orbital-debris impacts are much more likely if the orbiter is flying with its "belly" facing in the orbiter-velocity vector. Using the BUMPER computer program, NASA predicts the probability of critical failure of the ISS for extended periods and for the Space Shuttle orbiter for each individual mission prior to its launch. For Space Shuttle missions, NASA adjusts the attitude of the orbiter with respect to its velocity vector to minimize the likelihood of collisions with meteoroids and orbital debris.

Comparisons to Fast Shotline Generator (FASTGEN)/ Computation of Vulnerable Repair Time (COVART)

Since the 1970s, the U.S. Air Force has utilized the Comparisons to Fast Shotline Generator (FASTGEN)/ Computation of Vulnerable Repair Time (COVART) code combination for computing the Probability of Kill Given Hit (Pk/h) of aircraft by bullets or missile fragments. In this code, FASTGEN is used to generate the geometry of the aircraft with interior elements as viewed from each of 26 principal directions (spaced at 45-degree separations all around the body of the aircraft). COVART is similar to BUMPER—it is used to assemble data from input models and output the probability of critical failure. These input models include the following—

- Geometry inputs from FASTGEN (similar to IDEAS model inputs to BUMPER),
- Pk/h data for each individual component [similar to Thermal Protection System (TPS) damage tolerance inputs to BUMPER], and
- Empirical ballistic-penetration data (similar to the hypervelocity-damage prediction curves used in BUMPER).

As shown in Figure 5 (see page 29), both models must consider the nature of the threat (its mass, velocity, *etc.*); the target characteristics (geometry, components, exposed area, and mission parameters); and effects of threat and target interaction (failure modes and effects on end users). The details for these threats, targets, and effects are, of course, different for spacecraft and aircraft. For example, the M/OD kinetic threat to the Space Shuttle is generally faster (from 3.0 to 72 km/sec), smaller, and more unchanging than kinetic threats to aircraft and requires different (hypervelocity-impact) semi-empirical damage prediction models. Other differences highlight *areas in which spacecraft-vulnerability models could learn and improve from aircraft-vulnerability codes.*

- COVART examines the effects on internal components from penetrations through the aircraft along projected shot lines, whereas BUMPER deals only with exterior elements (and the penetration or hole size associated with them). Historically, this was because damage to spacecraft exterior elements was often directly responsible for spacecraft loss such as a breach of the pressure wall in the ISS or the loss of a TPS tile (as was the case in the loss of Space Shuttle Columbia). Nevertheless, spacecraft models often need

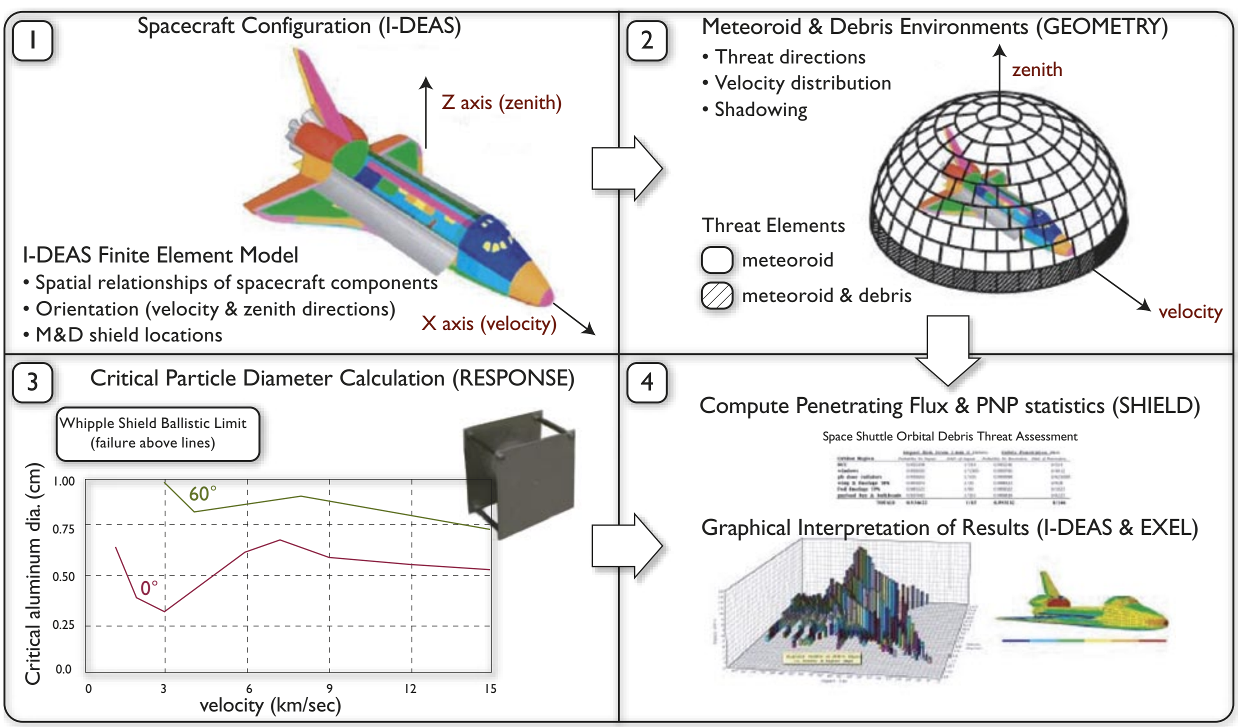


Figure 1. BUMPER code functional overview[1]

to consider "internal" failure modes, especially in unmanned spacecraft in which surface elements are often less critical to immediate spacecraft survival. In these cases, BUMPER must artificially associate an internal element with an external PID—a necessary evil that leads to errors of unknown magnitude.

- The penetration equations utilized within COVART are capable of accounting for a variety of threat shapes, orientations and materials, and multiple sheets of target material, whereas the ballistic limit equations within BUMPER are limited to aluminum spheres (for orbital debris) and water or iron spheres (for meteoroids) against single and dual plates. Clearly, neither of these space threats consists of perfect spheres, and the lack of more sophisticated threat and penetration models within BUMPER is a major deficiency within this approach.

- A number of failure modes, including fire (for internal spacecraft cabin areas) and hydrodynamic ram (within fuel-tank areas external to the ISS and Space Shuttle) have never been included in spacecraft-vulnerability models, though they are regularly considered within COVART aircraft models. The consideration of weightlessness within such failure modes would offer considerable technical challenges to the spacecraft-modeling community.

- BUMPER has a very limited user community, with perhaps two dozen active operators within government and industry. The limited user base has led to a "hobby shop" attitude towards Validation & Verification (V&V)—and no established accreditation methodology. While NASA is now addressing these areas in a significant, independent V&V effort, it has a long way to go in establishing an accreditation process similar to that employed for COVART.

On the other hand, several features of NASA's BUMPER code appear to offer definite advantages over FASTGEN/COVART and should be considered as *technical challenges for improving aircraft-vulnerability modeling.*

- BUMPER examines 90 threat directions for orbital debris and 149 threat directions for meteoroids (at a 400-km altitude) vs. the 26 threat directions viewed by FASTGEN/COVART. (NASA found that more threat directions lead to an improvement in prediction accuracy.)

- In addition to a larger number of threat directions, the threat directions are intentionally biased within BUMPER to reflect the predicted M/OD environment. In COVART (and other aircraft-vulnerability models), every threat direction is considered to be equally likely to occur, and Pk/h computations reflect this limitation. In air-vulnerability models, it is clear that threats should be weighted by how weapons are employed against aircraft in combat, not simply weighted equally because of a lack of data. If NASA can determine the relative directionality of their threats in Earth orbit, shouldn't the U.S. Department of Defense (DoD) be able to predict with more accuracy how earth-borne threats are employed against air vehicles—and use this data to establish and meet more realistic aircraft-vulnerability requirements?

- Most notably, the DoD combat aircraft-vulnerability community does not appear to be attempting to quantify the

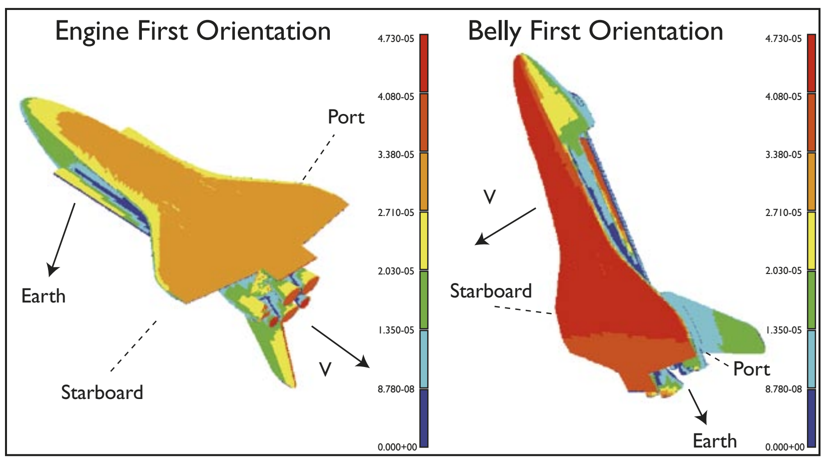


Figure 2. BUMPER graphical output showing probability of impact by orbital debris for two shuttle flight orientations

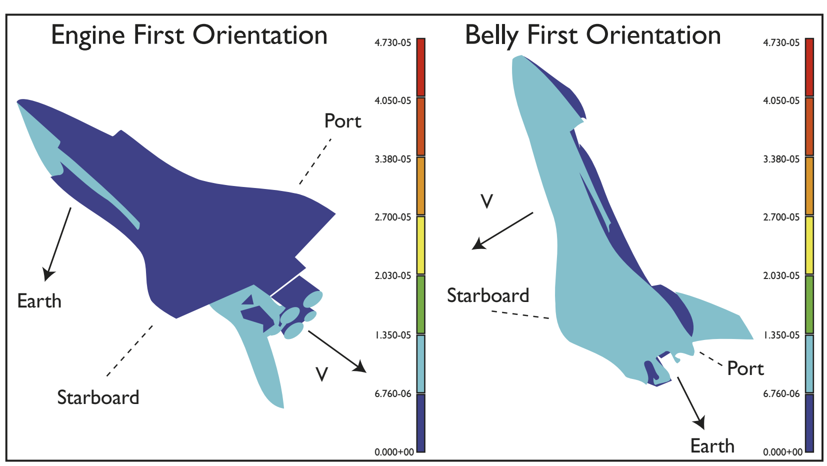


Figure 3. BUMPER graphical output showing probability of impact by meteoroids for two shuttle flight orientations[2]

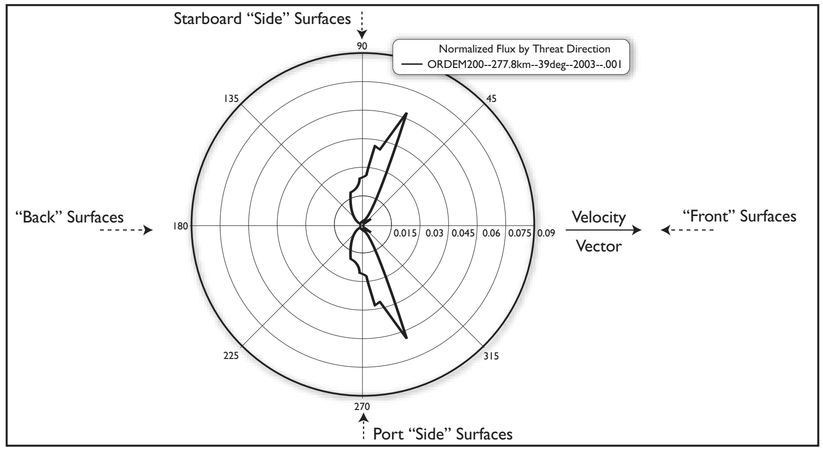


Figure 4. Directionality of the NASA orbital debris environment perpendicular to the orbital plane for spacecraft in low-earth orbit as viewed from Zenith[2]

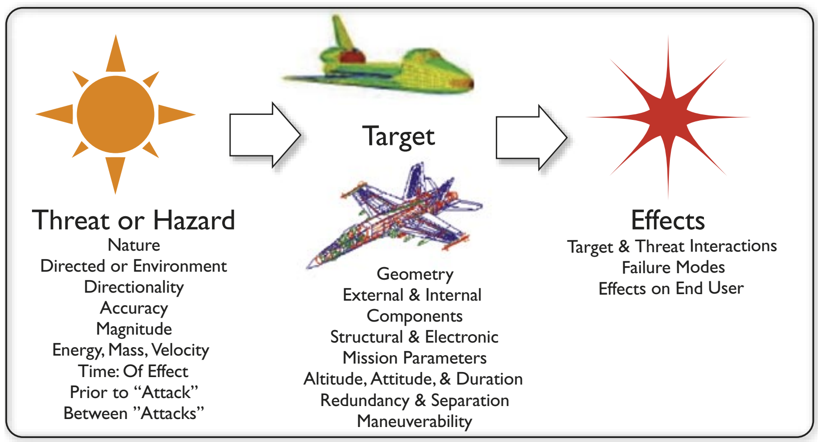


Figure 5. Model considerations for computing space shuttle and combat aircraft vulnerabilities[3]

uncertainty associated with its input models or its Pk/h calculations, whereas NASA is moving toward this as part of its overall Space Shuttle and ISS Probabilistic Risk Assessment. To accomplish this, an uncertainty (variance) is associated with each of BUMPER's input models (*e.g.*, the meteoroid flux, the orbital-debris flux, the critical-damage level, and the damage-prediction models for each PID). These individual model uncertainties are then mathematically combined to produce an estimate for uncertainty of the models as they act together (to predict overall critical risk). Using Monte Carlo modeling with hundreds of BUMPER runs, the characteristics of individual impacts are selected based on their variance within the environment, and their effects on the spacecraft are varied after they impact (based on the variance inherent in the damage-prediction model). By performing many impact calculations, the overall risk and variances associated with the onset of critical failure are combined and statistically determined.

Quantification of aircraft-vulnerability uncertainties within a Monte Carlo modeling framework would be time consuming, requiring use of far more computer resources (such as multiple workstations or supercomputers) than are used in an ordinary vulnerability analysis. However, as NASA has begun to implement the Monte Carlo uncertainty analysis associated with M/OD perforation of the Space Shuttle (using BUMPER), it is becoming clear that several assumptions are driving the results, even though many parameters (including hole-size models, penetration depth, environmental parameters, *etc.*) were considered, each with its own uncertainty distribution. The comprehensive nature of the assessment is being used to clarify NASA's focus on the important factors. *NASA is convinced only through identifying model uncertainties can they justify the resources for reducing risk and measure their progress when resources are allocated to addressing these uncertainties.*

Spacecraft and aircraft vulnerability-analysis methodologies each carry limitations and strengths. Rather than being viewed as weaknesses, however, these features should be viewed as challenges and opportunities for improving one another's capabilities in vulnerability modeling. ■

Dr. Joel Williamsen is a member of the Operational Evaluation Division at the Institute for Defense Analyses in Alexandria, Virginia, where he supports both aircraft live fire evaluations for the F–35 and F/A–22 fighter programs, as well as NASA spacecraft survivability assessments. He designed the enhanced shields and external M/OD repair kits for the International Space Station, and authored the Manned Spacecraft and Crew Survivability Code, utilized by NASA to quantify and reduce the likelihood of crew loss following the M/OD penetration of manned modules. Dr. Williamsen received NASA's Exceptional Achievement Medal for "advancement in the state-of-the-art of orbiting spacecraft hypervelocity impact and survivability analyses," and is an active member of the AIAA Survivability Technical Committee. He may be reached by E-mail at jwilliam@ida.org.

References

1. Hyde, J., and Christiansen, E. "Space Shuttle Meteoroid & Orbital Debris Threat Assessment Handbook." NASA Report JSC-29581, December 2001.
2. Williamsen, J. "Review of Space Shuttle Meteoroid/Orbital Debris Critical Risk Assessment Practices," IDA Paper P-3838, November 2003.
3. Williamsen, J. "Surviving Space—An Overview of Results from the Space and Air Survivability Workshop 2000," *Aircraft Survivability*, Joint Technical Coordinating Group on Aircraft Survivability, Winter 2000 Issue.

NDIA Combat Survivability Division Leadership to Change

■ *by Mr. John Vice*

Rear Admiral Robert H. Gormley, USN (Ret), the major impetus behind the establishment and operation of the Combat Survivability Division, announced on May 18, 2004, at the Division Executive Board meeting of his intention to step down from the chairman position. ADM Gormley said he intends to resign from the Executive Board on December 2, 2004, following the conclusion of the National Defense Industrial Association (NDIA) Aircraft Survivability 2004 symposium in Monterey, California. During his sixteen year tenure, the Division became a major advocate for increased aircraft survivability and provided an annual forum for discussion of the most important survivability topics at its annual symposium.

The Division formation culminated organizational efforts that began in Monterey at the Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS) Aircraft Combat Survivability Symposium held in December 1987. Proposed by ADM Gormley, a survey conducted at the symposium showed most attendees were in favor of an aircraft-survivability association. There were indications, however, that the scope of such an organization should be broadened to include land warfare and ship systems, and that affiliation with a prominent existing organization should also be considered.

To address these two suggestions, a second, more comprehensive survey questionnaire was sent to recipients in both government and industry. The overwhelming response was a preference for a survivability-professional association to be formed and an all-systems approach; *i.e.*, air, land, and ship adopted. The question of independence or affiliation with an existing association was divided about equally with the American Defense Preparedness Association (ADPA), a clear leader among those preferring the affiliation approach. When ADM Gormley approached the president of ADPA with the idea of forming an ADPA Combat Survivability Division, his idea was enthusiastically embraced. Further, the Division was promised a free hand in running its affairs, all in recognition of the heightened importance of survivability in both modern warfare and the U.S. Department of Defense (DoD) acquisition process. Thus, the ADPA, now NDIA, Combat Survivability Division, was born. The Division's mission is "to enhance survivability as an essential element of overall combat-mission effectiveness. This involves promoting communications and the exchange of survivability technical information between individuals and organizations that develop requirements for, design, build, and tactically employ military weapon systems." Regular Division meetings, chaired by ADM Gormley, began in 1988, and the Division's first national symposium was planned and executed in September 1989 at Johns Hopkins Kossiakoff Center on the theme "Combat Survivability: Challenges and Opportunities." Thus began the continuing series of survivability symposia that originally alternated the site between the East and West coasts. Ultimately, the Division settled on Monterey as its location for the annual event.

Under ADM Gormley's leadership the Division matured in its advocacy of weapon-system survivability. The Aircraft Survivability Symposium in the Fall at the Naval Postgraduate School is widely anticipated each year with the slogan "If you are in the Survivability business…the place to be is Monterey in November." Another standard annual feature is the presentation of the NDIA Combat Survivability Awards. Over the past 20 years, individuals have been honored for their contributions to combat survivability for Leadership, Technical Achievement, and Lifetime Achievement. The awardees have been involved in technical areas across the spectrum from low observables to low vulnerability. In recent years, the Division has concentrated on aircraft survivability and now works closely with the Association for Unmanned Vehicle Systems International to focus on unmanned-vehicle survivability and operations within the low-altitude battle space.

ADM Gormley is eminently qualified to head up efforts to promote survivability as a critical element of modern warfare. He studied at the U.S. Naval Academy and Harvard University and was awarded degrees by both institutions. A former career Naval officer and Naval aviator, he commanded the aircraft carrier John F. Kennedy, a combat stores ship, an air wing, and a fighter squadron during the Vietnam War. During that period, he also served as chief of operations and plans for the Navy's carrier task force in Southeast Asia. Principal shore assignments were with the Navy's Operational Test and Evaluation Force; the Office of the Assistant Secretary of Defense (Systems Analysis); and as chief of studies, analysis, and war gaming for the Joint Chiefs of Staff.

In other business activities, ADM Robert Gormley is President of The Oceanus Company, a technology-advisory and business-development firm serving clients in the fields of aerospace, defense, and electronics. He also is a Senior Vice President of Projects International, Inc., a Washington-based firm working to develop international trade and create investment opportunities for its clients. Special interests include airborne reconnaissance, Unmanned Aerial Vehicles (UAVs), vertical/short take-off and landing aircraft, air-traffic control, weapon-system combat survivability, military-requirements formulation, and test and evaluation planning.

A regular participant in national-security studies undertaken by the National Research Council, ADM Gormley has also been a member of study panels of the Defense Science Board and the Naval Research Advisory Committee. Study subjects include reconnaissance and surveillance, UAVs, counterterrorism, network-centric operations, tactical air warfare, fire support for amphibious operations, technology for future Naval forces, aircraft-carrier technology, mine warfare, and regional/littoral warfare.

ADM Gormley also is a long-time advisor to the Joint Technical Coordinating Group on Aircraft Survivability (now the Joint Aircraft Survivability Program). His early efforts with the Group focused on increasing the awareness of combat survivability among senior uniformed and civilian officials of the Military Services and the DoD. All who know him know how successful he was in these endeavors, and the survivability community applauds his efforts.

The leadership of ADM Gormley will be sorely missed by the Division's Executive Board. However, he has promised that his interest in weapon-system combat survivability remains as keen as ever, and he will continue to be engaged with the crucial issues facing the survivability community, our combat forces, and the nation. ■

Mr. John M. Vice is President of Skyward, Ltd. A long-time member of the aircraft survivability community, Mr. Vice is Chairman of the NDIA Combat Survivability Division's Communications and Publicity Committee. He may be reached at 828.679.5265 or jvice@skywardltd.com

Calendar of Events

JAN

10–13, Reno, VA
43rd AIAA Aerospace Sciences Meeting and Exhibit
www.aiaa.org

24–27, Alexandria, VA
Annual Reliability and Maintainability Symposium (RAMS)
703.550.9436

FEB

6–8, Anaheim, CA
HELI-EXPO 2005
203.268.2450

9–11, Washington D.C.
Munitions Executive Summit
cohara@ndia.org

15–16, Orlando, FL
NAVWAR Conference
www.crows.org

16–18, Atlantic Beach, FL
Reconfiguration and Surviavbility Symposium 2005
www.navalengineers.org

16–18, Ft. Lauderdale, FL
AUSA Winter Symposium and Expo

28–1 Mar, St. Louis, MO
Explosion Effects and Structural Design for Blast
ncerd@missouri.edu or 573.882.3285

MAR

1–2, Biloxi, MI
ShipTech 2005
www.navalengineers.org

1–3, Orlando, FL
AF Modeling and Simulation Conference
www.afams.af.mil

5, Cranfield, England
Survivability of Armoured Vehicles-Fundamentals of Armour Protection
www.rmcs.cranfield.ac.uk/esd/esdshort/456023

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

SURVIAC, Washington Satellite Office
Attn: Christina McNemar
3190 Fairview Park Drive, 9th Floor
Falls Church, VA 22042
PHONE: 703.289.5464
FAX: 703.289.5179

COMMANDER
NAVAL AIR SYSTEMS COMMAND (4.1.8 J)
47123 BUSE ROAD
PATUXENT RIVER, MD 20670-1547

Official Business

PRSRT STD
U.S. POSTAGE
PAID
PAX RIVER MD
Permit No. 22

To change, add or delete your mailing address, please fax a copy of this page with changes to 703.289.5179 or send an E–mail to: jasnewsletter@jcs.mil