AIRCRAFT SURVIVABILITY

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Aircraft Battle Damage and Repair

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News Notes

■ by Dennis Lindell

New Director, Live Fire Test and Evaluation

In January 2007, the Live Fire Test and Evaluation (LFT&E) mantle was passed from Mr. Larry Miller, who was retiring, to Mr. Richard Sayre. Mr. Sayre received his Bachelor of Arts degree in Chemistry from the University of Colorado in 1969 and his Master of Arts in Administrative Sciences (Business Information Systems) from The George Washington University in 1986. He was commissioned through ROTC in 1969. His military education includes Infantry Officer Advance Course, United States Army Command and General Staff College, Armed Forces Staff College, and the United States Army War College. Mr. Sayre has held a wide variety of command and staff positions including Command of the U.S. Army Operational Evaluation Command. In June 2000 upon retirement from active duty from the Army at the rank of Colonel, Mr. Sayre joined the Institute for Defense Analyses as a member of the professional research staff, focusing on C4I systems, joint interoperability, and simulations. He returned to government service with an appointment to the Senior Executive Service on 8 July 2002, with duties in the Office of the Deputy Under Secretary of the Army (Operations Research). He served as Director of Test and Evaluation, supervising the development of test and evaluation plans for most of the Army's major acquisition programs. His final assignment within the Army before coming to the Office of the Secretary of Defense was as the Technical Director of the Army Test and Evaluation Command.

Mr. Sayre is immersing himself within the LFT&E community through site visits and face-to-face meetings with senior service personnel. He has recently visited Navy operations in New Orleans, Mobile, and Norfolk and will be visiting Wright-Patterson AFB in early May 2007. If you are involved with LFT&E and have yet to meet Mr. Sayre, stand by for he will soon be visiting a location near you.

Richard Sayre
Office of the Director, Operational Test and Evaluation Office of the Secretary of Defense

Live Fire Test and Evaluation (LFT&E) Short Course held at Pax River

On 24–26 April 2007, the SURVICE Engineering Company and the Southern Maryland Chapter of the International Council on Systems Engineering (INCOSE) sponsored another session of "Building Survivable Systems: A Short Course on Live Fire Test and Evaluation (LFT&E)," in Lexington Park, MD, near the Patuxent River Naval Air Station. The 3-day course was developed and taught by James O'Bryon, former Deputy Director of Operational Test and Evaluation/ Live Fire Testing, President of The O'Bryon Group, and recent recipient of the Walter W. Hollis Award for Lifetime Achievement in Defense Test and Evaluation.

The course was designed to provide practical LFT&E information to a wide range of military and civilian personnel involved in LFT&E, defense acquisition, program management, and various aspects of weapon system design. Discussion topics included the following:

- LFT&E Origins, Objectives, and Legislation
- LFT&E Funding, Planning, Facilities Documentation, and Training
- Damage Mechanisms

Figure 1. F-14 MANPADS Test

- Current/Emerging Threats and Targets
- The Joint Live Fire Program
- Modeling and Simulation in LFT&E
- Battle Damage Assessment and Repair (BDAR)
- Roles of Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME), Joint Aircraft Survivability Program Office (JASPO), and Office of the Secretary of Defense (OSD)
- LFT Test Planning and TEMPS
- Commercial-off-the-Shelf (COTS)/NDI Systems
- Stealth *vs.* Vulnerability Reduction
- Systems of Systems/Interoperability

Another session of the short course is scheduled for 25–27 September 2007 in Las Vegas, NV. For more information or to register, please visit http://lftetraining.survice.com or contact SURVICE's Ray Terry at 702/492-6969 or ray.terry@survice.com or Greg Thompson at 410/273-7722 or greg.thompson@survice.com.

JASPO 2007 Short Course

The 2007 annual short course was held 2-5 April at the Naval Postgraduate School in Monterey, CA, and was sponsored by the Joint Aircraft Survivability Program Office (JASPO). The lead instructors were CDR Mark Couch from NROTC University of Illinois and CDR Chris Adams from Naval Postgraduate School. Attendees for the course included military and civilian employees working for Department of Defense, Department of Homeland Security, and industry. While the level of experience in survivability varied among attendees, most had less than five years experience in the field.

This year's short course was reformatted to more closely follow the 2nd Edition of Dr. Ball's textbook, *The Fundamentals of Aircraft Combat Survivability Analysis and Design* published by AIAA. The course was divided into four sections: overview, threats and threat effects, susceptibility, and vulnerability. Each section contained a series of academic lessons taught by CDR Couch or CDR Adams that were designed to provide an educational foundation in the aircraft survivability discipline. Due to the breadth of the survivability discipline, these lessons were designed to highlight key aspects of the survivability to give students a general understanding of the material. Interspersed between the lessons were briefs from key program offices and subject matter experts. These experts included the following:

- Mr. Dennis Lindell, Program Manager JASPO, who provided an overview of the Joint Aircraft Survivability Program and discussed the current projects and future initiatives being investigated by Susceptibility Reduction and Vulnerability Reduction Subgroups.
- Mr. Kevin Crosthwaite, Director Survivability/ Vulnerability Information Analysis Center (SURVIAC), who provided an overview of SURVIAC and taught lessons on the use of historical combat data, modeling and simulation.
- Maj Greg Thompson, USAFR, from the Joint Combat Assessment Team (JCAT), who provided an overview of the command structure of JCAT and described current and future initiatives for JCAT.
- Dr. Lowell Tonnessen of the Institute for Defense Analyses, who discussed the impact of personnel casualties and safety on aircraft survivability.
- Mr. Tracy Sheppard of the Live Fire Test and Evaluation Office, Office of the Secretary of Defense, who discussed implementation and requirements of the Live Fire Test law and Joint Live Fire program.
- Dr. Phil Pace of the Electrical and Computer Engineering Department, Naval Postgraduate School, who discussed intercept receiver strategies and signal processing for detection and tracking of Low Probability of Intercept (LPI) radars.
- Dr. David Jenn of the Electrical and Computer Engineering Department, Naval Postgraduate School, who taught the fundamentals of radar signatures.
- Professor Knox Millsaps of the Mechanical and Astronautical Engineering Department, Naval Postgraduate School, who taught the fundamentals of infrared signatures.
- Mr. Tony Muccio of the 46th Test Wing, 780th Test Squadron, who discussed the Large Aircraft Survivability Initiative (LASI).
- Mr. Ray Schillinger of the Department of Homeland Security, who discussed homeland security initiatives in aircraft survivability.
- Mr. Ron Dexter of SURVICE Engineering, who discussed helicopter specific aspects of survivability.
- RADM (Ret.) Robert Gormley of The Oceanus Company, who provided capstone summary of aircraft survivability—yesterday, today, and tomorrow.

Attendees received a copy of Dr. Ball's textbook and a CD containing the lessons and briefs. They were also shown the recently released "Threat Effects" video developed by Robert Ball, Jr. that highlighted the current threats to aircraft and included footage from interviews from experienced combat pilots in Iraq and Afghanistan. To foster closer working relationships, attendees were treated to dinner Tuesday night at *A Taste of Monterey* on Cannery Row where they were given an opportunity to informally network with other attendees.

In future courses, attendees expressed a desire to see more detail in specific sub areas such as radar and IR, susceptibility reduction, vulnerability reduction, modeling and simulation, and tactical implementation of aircraft survivability equipment. Since this level of detail cannot be provided in an overview course, it may become desirable to hold a series of 1–2 day short courses tailored to specific aspects of survivability where prerequisite level of knowledge of that sub area can be assumed.

Overall, the course provided a good mix of academic fundamentals with practical application and was rated excellent by most of the attendees. Tentatively, next year's course is being set for April 2008 and will be held in Monterey again.

Figure 1. MANPADS Launcher Training

2007 Threat Weapons and Effects Seminar

JCAT hosted their annual Threat Weapons and Effects seminar at Hurlburt Field and Eglin AFB from 24–26 April 2007. Over 200 registered attendees packing the Hurlburt Theater and the stands on the Eglin range were treated to a range of briefings and a very successful series of demonstrations. Speakers from all Services, the Defense Intelligence Agency, the Defense Advanced Research Projects Agency, civilian law enforcement, and industry gave briefings on current aircraft incidents, ongoing military operations, emerging anti-aircraft threats, and threat capabilities.

Seminar demonstrations included hands-on stinger and SA-7 launcher familiarization; the Missile and Space Intelligence Center's MANPADS display, small caliber machine gun demonstrations, three RPG shots, and an unforgettable MANPADS live fire demonstration. Figure 1 and Figure 2 illustrate two of this year's demonstrations. The seminar was sponsored by the JASP and supported by Aeronautical Systems Center, the 46th Test Wing, Air Force Special Operations Command, the Defense Intelligence Agency, and the Cruise Missile Defense System Program Office. The next Threat Weapons and Effects Training Seminar will be held on 22–24 April 2008. Additional information is available from Maj Chuck Larson, U.S. Air Force Reserve (USAFR) at 850/678–8333 or emailing him at larsonca@cox.net. ■

Figure 2. Small Arms

Battle Damage Assessment and Repair (BDAR) Capability Improvement Program

■ by Dan Cyphers

Editor's Note

Details in this article were accurate at the time of the study, but the BDAR climate is very fluid and changes are continuing to occur since the study concluded. However, the substance of the BDAR Capability Improvement Program (BCIP) Roadmap suggestions should not be significantly affected.

The increasing trend to procure more technologically sophisticated, multimission capable, and more expensive aircraft is resulting in the air combat warfighter having a limited number of aircraft and resources available for combat. As a result, aircraft battle damage repair (ABDR) or battle damage assessment and repair (BDAR), as it will be referred to here, is becoming even more critical to maximizing sortie generation and reducing aircraft downtime, particularly since aircraft have been returning with damage in recent combat operations. Since Operation Desert Storm, changes have been made in the BDAR Concept of Operations, threat effects, and the warfighting technology being deployed. Advancements in BDAR have been slow to respond to these changes, especially when dealing with new and emerging aircraft. New rapid, affordable, and effective (including cost and weight) technologies are needed for BDAR in support of emerging and future weapon systems. Foremost, a set of needs and requirements related to concepts, policies, procedures, training, and technology must be defined to ensure the services' BDAR capabilities can meet these challenges.

Initiating efforts to address these challenges, the BDAR Subgroup, recently created again under the auspices of the Joint Aircraft Survivability Program (JASP), formulated a project to develop a roadmap for enhancing aircraft BDAR capability. This joint service project was called the BDAR Capability Improvement Program (BCIP). BCIP was a 2-year, two-phase effort beginning in 2005. A final report summarizing work performed under JASP project number V-5-02 is in final review and will be released soon.

The objective of BCIP was to define a set of needs and requirements through the development of a roadmap to assist in effectively upgrading BDAR capability within the services to meet current and emerging warfighter mission requirements. To develop this roadmap, it was necessary to collect, analyze, and document data related to the various elements that define BDAR, including those mentioned above and many more. In the course of gathering this data, key BDAR capability drivers were identified. The resulting BCIP roadmap proposes an approach for progressing from a current BDAR capability to an ultimate goal capability that allows new and emerging aircraft, as well as current legacy aircraft, to be repaired in the field without being forced to a depot. The developed roadmap quantifies BDAR research and development (R&D) requirements and suggests projects to keep pace with advancing technology. The BCIP roadmap also provides suggestions for enhancing BDAR capability through improvements in BDAR concepts, policy, procedures, and

Figure 1. Members of a combat logistics support squadron sort through tools and supplies during an aircraft battle damage repair exercise. The squadron members are equipped with nuclear-biological-chemical warfare gear.

training. Benefits that can be achieved by following the suggested roadmap include the following:

- Increased warfighter BDAR capability, including an ability to assess and repair advanced technology aircraft
- Enhanced warfighter capability to meet sortie demands with a limited number of aircraft and resources

Phase I of this program entailed data collection and preparation of an analysis plan necessary for developing the BCIP roadmap. BCIP focused on knowledge learned post-Desert Storm, but comparisons were made with older data to determine whether pre-existing problems had been resolved. No formal tracking of BDAR had been implemented for recent combat operations, so post-Desert Storm, data was collected through examinations of prior BDAR studies and more notably through the conduct of a number of interviews with personnel involved in BDAR throughout each of the services. Data gathered or created during the BCIP included items from the following list:

- Key BDAR service contacts
- Service policy and guidance documents
- Service Concept of Operations (CONOPS) briefings
- BDAR equipment lists and digital images
- BDAR functional flow diagrams for each service, created from data
- General and weapon-specific ABDR/BDAR technical orders/manuals
- Previous assessments of U.S. BDAR Programs (*e.g.,* Logistics Management Institute [LMI] studies, Air Force Institute of Technology [AFIT] theses)
- Documented interview notes and meeting minutes
- Operation Iraqi Freedom/Operation Enduring Freedom BDAR lessons learned
- Information on recent assessment/repair developments
- Other BDAR reports, articles, and briefings (bibliography created).

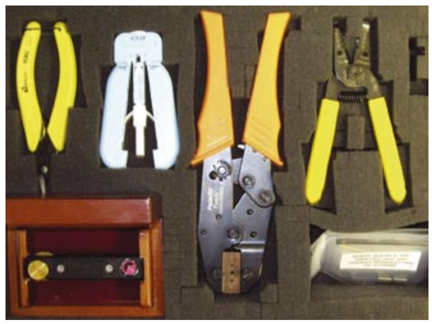


Figure 2. New Multi-Mode Fiber Optic Slice Kit

The data gathering effort focused on technology and R&D. Newer aircraft are posing significant technical challenges in assessment and repair (BDAR and general maintenance) related to such areas as low observables (LO), composites, and fiber-optics. Technology developments may be necessary for tools, methods, and materials to address these emerging technical challenges for new and recently fielded aircraft such as the F-22, F-35, V-22, and even B-2. Individuals experienced with BDAR technology issues were contacted as well as individuals involved in newer weapon system acquisition, including program offices. On the other side of the technology issue, potential technology solutions to current or future BDAR problems were identified.

Phase II involved the execution of the analysis plan and the development of the BCIP roadmap. During the course of the analysis, key BDAR benefits and drivers, and R&D requirements were identified. Underlying issues were examined under three BDAR topic areas defined for the data analysis effort:

- Concepts, policies, procedures
- Training
- Technology (equipment, tools, materials, R&D).

As new roadmap items were identified to enhance BDAR capability, a format was established to document the issues necessitating the suggestion and necessary actions to develop or advocate the item. The established format provided a convenient method of ensuring all required supporting data was documented and allowed for easy archiving and presentation of the data. Data defined for each of the roadmap items included the project title, the issue addressed, points of contact (organizations and/or individuals) with knowledge of the issue or who may take ownership for the effort, the objective, approach, payoffs and qualitative metrics addressed, deliverables from the effort, BCIP topic areas addressed, services addressed, priority, and notional funding and schedule plans.

A method was developed for prioritizing the items using various evaluation criteria and a simple scoring method. The evaluation considered the need and focus of the item, technical risk, the ability of the item to provide joint service benefit, the estimated cost, and predicted schedule. Following the prioritization of the roadmap items, the suggestions were organized, and then screened and prioritized again by a team of government and industry BDAR experts. From this effort, a final plan of action or roadmap was formulated. The resulting BCIP roadmap proposes an approach for progressing from a current BDAR capability to an enhanced and more responsive capability that addresses identified shortcomings.

Before formulating the final BCIP roadmap, it was helpful to understand the current state of BDAR and the concepts, policies, and procedures that drive its influence in each of the services. For example, although structurally different, all of the services have a similar hierarchical decision-making process in response to a battle damage situation. In-theater repair judgments are made within hours or days to return the aircraft as quickly as possible to the inventory and mission-capable status. And, as could be expected, theater commanders make the ultimate decisions for disposition of the damaged aircraft.

In general, the BDAR concept has transformed overall since Desert Storm, despite relatively similar policy guidance. In the past (*e.g.,* Southeast Asia), the potential for the highest level of sortie generation appeared to be the driving factor for BDAR. Repairs with less than full capability could be accepted, if the situation warranted quick turnaround of the aircraft to get back into battle. Findings from BCIP have demonstrated that currently the goal for each of the services appears to be to return each damaged aircraft to the highest level of mission capability as soon as possible. If at all possible, aircraft are returned to full capability whether this occurs in the field, at an intermediate maintenance site, or even if the aircraft must be sent back to a depot. In many recent cases, this has not sacrificed sortie generation because of the nature of the conflict, the availability of aircraft, or the commander's ability to alter mission requirements.

Along with the apparent effort to approach full mission capability with each battle damaged aircraft, there has also been a desire to push depot-level capability closer to the field. This includes not only obvious efforts to place artisans and engineers often closer to forward repair areas but also a desire to obtain technology advances for getting higher-level assessment and repair capability into the field.

Although the analysis showed that a push for full mission capability after each repair is apparently the goal, many of the interviewed individuals said that this was likely a reflection of the nature of recent encounters. The burning question was "what happens if we are in a conflict where we do not readily establish air superiority or the intensity or effectiveness of the enemy air defenses is much greater?"

Results from the data collection and analysis effort directly highlighted the need for many of the items appearing in the final BCIP roadmap. One such roadmap suggestion stems from an apparent lack of communication between services in the BDAR area. For example, it was noticed the other services were not aware of the extent of efforts the U.S. Air Force had placed on establishing composite assessment and repair technology or implementing a multimode fiber-optic repair. In another example, the other services were not aware of new BDAR kit developments within the U.S. Army. In an exception, discussions are currently under way between the services for the development of a joint general ABDR technical order (referred to as TO 1-1H-39 in the U.S. Air Force).

BCIP also revealed the lack of a documentation trail for BDAR in each of the services. The U.S. Army and U.S. Navy do not uniquely record BDAR actions, but the actions become part of the service's maintenance data collection system. As a result, battle damage occurrences and associated repair actions are not readily distinguishable. The U.S. Air Force has a unique form for BDAR assessment and repair plans/actions (Air Force Technical Order Form 97); however, these forms most often do not make it back to a repository, such as the Survivability/Vulnerability Information Analysis Center (SURVIAC), for later analysis. The result is a lack of data that can be used for studies to assess the state of BDAR, establish performance metrics, or advocate improvements.

BDAR personnel in various services expressed concerns over the current structure of BDAR or maintenance programs within their service and the flexibility of these programs to meet sudden, high BDAR needs. This lack of structure is particularly evident in the training area. Interviews revealed that BDAR capability management is often the responsibility of a squadron-level commander. Variance in the quantity of training between units results from the difference in value commanders place on BDAR. This results in BDAR training inequality and often dictates how a unit can approach a BDAR situation. For example, the U.S. Army's philosophy does not include a "go-to" depot-level

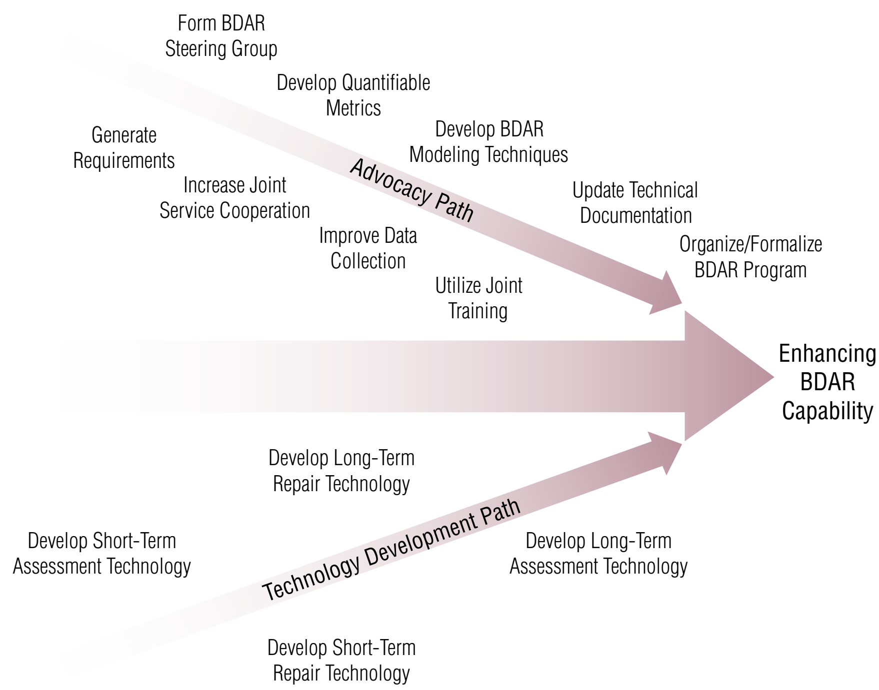


Figure 3. Roadmap: Two Concurrent Paths

expert for BDAR, so they do not have a specific program of instruction for training. Selected Military Occupational Specialties receive brief BDAR training and then additional training as they progress in their career, but tracking of trained soldiers and standardization of training are issues. The U.S. Navy currently has no formal ABDR training program. Although the U.S. Air Force has specific training programs for ABDR, it has issues as well. Air Force Special Operations Command (AFSOC) ABDR personnel, the only organic ABDR personnel within a U.S. Air Force Command, undergo training at the discretion of the unit's wing commander, and the unit commander determines who and how many personnel receive ABDR training. The ABDR capability resident in the Combat Logistics Support Squadrons (CLSS), that perform ABDR for all the U.S. Air Force Commands, also have formal ABDR programs, but funding constraints and manpower reduction initiatives have shrunk the number of Active units to three (no Reserve units remain) and continue to put pressure on the very existence of the remaining CLSS units.

As mentioned earlier, two areas were examined during the BCIP data analysis in the technology topic area. First, newer aircraft are posing significant technical challenges in assessment and repair (BDAR and general maintenance). As these weapon systems are equipped with more and more advanced technology, BDAR capability must keep pace to ensure subsystems and components associated with these technologies can be assessed for damage and subsequently repaired. In addition to concerns expressed with newer aircraft and newer onboard technologies, many legacy aircraft have existing assessment and repair issues that may be addressed by new BDAR technology developments. Among the technical issue areas cited in interviews were the following:

- Damage assessment and repair of LOs
- Damage assessment of composite materials
- Structural bonding repair assessment
- Fiber-optic repair
- Titanium tube bending in the field for 5,000 psi hydraulic systems
- Ceramic coating repair for engines

Following an analysis of the data gathered during BCIP, it was evident that BDAR capability improvements were possible in the three main topic areas examined (concepts, policies, procedures; training; and technology). Roadmap items were defined to address the identified current or future shortcomings. The BCIP roadmap suggests two concurrent paths for BDAR enhancement. First, a series of recommendations were made that could contribute to advocating the importance of BDAR and improving the structure of BDAR in each of the services. These suggestions are long-term efforts that need to begin now because they involve a dependent series of actions that build upon each other. These suggestions were designed to increase BDAR visibility, funding, involvement in weapon system acquisition trade-offs, organization, and training capability.

The second concurrent path suggested for the roadmap involves items that promote technology development in BDAR assessment and repair. These suggestions involve largely independent short-term and long-term efforts that can begin simultaneously with the aforementioned advocacy efforts. A qualitative objective for these efforts was to develop field-level tools that could address the most likely assessment and repair needs for legacy and currently planned aircraft. These suggestions were framed in such a way to aid in future attempts to obtain funding for development through such means as the JASP proposal process, Small Business Innovation Research programs, service-funded broad agency announcements, or other means.

Key recommendations in the BCIP roadmap can be summarized by the following actions: (1) establish a body of experts or a BDAR steering group to coordinate and facilitate the BCIP roadmap, (2) establish a quantifiable metric or series of metrics for demonstrating the benefits of BDAR and determining the BDAR capability improvement potential from suggested roadmap actions, (3) establish a joint service training program to expand BDAR training within the services while minimizing costs, and (4) implement a joint service technology development plan focusing initially on current BDAR capability shortfalls and later expanding to the assessment and repair of advanced

Topic Area/ Roadmap Item	Recommendation Summary
Concepts/Policies/Procedures	
BDAR Steering Group	Form coordination/ facilitation body
- Joint Service BDAR Cooperation	Foster cooperation through Steering Group
- BDAR Requirement Generation	Advocate BDAR requirements; weapon system acquisition focus
- BDAR Advocacy through Quantifiable Metrics	Define metrics to assist in BDAR advocacy and trade-off studies
- BDAR Campaign Modeling	Using metrics, insert BDAR methodology into existing models to perform trade-off studies
BDAR Record Keeping	Improve BDAR data collection
BDAR Lessons Learned from LTF&E, JLF	Improve BDAR learning through live fire testing
Electronic BDAR Assessment Implementation	Continue development of electronic onboard means for damage assessment/data recording
BDAR Technical Manual Updates	Improve currency/ development of technical manuals
Formalized U.S. Army BDAR Program	Formulate standardized U.S. Army BDAR program

Table 1. BCIP Roadmap Recommendations for Concepts/Policies/Procedures

technologies and materials used on new and emerging aircraft. Tables 1 to 3 provide the complete list of recommendations grouped by BCIP topic area.

In summary, it is believed that for the BCIP roadmap suggestions to be successful and for the roadmap to be sustained, several actions must be taken in an expeditious manner. These requirements include:

- The BDAR steering group should be formed quickly for roadmap advocacy, coordination, and facilitation, preferably drawn from BDAR advocates already in place.
- Advocates must also be identified at higher levels of the Department of Defense and within the Office of Secretary of Defense structure to support BDAR initiatives and the establishment of BDAR requirements. These advocates should not be limited to the vulnerability community, which has often taken ownership of the BDAR role, rather the logistics community should be examined for supporters who understand the importance of BDAR.
- A means for demonstrating, by quantifying, the value of BDAR is required to institute many BCIP roadmap suggestions. ■

About the Author

Mr. Dan Cyphers is Vice President and Manager for Skyward, Ltd. He received a BS degree in Mechanical Engineering and an MS degree in Aerospace Engineering, both from the University of Dayton. Mr. Cyphers' professional experience includes more than 15 years involvement in aircraft survivability/vulnerability testing and analysis, including ballistic live fire test and evaluation and vulnerability reduction concept evaluation. His technical experience also includes aircraft battle damage repair analysis. He led Skyward efforts during BCIP and welcomes associated questions. He may be reached by email at dcyphers@skywardltd.com or at 937/252-2710, ext. 102.

Topic Area/Roadmap Item	Recommendation Summary
Training	
Joint Training for Advanced Systems & Institute Joint Exercies	Implement Joint Services training curriculum for advanced technology, materials, and processes
Institute USN/USMC BDAR Training	Develop/re-institute standardized BDAR training in USN/USMC

Table 2. BCIP Roadmap Recommendations for Training

Topic Area/Roadmap Item	Recommendation Summary
Technology Development	
Multi-Functional Composite Nondestructive Evaluation Tool	Develop modular field level NDE system capable of fully characterizing composite material damage
Fiber-Optic Repairs-Single and Multi-Mode Extension	Qualify multi-mode BDAR repair and extend to other fibers, develop single mode repair
Titanium Issues Oversight	Develop repair solutions/material substitutions for titanium repair
Bond Strength Assessment	Develop tools/methods to verify structural integrity of bonded repair
Bonded Structural Repairs for BDAR	Develop accepted methods/materials for increasing usefulness of bonded field repair
Honeycomb Core Repair	Develop methods/materials for structural honeycomb core field repair
Transparent Canopy Repair	Develop tools/techniques for rapid repair of transparent canopies without optical distortion
Wire Assessment and Repair	Develop/validate tools/techniques to facilitate rapid assessment and repair of electrical wiring
BDAR for New Technology Engines	Develop procedures to allow BDAR on advanced engine subsystems
Ceramic Matrix Composite Repair	Develop field repair for ceramic matrix composites
Low Observable (LO) BDAR Program Monitoring	BDAR Steering Group effort to monitor current LO repair development programs, advocate BDAR capability inclusion, and seek funding to transition the technology to BDAR
- Multi-Functional LO Nondestructive Evaluation Tool	Field-level system capable of performing NDE on multiple LO material systems
- LO Sealer-Primer for BDAR	Adapt sealer-primer LO treatment materials and techniques to BDAR
- Radar Absorbing Material (RAM) Removal Tools	Evaluate RAM removal tools for BDAR and develop miniaturized RAM removal technology, if necessary
- Radar Absorbing Structure (RAS) BDAR	Develop/transition RAS BDAR techniques and materials
- High Temperature RAM BDAR	Transition/validate high temperature BDAR RAM repair methods
- HOT Melt LO Filler and Fastener Treatments	Develop/transition generic multipurpose hot melt LO materials and filler/fastener treatments for BDAR
- LO Rapid Cure Fairing Material	Develop/transition rapid cure LO fairing treatment materials/techniques for BDAR
- LO Rapid Cure Surface Coating	Transition BDAR rapid cure LO coating materials and surface treatments
- LO Canopy Coating BDAR	Develop/transition field level BDAR technique/technology for LO canopy coatings
Effect of Non-Standard Repairs on Radar Cross-Section of LO Platforms	Perform necessary testing to define levels of acceptability for LO Repairs

Table 3. BCIP Roadmap Recommendations for Technology Development

Naval Postgraduate School Establishes All-Platform Center for Survivability and Lethality

■ by Barbara Honegger

On 30 January 2007, the Naval Postgraduate School (NPS) announced the creation of the Center for Survivability and Lethality. The new research and education enterprise is the first interdisciplinary center dedicated to increasing the survivability of the broad range of U.S. and allied military, homeland security, and critical infrastructure platforms and the lethality of these platforms to hostile platforms and systems.

Twenty NPS faculty members from the departments of Mechanical and Astronautical Engineering (MAE), Physics, and Electrical Engineering have agreed to participate in the research and education activities of the new center.

"This is the start of something we expect to be huge," said center Co-Director and Associate Dean of the NPS Graduate School of Engineering and Applied Sciences CDR Chris Adams. "The goal is to significantly expand survivability and lethality engineering as a formalized scientific discipline and become a conduit for research and education funding focused on developing innovative survivability and lethality applications for industry, government, and the military."

The new center builds on the pioneering work of Distinguished Professor Emeritus Robert Ball, who founded the first and only course on all aspects of aircraft combat survivability at NPS in the 1970s and wrote the field's "bible," *The Fundamentals of Aircraft Combat Survivability Analysis and Design*.

"In standing up this center, we stand on the shoulders of Bob Ball, who is truly the 'Father of Aircraft Combat Survivability Education' and the world's foremost authority in the field," said CDR Adams, a former thesis student of Ball's at NPS. "We're extremely fortunate that Professor Ball has worked on both the aircraft and ship survivability aspects of our new MAE platform survivability course and generously agreed to help with the center."

CDR Adams emphasized the value of extending survivability and lethality research across all platforms. "Everything that can be built can be built better," said CDR Adams, "and expanding the focus of the engineering discipline from aircraft to all platforms—ships, missiles, submarines, satellites,

Figure 1. Co-director of the new Naval Postgraduate School Center for Survivability and Lethality and Associate Dean of the University's Graduate School of Engineering and Applied Sciences CDR Chris Adams (second from left) with officer students in his course on platform survivability and systems reliability. The new interdisciplinary research and education center, the first of its kind in the world, is dedicated to making the broad range of U.S. and allied military, homeland security and critical infrastructure platforms more survivable to attack from sea mines (center) and other weapons, as well as more lethal to hostile platforms and systems.

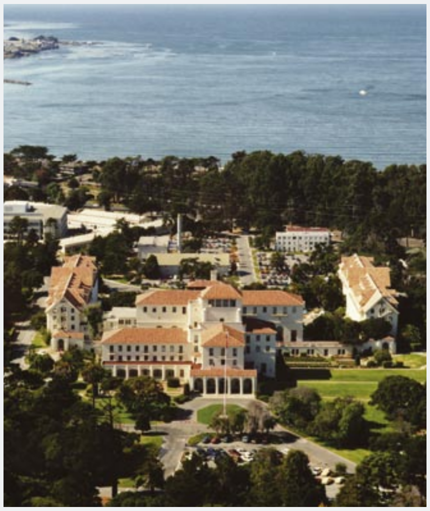


Figure 2. Aerial view of the Naval Postgraduate School (NPS), Monterey, CA.

Figure 3. Co-directors of the new Naval Postgraduate School Center for Survivability and Lethality, Associate Dean of the Graduate School of Engineering and Applied Sciences CDR Chris Adams (right) and Associate Chairman of the Department of Mechanical and Astronautical Engineering Knox Millsaps.

tanks, trucks—will enable us to move our military expertise out to the civilian automobile and aircraft industries."

"The center will support the ongoing NPS missile systems engineering track," said center Co-Director and Associate Chairman of the Department of Mechanical and Astronautical Engineering Professor Knox Millsaps, "as well as pursue critical homeland security and military and civilian infrastructure issues that can benefit from the same analytical framework."

"In the post-9/11 world, a lot of people are clamoring for survivability education," stressed CDR Adams, who is currently teaching an NPS course on platform survivability and systems reliability, ME 4751. "We knew we were really onto something when this course became the most heavily subscribed ME 4000-level course here at NPS over the last two years. And there are a lot of air combat groups and civilian industry experts who also want to take it *via* distributed learning."

Some of the other courses that will be taught under the auspices of the center are platform signatures, ship systems, satellites, warheads, weaponeering, directed-energy weapons, electronic warfare, and modeling and simulation.

According to Professor Millsaps, the NPS Center on Survivability and Lethality also will include an industrial consortium through which industry representatives will be able to support its research efforts, take short courses, and receive up-to-date publications in the field.

Dr. Ball recently won the American Association of Aeronautics and Astronautics Summerfield Book Award for his book, *The Fundamentals of Aircraft Combat Survivability Analysis and Design, Second Edition*, which was judged the best book recently published by the professional association (see story at http://www.nps.edu/News/ReadNews.aspx?id=3118&role=pao&area=media).

For more information on the NPS Center for Survivability and Lethality, contact CDR Adams at caadams@nps.edu, 831/656-2682, or Professor Millsaps at millsaps@nps.edu, 831/656-3382. To learn more about aircraft combat survivability, visit Professor Ball's Aircraft Combat Survivability Education website at http://www.aircraft-survivability.com/. For detailed information about all NPS programs, go to http://www.nps.edu. ■

About the Author

Barbara Honegger, MS is Senior Military Affairs Journalist at the Naval Postgraduate School, the nation's premier defense and security research university. Prior to coming to NPS in 1995, Ms. Honegger held a number of positions in the federal government, including White House Policy Analyst and Special Assistant to the Assistant to the President in the first Reagan Administration; the President's liaison to the Defense Advisory Committee on Women in the (Military) Services (DACOWITS); and Director of the Attorney General's Task Force on Legal Equity in the U.S. Department of Justice. She is co-author of *The Military Draft* (Hoover Institution Press, Stanford University), and author of *October Surprise*, on the genesis of Irangate. Ms. Honegger is a Naval War College graduate in National Security Decision Making, and holds a bachelor's degree in Honors Writing from Stanford University and a master's degree in Psychology from John F. Kennedy University, in CA. Over the past decade, she has written and published hundreds of articles on the Naval Postgraduate School's cutting edge research and educational programs. For current and archived articles, see http://www.nps.edu.

Force Protection Evaluation for Combat Aircraft Crews

■ by Torger Anderson and Joel Williamsen

Current acquisition program requirements often relate to aircraft survivability during specific segments of a combat mission (*e.g.,* the threat encounter) with very narrowly defined conditions (*e.g.,* aircraft configuration, flight, and encounter conditions), and evaluate survivability (or aircraft attrition) to the point where the pilot ejects, the aircraft is lost, or the aircraft is considered "safe" following completion of the mission goals as it crosses some geographic threshold (*e.g.,* a Forward Line of Own Troops, or FLOT). Delayed effects of combat damage that add risk to a safe return and recovery beyond this point do not enter into these analyses, but are important for an accurate assessment of aircraft attrition and crewmember survivability. The risks of surviving in-flight egress or ejection resulting from combat damage are also not considered in these assessments.

The introduction of the National Defense Authorization Act of 2005 [1] requires that all acquisition programs for manned systems which may be employed in an asymmetric threat environment establish Survivability and Force Protection Key Performance Parameters (KPPs). All programs, with or without products designated for Live Fire Test and Evaluation (LFT&E) coverage, are forced to consider crewmember survivability. As indicated in the Venn diagram in Figure 1, KPPs are somewhat complementary in that the Survivability KPP is meant to address the platform robustness (probability of an aircraft kill given a hit, or $P_{K|H}$) while the Force Protection KPP is meant to ensure that some level of protection for personnel is considered (probability of a personnel casualty given a hit, or $P_{PC|H}$). The evaluation is extended to any casualties, critical crewmembers or otherwise. However, the legislation addresses only "asymmetric threat environments." Although this term is not clearly defined, this tends to limit these assessments to only a portion of the aircraft mission profile, often departure and approach to the home field when man-portable air defense missile systems (MANPADS) are potential risks.

Expanding the survivability analysis to include every aspect of a mission, from takeoff to recovery and, in the case of aircraft loss, to the recovery of the crewmembers and passengers may produce more accurate and very different results from those arrived at in current analyses. These changes would make the following improvements to the process:

- Provide the developer with a tool for use early in the design process to consider a variety options for reducing casualties, including armor, ullage protection, fuel bladders, fire detectors, fire suppressors, system redundancy, system separation, ejection systems, crashworthy design features, crew egress after landing, etc.

- Result in the first "global" approach for optimizing an "integrated" design for aircraft vulnerability reduction and aircrew survivability, considering features that address each of these aspects and their interactions. For example, crashworthiness features would at last have a way of "buying" their way onto a helicopter—historically, a difficult "sell" to a program, but vital to occupant survivability.

- Produce a methodology that comprehensively addresses the Congressional mandate to evaluate system survivability and personnel casualties.

- Increase accuracy in the assessment of aircraft attrition and crewmember survivability against acquisition program requirements and to guide operational procedures and combat employment.

Methodologies and Issues

Post-Egress Survival

A comprehensive assessment of crewmember and passenger survivability would require an expanded vulnerability analysis as shown in Figure 2 The boxed area on the left contains the current vulnerability analyses using the Computation of Vulnerable Area and

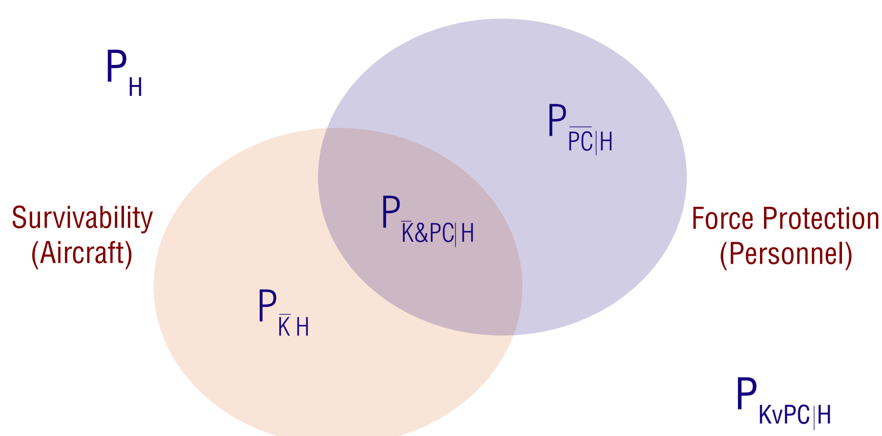


Figure 1. Aircraft and personnel kill probability overlap.

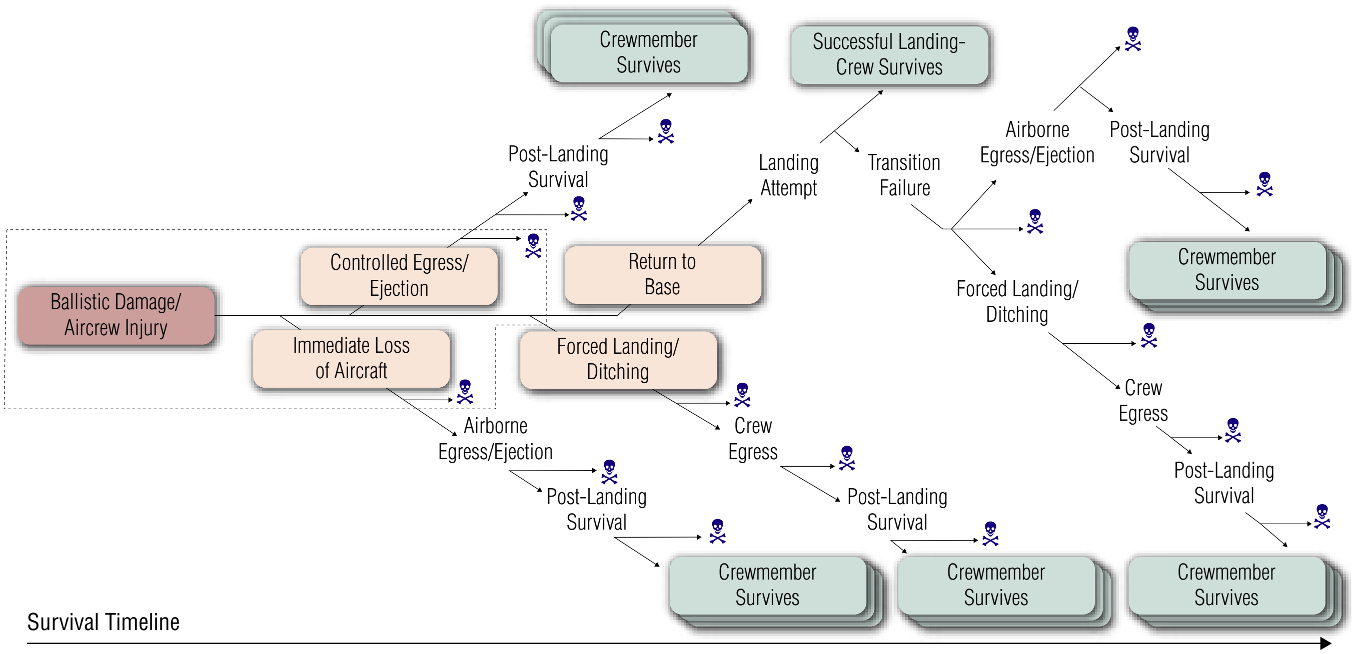


Figure 2. Post-egress survivability sequence to be added to the vulnerability analysis.

Repair Time (COVART) model or the Advanced Joint Effectiveness Model (AJEM). The branches to the right of that box describe the additional analyses required for a comprehensive crew/passenger casualty assessment. Each branch leads to personnel survivability issues with options of survival or casualty (☠) that require evaluation. The probabilities of survival are then combined along a branch to assess the survivability of the overall event (*e.g.,* "Controlled Egress/Ejection"). Multiple crewmembers/passengers can be dealt with by treating each person independently and combining the branches statistically. "Immediate loss of aircraft" evaluated in the original vulnerability analysis now has some possibility of aircrew survival that is determined by evaluating the issues on that branch. This would be degraded somewhat by the probability of critical damage to the egress equipment or ejection system.

The proposed analysis goes beyond this, though, to account for factors that can reduce aircrew/passenger survivability when egress is necessary. The ejection/egress process and post-landing survival issues each introduce their own aspects affecting likelihood of survival. Table 1 summarizes the sequential issues that must be addressed for ejection from a tactical aircraft. Data may be readily available for many of these issues, or some issues may need to be addressed with subjective factors. Standard practice, though, for any such vulnerability or survivability analysis should be to assess the confidence of each analysis assumption and conduct sensitivity analyses to determine the uncertainties in the analysis results. It should be noted that this is required in order to generate a valid assessment and is a significant effort that should not be underestimated.

The issues related to ejection in Table 1 are listed according to the ejection sequence. The effect of pre-ejection injuries is to reduce the ability to successfully complete each of the subsequent items. The probabilities of injuring critical aircrew members in various ways are determined as part of the normal vulnerability analysis and can be extended to all aircrew. The ejection seat manufacturers may be able to provide some insight into the effects of these injuries on survivability through the ejection event, but this

Event	Description	Data Sources
1	Pre-ejection injuries	Vulnerability analysis
2	Ejection initiation	Encounter conditions
3	Ejection system capabilities	Ejection seat envelope
4	Ejection system damage	Ejection system DMEA
5	Ejection system reliability	Ejection system FMECA/safety statistics
6	Landing environment	Ejection/egress safety statistics
7	Enemy disposition	Combat incident data
8	Survival to recovery	Survival data/Combat incident data

Table 1. Ejection Survival Issues.

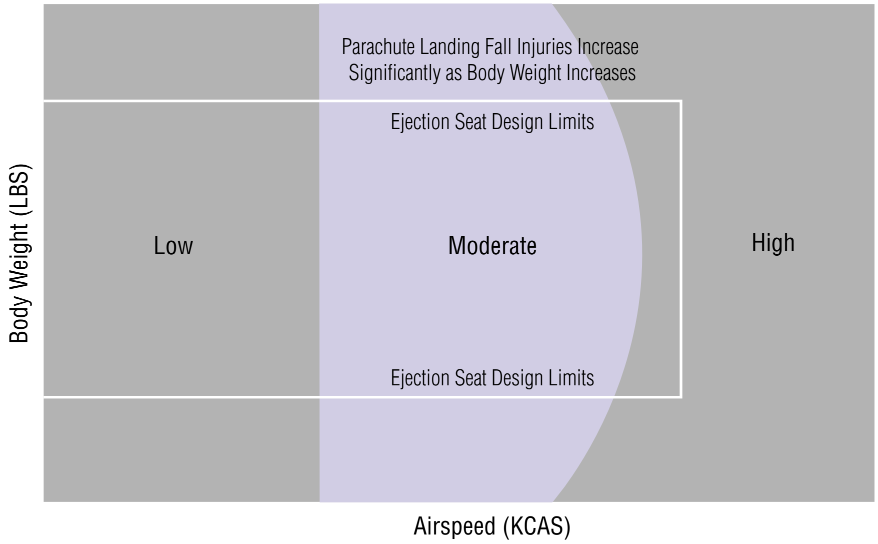


Figure 3. Ejection envelope from a typical flight manual.

will most likely be a subjective factor reducing the probability of surviving the subsequent events.

The ejection seat envelope is an extension of this issue and considers the likelihood of the aircrew member suffering injuries from aerodynamic forces or hitting the ground before the ejection seat sequencing is complete. The ejection seat manufacturer will have data describing the flight envelope for a successful ejection and it is often provided in the aircraft operator's manual [Naval Air Training and Operating Procedures Standardization (NATOPS) manuals or Air Force Tech Orders] in a form as shown in Figure 3. Without any additional information, one could presume that an ejection outside of the envelope is not survivable and, within the envelope survival depends on the remaining events in Table 1.

The effects of ejection seat damage should be accounted for in the aircraft Damage Means and Effects Analysis (DMEA) as part of the overall vulnerability analysis. Ejection seat reliability (probability of successful functioning given a successful initiation in an undamaged seat) may come from the seat manufacturer's data including Failure Means and Effects Criticality Analyses (FMECAs) and from ejection statistics for specific seats for non-combat ejection events that are compiled by such agencies as the Naval Safety Center and the Air Force Safety Evaluation Center.

Survival after a successful ejection has not been considered as part of a vulnerability analysis, in part because of the variability of possible conditions and the lack of statistical data to put into the analysis. Data obtainable from the Naval Safety Center or Air Force Safety Evaluation Center for ejections and other parachute landing incidents may be adequate to characterize some of these conditions (*e.g.,* probability of casualty for landing in flat surface environments), but there may be insufficient data to characterize casualties for landings with high winds, in mountainous terrain, or in heavily wooded environments. Survival after landing and until recovery by friendly forces also needs to be examined. Limited data for developing statistical information can also be obtained from the Naval Safety Center with a fairly high level of confidence.

While this discussion has dealt with tactical aircraft, similar issues exist for larger aircraft and helicopters, neither of which have ejection seats. Lists of post-egress or forced landing issues similar to Table 1 can be generated and evaluated for crew casualties in these situations.

Beyond the FLOT

The second way in which a survivability analysis needs to be extended in order to assess crew survivability is to take it beyond the end of the combat portion of the mission, across the boundary of the "safe" zone to final aircraft recovery. Combat damage that does not lead to an aircraft kill as defined in Table 1 will not affect current survivability analyses. In fact, some of these damage modes, even without affecting "flight critical" systems, can result in a kill if the analysis is taken to the aircraft returning to base. Some examples follow that show how this might occur for fixed wing aircraft:

- Projectile or warhead fragment damage to fuel tanks may result in undiscovered fuel leakage slow enough to prevent a crew from recognizing it, but sufficient to prevent a return to home base and could result in the loss of an aircraft. In this case, it may be under fairly controlled conditions in "friendly" airspace but the aircrew would be forced to make an airborne egress or a forced landing or ditching. Modifying computerized fuel management systems to provide the pilot with an early warning of discrepancies between engine fuel consumption and fuel tank quantities could allow early decisions to avoid loss of the aircraft and risk to the crew. Immediate recognition of such a problem may allow the crew to divert to an alternate field or make arrangements to rendezvous with a tanker and avoid the possibility of fuel starvation.

- Similarly, if combat damage to an aerial refueling system is not recognized and refueling is required to return to base, the aircraft may be lost to fuel starvation. While this event may occur under controlled conditions and in friendly territory, the likelihood of such an event and the risks of surviving the egress need to be considered in a comprehensive survivability analysis.

- Unrecognized damage to the Identification Friend or Foe (IFF) system might result in an intercept, potential encounter with friendly threats upon return to friendly airspace and possible loss of the aircraft and aircrew. Based on the likelihood of this damage, a survivability analysis will be required to include additional (friendly) threat engagements to properly assess crew survivability.

- Systems required for slow flight (*e.g.,* flaps and slats) or hover (in STOVL aircraft) are not considered "flight critical" and, since they are not used before a combat aircraft returns to FLOT, they have not normally been considered in survivability analyses of aircraft under development. However, failure of such systems has become an issue in recent development programs highlighting the need for continuing the analysis beyond the FLOT to safe aircraft recovery. The stability issues associated with transition to slow flight or hover are recognized in the design of aircraft so compensation for normal failure modes is often incorporated in the design to make it "failsafe." This may also be accomplished by providing the pilot with warnings that a failure has occurred or by preventing a transition before it becomes an issue. In some cases the vulnerabilities have been mitigated through design changes for safety of flight. However, unlikely failure modes associated with ballistic damage may not have been considered.

- The possibility of damage to landing-related systems (*e.g.,* landing gear, brakes, tail hook) will also affect survivability. If the damage can be recognized early, options may be available to the crew that would prevent any risks at all. For example, early recognition of damage to a tail hook on a carrier-based aircraft may allow the crew to elect to return to a land base where that system is not even required. If it is discovered at the carrier, though, and airborne refueling is not capable of getting them to an alternate airfield, a barrier landing or over-water ejection may be required. In either case, the risks of aircrew casualty increase and should be accounted for in a comprehensive survivability analysis.

While some of these issues have not been dealt with in survivability analyses in the past, the methods and data required to include them is not new or unknown. The extension of the survivability analysis process to include landing and recovery will allow a more complete assessment of the overall survivability of the platform. More importantly it may identify specific issues such as the possibilities described above, which can be mitigated in the development of the aircraft. ■

Reference

1. U.S. Congress, 2005. National Defense Authorization Act (NDAA) for Fiscal Year 2005, Section 141, "Development of Deployable Systems to Include Consideration of Force Protection in Asymmetric Threat Environments." Section 141 was also implemented as Public Law 108-375.

About the Authors

Dr. Torg Anderson is a member of the Operational Evaluation Division at the Institute for Defense Analyses in Alexandria, VA, where he supports aircraft live fire evaluations for several programs including the F–35, the Multi-mission Maritime Aircraft and the E-10A. He has 25 years of experience at United Technologies Research Center and Pratt & Whitney primarily working in aircraft engine combustor development and design and combustion diagnostics development. He is an active member of the AIAA Weapon Systems Effectiveness Technical Committee. He may be reached by email at tanderso@ida.org

Dr. Joel Williamsen is the task leader for fixed wing aircraft live fire test and evaluation within the Operational Evaluation Division at the Institute for Defense Analyses in Alexandria, VA. Joel supports fixed wing aircraft live fire evaluations for acquisition programs, as well as Joint Live Fire assessments for existing fixed wing aircraft and rotorcraft in support of the Director, Operational Test and Evaluation of the Department of Defense. Dr. Williamsen has received the Army's Research and Development Achievement Award for armor/anti-armor design, and NASA's Exceptional Achievement Medal for "advancement in the state-of-the-art of orbiting spacecraft hypervelocity impact and survivability analyses." He is an Associate Fellow of the AIAA, and a former chairman and an active member of the AIAA Survivability Technical Committee.

Douglas Carter

Excellence in Survivability

by Dale Atkinson

The Joint Aircraft Survivability Program Office (JASPO) is pleased to recognize Mr. Douglas Carter for Excellence in Survivability. Doug is a Senior Materials Engineer and Program Manager in the Materials and Manufacturing Directorate of the Air Force Research Laboratory (AFRL) at Wright-Patterson Air Force Base in Dayton, OH. Doug graduated from the University of Louisville in 1987 with a BS and MS in Mechanical Engineering.

In 1988, Doug began his career in the Aircraft Survivability Branch of AFRL's Flight Dynamics Directorate at Wright-Patterson, where he developed aircraft battle damage repair (ABDR) technology for advanced composite structures and integral fuel tanks. Doug also developed and built a test and evaluation laboratory to evaluate new battle damage repair techniques and evaluated techniques for a variety of mechanical and electrical components. He also validated battle damage repair techniques for the F-15 horizontal stabilizer and wrote the procedures for the F-15 technical order. During this time period he also taught ABDR and design for repair courses for technicians and engineers.

In 1994, Doug moved to AFRL's Materials and Manufacturing Directorate, where he developed and conducted field evaluations of the Vacuum Mold Repair System (VMRS) to rapidly fabricate a revolutionary reusable splash tooling system for composite repair. He worked with industry to commercialize the system, which is currently sold by Airtech International. It is also being used by the Air Force and commercial aircraft companies such as Cessna and Boeing.

In addition, Doug participated in the international Four-Power Air Senior National Representatives Cooperative Long-Term Technology Projects as a key member of the ABDR Technical Group. The objective of the Technical Group is to develop and exchange generic techniques and procedures that will enhance the ABDR capability of the nations (France, Germany, United Kingdom, and United States). Doug was chairman of the ABDR Technique Evaluation Subgroup. He lead the subgroup in establishing common test parameters and procedures that are used for testing repairs to aircraft systems such as control rods, fuel tanks, hydraulic tubes, and canopies. From 2000 to 2006, Doug became the USAF representative and Chairman of the Technical Group. During his tenure, the Technical Group successfully developed sandwich structure repair and initiated the evaluation of composite structure repair methods under field conditions. Also, the Technical Group established ABDR training seminars leading to the improvement of training techniques among the nations and developed and evaluated many aircraft system repairs that are now being used by the nations.

Doug also conceived, tested, and developed an alternate maintenance equipment system for the B-2 composite exhaust structure during this time period. The system he developed reduced recurrent aircraft downtime from 50 hours to 4 hours, reduced equipment weight from 480 pounds to 98 pounds, and decreased installation time from 2 hours to 15 minutes. It also reduced the deployment footprint by eliminating large ovens and portable shelters. Doug built the first system for a 90-day field evaluation and redesigned and built eight units for fleet-wide implementation. Doug received an engineering expertise award for the development and transition of this system to the fleet. During this time, Doug also rapidly developed and qualified composite repair procedures for the F-117 in support of Operation Allied Force.

In 2002, Doug was promoted to manage a $27 million, 6-year effort to develop technology for reducing the maintenance burden resulting from low observable treatments on stealth aircraft. Doug lead a multiorganizational, multidiscipline technical team to develop fast-curing, durable repair materials, coating removal equipment, and nondestructive inspection equipment.

To improve the B-2 fleet mission capability rate, a major effort was initiated by the B-2 System Group in 2002 to remove tape covering access panel gaps and fasteners and replace it with a material called Alternate High Frequency Material (AHFM). AHFM is a spray-on material that exposes the gaps and fasteners for easy removal and replacement of access panels without any material restoration required. Successful flight tests demonstrated the effectiveness of the

Figure 1. Over the Pacific Ocean a U.S. Air Force (USAF) B-2 Spirit bomber refuels from a KC-135 Stratotanker.

AHFM design, but upon material scale-up for fleet-wide implementation, consistent batch-to-batch performance could not be obtained.

Doug initiated a $2.8 million manufacturing technology effort, the AHFM Rapid Response Process Improvement Program (RRPI), to solve the consistency problem. The successful program gave the B-2 Systems Group and Air Combat Command the confidence to implement AHFM fleet-wide, increasing mission capability rate and decreasing maintenance man- hours per flight-hour by 50 percent. This program resulted in a significant increase in aircraft availability and cost savings.

The AHFM RRPI enhanced the fleet's high-priority maintainability program and improved material delivery schedule and production cost. The program reduced the material production schedule from 26 weeks to 12 weeks and implemented an improved test method, which saves 8 calendar days per batch. Maintenance actions previously requiring a week of aircraft downtime for repair now require as little as 30 minutes. This highly successful program resulted in Doug receiving the prestigious Air Force Science and Engineering Award for manufacturing in 2005, which he richly deserves.

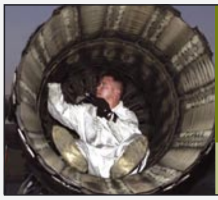
Doug is also a valued member of the Joint Aircraft Survivability Program's Battle Damage Repair Committee under the Vulnerability Reduction Subgroup. In that role he is responsible for initiating and managing the JASPO's Battle Damage Assessment and Repair (BDAR) Capability Improvement Program (BCIP) discussed in the lead article of this issue.

Doug has been married for 19 years and he and his wife Martha have four children, ages 4 to 13. He is a coach and sports coordinator for his children's elementary/middle school. During his spare time, Doug enjoys playing tennis.

It is with great pleasure that the JASPO honors Mr. Douglas Carter for his Excellence in Survivability contributions to the JASPO, the survivability discipline, and the warfighter. ■

About the Author

Mr. Dale Atkinson is a consultant on the aircraft combat survivability area. He retired from the Office of the Secretary of Defense in 1992 after 34 years of government service and remains active in the survivability community. Mr. Atkinson played a major role in establishing survivability as a design discipline and was a charter member of the tri-service JTCG/AS which is now JASPO. He was also one of the founders the DoD sponsored SURVIAC. He may be reached at E_GGM_GS_jasnewsletter@bah.com.



Combat Damage Incident Reporting System (CDIRS)

by Donna Egner and David Mulllins

A portion of the funding for the Joint Combat Assessment Team (JCAT) project is used by the Survivability Vulnerability Information Analysis Center (SURVIAC) located at Wright-Patterson Air Force Base, OH, to support an aircraft combat damage reporting site and its development. This website, called the Combat Damage Incident Reporting System or CDIRS, serves as a database system for all recent documented Operation Iraqi Freedom (OIF) combat damage incidents. The initial concept of CDIRS, begun in June 2005, was to meet the needs of the JCAT and the Aircraft Shoot Down Assessment Team (ASDAT). It was apparent that these teams when deployed needed the ability to distribute, store, add to, search, view, edit, and discuss combat media and data in a centralized environment. The initial website was a static information management system that did not support dynamic data or a database system. Although the website allowed for the central storage of data, it became obvious that a more robust solution would be needed.

As a result of recent funding, the CDIRS is being upgraded to allow combat data analysis and dissemination. The objective now includes aiding the warfighter in accessing and searching combat data and disseminating and archiving this highly perishable information. As a result of recent outreach to combat data users, several search features have been identified. They include the ability to search and sort by aircraft type, threat type, incident date, damaged components, kill level (damage with no major effect, mission abort, forced landing, attrition), major maintenance system damaged (hydraulic, engine, transmission, rotor blade, fuel system, etc.). It is also anticipated that this combat damage and other survivability data will be used to train/educate a unit's pilots prior to leaving on a mission.

A future version of CDIRS will allow easier access by CDIRS users to some incident data, a smoother registration process, better reporting and notification capabilities, more robust file storage, and most important, an improved user experience. As a side benefit, it is expected that other JASP projects will use this system as a means of managing and transferring survivability data. ■

About the Authors

Donna Egner has served as the Deputy Director for the Survivability/Vulnerability Information Analysis Center (SURVIAC) located at Wright Patterson AFB, OH since October 1991. Her association with combat data began in 1978 at the Combat Data Information Center (CDIC), the predecessor to SURVIAC. She oversees the day-to-day operations of the SURVIAC Core including technical/bibliographic inquiries, library and combat database maintenance/enhancement, and oversees promotional activities. Ms. Egner serves as a liaison between JCAT personnel, the OEF/OIF combat data and the Information Technology personnel developing the Combat Damage Incident Reporting System (CDIRS). She may be reached at 937/255-3828, ext. 282 or donna.egner@wpafb.af.mil.

David Mullins is a database and application developer at the Survivability/Vulnerability Information Analysis Center (SURVIAC) located at Wright-Patterson Air Force Base, OH. Mr. Mullins has a degree in Management Information Systems from Wright State University and has focused on a wide range of business process and data management applications since joining SURVIAC in 2002. David may be reached at 937/255-3828, ext. 207 or dave.mullins@wpafb.af.mil.

What is in a Name?

■ by Donald Voyls

What is in a name? Aircraft battle damage repair (ABDR), battle or battlefield damage assessment and repair (BDAR), expedient repair (ER), combat maintenance, combat resilience, sustainability, and others are names that have been used over the years to refer to a program or concept to provide the assets a warfighter needs to continue the fight and win. Many times these names have been used interchangeably with a variety of interpretations. To some these names may mean performing shade tree maintenance using speed tape and broom sticks to get damaged aircraft back into the fight. To others these names may mean returning the aircraft to a main operating base or depot for a full peacetime repair. Yet, to others these names may refer to doing what is necessary to get damaged aircraft back to the commander. The names can be interpreted many different ways, but they should never detract from the overall objective of taking the action needed to help the warfighters fulfill their mission.

Some of the names have several interpretations while others have specific objectives. For example ABDR, the most widely used name or acronym in this area, has various meanings and interpretations depending on nation, service, organization, and in what context it is used. Some meanings and interpretations restrict the use of ABDR to wartime or crisis as the result of enemy action only (ballistic damage) and state specifically who has the authority to make and approve the repair or action. Other interpretations of ABDR are broader in scope and include any damage incurred in time of war or crisis whether it is from enemy action or other causes. However, no matter what the ABDR program or concept, the common objective is to make the best repair possible to provide needed combat resources to the commander.

The British Royal Air Force recognized that its traditional ABDR policy no longer met the needs of modern aircraft operation in an expeditionary era. The RAF traditional ABDR concept, which was based on making temporary repairs in wartime, was replaced with "expedient repair (ER)." The ER concept expanded the repair capability ranging from a full peacetime repair to the traditional ABDR temporary repair. The ER concept is similar in many ways to the United States Air Force (USAF) ABDR concept that was restructured in 1995. Like the USAF's ABDR concept, the RAF's ER concept provides the capability to balance the Commander's requirements against airworthiness risk. Although the RAF has changed the name, the overall objective of generating needed combat operational capability has not.

Major General Welch, USA , constituted the Army's BDAR program in the early 1980s covering both ground and air systems. The program was directed at doing everything possible to maximize and sustain the necessary firepower to fight and win. Brigadier General Stalcup explained in his paper titled *The Need for Combat Resilience*, the name "battlefield damage" rather than "battle damage" was very carefully chosen. He stated that when BDAR was coined "it was the best that the people on the program could come up with to express what they understood to be General Welch's concerns." The concerns were based on previous studies and experiences and the Cold War situation at the time to hold back the enemy in a "come as you are war." The study results BG Stalcup presented revealed that only 40 percent of combat vehicle breakdowns on the battlefield were caused by enemy action; however, other causes were just as effective in reducing needed combat resources. BG Stalcup emphasized that the name should not be used to restrict recognizing and attacking the whole problem.

Unfortunately names have restricted recognizing the mission and attacking the whole problem. When BDAR, ABDR, ER, combat maintenance, and any of the other related names are used is it restricted to what is being done or does it reflect why it is being done? It other words does the name interpretation limit the program or concept to just repairing weapon systems or does it reflect the overall objective of providing needed combat assets to the warfighter? BG Stalcup put it well when he said "the purpose of BDAR (or any other of the names used) is to help the troops on the battlefield to continue the fight and win even though their weapons, supply functions, or equipment become battle-damaged, break down, or are ineffective for any reason." When an aircraft or combat system becomes ineffective and is not repaired and returned to the commander, it is a loss. No matter what the repair program is called, its purpose is to help the troops continue the fight and win.

About the Author

Mr. Donald Voyls has more than 40 years of professional experience encompassing aircraft survivability and battle damage repair. He is currently technical advisor to the Material Directorate of the Air Force Research Laboratory (AFRL) on aircraft battle damage assessment repair activities. Before retiring from AFRL, Mr. Voyls was Program Manager of the USAF Advanced Combat Maintenance Technology Advanced Development Program for the development of battle damage assessment and repair techniques for current and emerging aircraft. Prior to holding these positions, Mr. Voyls held various position in the USAF aircraft survivability development area. ■

Joint Aircraft Survivability Program (JASP) Fiscal Year 2007 Projects

■ by Dennis Lindell

Introduction

The Joint Aircraft Survivability Program (JASP) mission is to increase the affordability, readiness, and effectiveness of tri-service aircraft through the joint coordination and development of survivability (susceptibility and vulnerability reduction) technologies and assessment methodologies. This article provides a synopsis of JASP projects in fiscal year (FY) 2007 and is a reference for those interested in aircraft survivability research, development, test, and evaluation. The JASP and the projects presented in this article are organized by JASP technology subgroup: Survivability Assessment, Susceptibility Reduction, and Vulnerability Reduction. The JASP subgroups, and their committees, incorporate the technical expertise of the Department of Defense (DoD) aircraft survivability community. For additional information or questions, the reader is invited to contact the Joint Aircraft Survivability Program Office (JASPO).

Focus Areas

Beginning with the FY2006 program build, the JASP defined a limited number of focus areas in which to concentrate its effort. The intent was to make significant progress on a few defined aircraft survivability requirements in 3–5 years time. In this first attempt, the focus areas were brought forward from the three subgroups: Survivability Assessment, Susceptibility Reduction, and Vulnerability Reduction. The JASP is working to refine the focus area development process to incorporate warfighter and acquisition community input and to create roadmaps defining the survivability gaps and the plans to fill them. Following are the six focus areas for the fiscal year 2007 program build:

Survivability Assessment

- Identify and address deficiencies in the current JASP vulnerability/endgame modeling and simulation (M&S) environment that limit the application of the Integrated Survivability Assessment methodology. This effort supports a goal of reducing developmental test, operational test and evaluation, and live fire test and evaluation cost by 20 percent through the use of M&S.

- Plan, execute, and document sufficient verification and validation (V&V) to confirm the credibility of the JASP M&S toolset. Acceptance of the toolset by the developmental test, operational test and evaluation, and live fire test and evaluation communities will also support the goal of reducing test costs by 20 percent.

Susceptibility Reduction

- Explore Directional Infrared Countermeasures (DIRCM) technologies/techniques leading to a demonstrated capability (TRL 5/6) to defeat current and next generation threats with a significant (25 percent) reduction in system or component cost, weight, or a significant increase in reliability or effectiveness. Emphasis is on technologies/techniques that enhance affordability and/or significantly increase capability (*e.g.*, multifunction capability, flares in combination with DIRCM, signature reduction in combination with DIRCM).

- Explore technologies/techniques leading to a demonstrated capability (TRL 5/6) to counter advanced, coherent, parameter-agile threats with a significant (25 percent) reduction in detection/engagement range and lower cost (5-10X) over current operational systems. Emphasis is on technologies/techniques that are modular and support open-architecture concepts for incorporation into small platforms or significantly reduced footprints for legacy systems.

Vulnerability Reduction

- Develop opaque and transparent ballistic protection systems that are 33 percent lighter (in areal density) than current state-of-the-art systems for an equal level of threat protection.

- Develop fuel containment technologies for fuel tanks/cells and lines that are 50 percent lighter than current systems for an equal level of threat protection.

FY07 Program

Survivability Assessment

M-97-03 Survivability/Vulnerability Information Analysis Center (SURVIAC) M&S Accreditation Support Information Development

The objective of this project is to prepare the JASP Fire Prediction Model (FPM) for accreditation. The principal tasks are to document the code development, establish the criteria and data for code V&V, and prepare an accreditation support package for the baseline model. By establishing the model's foundation, this effort will increase the community's confidence in—and use of—the model in aircraft survivability analyses. The FPM Accreditation Support Package and configuration management plan will be completed in this final year of effort

Project Engineer—
Michelle Killikauskus, United States Navy (USN), Naval Air Systems Command (NAVAIR)

M-98-01 SURVIAC Model Manager Support

This project provides model manager support for SURVIAC models, including monitoring software change requests for each model, and planning, hosting, and documenting two JASP Model User Meetings (JMUM) per year. These efforts contribute to the improvement of key aircraft survivability models and their configuration management, resulting in more capable and credible tools for survivability analyses. The 2007 JMUMs are scheduled for 19–21 June 2007 at the Air Force Academy, Colorado Springs, CO, and mid-November at Nellis AFB, NV.

Project Engineer—
Mike Weisenbach (JASPO)

M-00-04 Dry Bay Fire Model/ WINFIRE Enhancements

This task further develops a standard, physics-based dry bay fire model for use by the survivability analysis, live fire test and system evaluation community. By improving the model analytical capability and configuration management, this effort supports all the DoD services, program offices, and industry partners with a credible fire and explosion prediction capability. Products include incorporating approved changes into the stand-alone computer code, updating the graphical user interface, and updating analyst and user manuals.

Project Engineer—
Marty Lentz, United States Air Force (USAF), 780 Test Squadron (780 TS)

M-04-04 Integrated Survivability Assessment (ISA) Demonstration

This task applies the JASP ISA process to the Multimission Maritime Aircraft (MMA) program to demonstrate and further refine the ISA process. The project will thoroughly test the ISA process and supporting models and identify key areas for future improvements. Integrating susceptibility, vulnerability, and mission-level modeling will allow credible assessment of survivability enhancements on aircraft mission effectiveness.

Project Engineer—
Ron Ketcham (USN, NAVAIR)

Figure 1. Screen shots from the Threat Effects in Aircraft Combat Survivability DVD.

M-06-02 Structural Response to Internal Blast

This project will enhance and standardize methodologies used to evaluate the effects of internal blast effects on aircraft structures in aircraft vulnerability analysis models. This will allow accurate assessment of aircraft vulnerability to explosive effects inside the aircraft body.

Project Engineer—
David Lynch, United States Army (USA), Army Research Laboratory (ARL)

M-06-03 Enhanced Surface-to-Air Missile Simulation (ESAMS) Validation

This project will validate eight critical model functions for Russian radio frequency (RF) threats in ESAMS. A functional element validation report will be provided for each threat. This project will improve the credibility of ESAMS and allow its use in systems evaluations and other assessments requiring threat engagement analysis.

Project Engineers—
Ralph Mattis (USN, NAVAIR) and Jim Begovitch (USAF, Aeronautical Systems Center / Engineering Directorate [ASC/EN])

M-06-04 Fuel Bladder Survivability for FPM

This project will develop penetration algorithms for ballistics threats versus fuel bladders and bladder materials. It will further extend the applicability of the FPM to helicopter fuel subsystems and support the V&V of the model.

Project Engineer—
Linda Moss (USA, ARL)

M-06-06 Joint Combat Assessment Team (JCAT) Data Correlation to Vulnerability/ Survivability (V/S) Analyses

This project will compare JCAT damage reports on AH-1Ws in Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) to Navy maintenance data and vulnerability analysis M&S input development and output results. This effort will further improve the JCAT damage assessment process and support V&V of conventional aircraft vulnerability analysis tools and procedures.

Project Engineer—
Ralph Mattis (USN, NAVAIR)

M-06-07 Probability of Kill (Pk) Workshop

This project will host a workshop at which analysts and test engineers from all services can discuss Probability of Damage given a Hit (Pd/h) methodologies and develop Pd/h standards. The workshop will produce a methodology document for a select class of aircraft components. The 2007 workshop will focus on blast damage and synergistic effects.

Project Engineer—
Kelly Kennedy (USAF, ASC/EN)

M-06-08 Man-Portable Air Defense Systems (MANPADS) Damage Effects Models

This project will generate standardized finite element models (FEM) of MANPADS threats in LS-DYNA. These models will add to the existing JASP library of validated MANPADS and high-explosive projectile threat models that engineers are using to develop more survivable aircraft.

Project Engineer—
Alex Kurtz (USAF, 780 TS)

M-06-09 High-Explosive Incendiary (HEI) Damage Effects Models

This project will develop validated, physics-based (LSDYNA) models of HEI and blast-fragmentation rocket-propelled grenades (RPG) that include fragment and blast effects for use in hydraulic ram analyses. This project will provide validated models that can be used with confidence to evaluate the damage tolerance of aircraft to blast and fragmentation threats.

Project Engineer—Alex Kurtz
(USAF, 780 TS)

Figure 2. F-22 Raptor in flight.

M-06-10 Passive Covert Radar (PCR) Countermeasures

This project will develop and assess a PCR evaluation tool for few-on-few simulations, construct a PCR test bed, develop and assess electronic attack techniques, and demonstrate PCR countermeasures. The capability to assess PCR countermeasures does not exist currently; this project will fill the gap.

Project Engineer—
Richard Smith (USAF, Air Force Research Laboratory [AFRL])

M-07-01 Red on Blue Data Requirements

This project will define and verify data requirements for three users (Strategic Air Command [STRATCOM], fixed wing training centers, and Army/USMC rotary wing tactics/training centers); determine tools and data products that best address each user's requirements; develop a process to address those requirements; and provide near- and long-term plans to fulfill those requirements. This effort is a collaboration between the JASP and the Joint Technical Coordinating Group on Munitions Effectiveness (JTCG/ME).

Project Engineers—
Dennis Lindell (JASPO), Hugh Griffis (USAF, ASC/EN), and Ron Ketcham (USN, NAVAIR)

M-07-02 ESAMS Configuration Control Board (CCB)/ Change Review Board (CRB) Activities

This project will provide support for users of the ESAMS through ESAMS model manager and developer participation in the June and November JMUM meetings, improving the ESAMS graphical user interface and completing upgrades for the next ESAMS release.

Project Engineer—
James Begovich (USAF, ASC/EN)

M-07-03 Vulnerability M&S Enhancements and Studies

This project will address important short-term requirements for the vulnerability analysis codes COVART and FASTGEN and develop analysis-based priorities for all the Joint Aircraft Survivability Community (JASC) vulnerability codes. Collaboration with vulnerability analysts at the Army Research Laboratory, NAVAIR, and Naval Surface Warfare Center (NSWC) Dahlgren is a key aspect of this project.

Project Engineer—
Kelly Kennedy (USAF, ASC/EN)

M-07-04 Threat Modeling and Analysis Program (TMAP) Missile Modeling System for Advanced Investigation of Countermeasures (MOSAIC) & Joint Surface-to-Air Missle Simulation (JSAMS)

This project will demonstrate a methodology for integrating Missile and Space Intelligence Center (MSIC) infrared (IR) and RF TMAP Threat System Models (TSM) into engagement simulations (MOSAIC [IR] and JSAMS [RF]). This 3-year project will integrate and fully test six (three per engagement simulation) JASC priority TMAP TSMs in official releases of MOSAIC and JSAMS.

Project Engineers—
Luke Borntrager (USAF, AFRL) and
James Begovich (USAF, ASC/EN)

M-07-05 Combat Assessment Tool (CAT) Upgrade

This project will improve the effectiveness and applicability of the CAT as used for the JCAT for combat damage assessment. Capability improvements will include the ability to display threat warhead fragment impact holes, adding fixed and rotary wing target models to the aircraft library, updating all the CAT manuals, and providing training to the JCAT users.

Project Engineer—
Andrew Kurpik (USAF, ASC/EN)

M-07-06 Fire Modeling Roadmap

This project will develop a fire test and analysis methodology investment strategy for the JASP as it relates to fixed and rotary wing aircraft. Many unknowns in fire prediction and analysis need to be identified and prioritized to support development fire prediction and test methodology. The resulting roadmap will allow the community to focus limited resources on those shortfalls with the greatest potential for improving our ability to understand and predict fire damage to aircraft.

Project Engineer—
Martin Lentz (USAF, 780 TS)

M-07-07 Multiple Hit Methodology for Key Performance Parameters (KPP)

This project will develop a methodology (with corresponding code changes) to address gun barrage or burst vignettes for force protection and survivability KPP analyses. More realistic engagement probabilities of kill will result in a better understanding of our weapon systems' strengths and weaknesses in real combat scenarios.

Project Engineer—
Kelly Kennedy (USAF, ASC/EN)

M-07-08 Advanced Monopulse Countermeasure Development (AMCD) Simulation Enhancement

This project will develop a simulated flight test capability with hardware-in-the-loop (HITL) countermeasures (CM) technique development and analysis using the AMCD hardware with its embedded CM technique as it jams a given mono-pulse radar. The expected performance will be a simulated level and steady flight profile mimicked by changing the position of transmit and receive antenna heads representing the target skin return during experimentation.

Project Engineer—
Jared A Herweg (USAF, AFRL)

M-07-09 Accelerated Reticle Processing for Digital Models

This project will demonstrate the adaptation of the commercial off-the-shelf (COTS) field programmable gate array (FPGA) based reticle processor developed under JASP project M-05-01 to the digital IR engagement model MOSAIC. MOSAIC will be upgraded to use the FPGA-based reticle processor to accelerate imaging model runs and thus significantly shorten engagement analysis run times. Successful demonstration will allow similar integration in other digital IR engagement models like Georgia Tech Synthetic Imaging Missle Simulation (GTSIMS) and Joint Threat Engagement Analysis Model (JTEAM).

Project Engineer—
Mike Murray (USAF, AFRL)

M-07-10 Small Caliber Projectile Methodology

This project will improve the penetration prediction methodology for armor-piercing (AP) and ball small caliber projectiles. Recent studies comparing penetration prediction methodology with test data have indicated significant errors in residual speed and mass predictions—this project will correct he errors and provide the analytical community with improved projectile penetration prediction capability.

Project Engineer—
David L. Dickinson [USN, Naval Surface Warfare Center (NSWC)]

Susceptibility Reduction

S-04-04 Impact of Electronic Limiting on Imaging Seeker Countermeasures

This project is investigating the laser power, pulse repetition frequency, and pulse width that will consistently saturate IR focal plane arrays (FPA) made of known and widely available materials. Understanding the phenomenology of the laser-FPA interaction will enable the design of more effective laser countermeasures against imaging IR seekers.

Project Engineers—
Rick Moore [USN, Navy Research Laboratory (NRL)] and John Keat (USA, Aviation & Missile Research Development & Engineering Center (AMRDEC)]

Figure 3. F-35 Joint Strike Fighter

S-04-10 Millimeter Wave Radar Warning Receiver (RWR) for Unmanned Aerial Vehicles (UAV)

This project is developing millimeter wave hardware suitable for use in UAVs. The project will integrate prototype hardware with existing receiver hardware and demonstrate functionality with flight tests on a UAV. This project fills a gap in small UAV RWRs and pushes the frequency range coverage into the millimeter wave (MMW) region where many advanced threats operate.

Project Engineer—
Pete Bartolomeo (USN, NAVAIR)

S-05-01 IR Hollow Core Photonic Bandgap Fibers

This project, in its final year, is designing and fabricating hollow core photonic band gap (HC-PBG) glass fibers for the transmission and distribution of multispectral IR high-power laser energy to various infrared countermeasures (IRCM) apertures at the aircraft surface. Using HC-PBG fibers will reduce the weight and cost of directed energy IRCM systems and therefore make them available to more aircraft.

Project Engineer—
Dr. Ishwar D. Aggarwal (USN, NRL)

S-06-01 False Alarm Reduction Technology

This project is characterizing the RF signatures of potential false alarm sources identified in the System Specification for Advanced Threat Infrared Countermeasure System / Common Missile Warning System (ATIRCM/CMWS). The data from this effort will help establish requirements for correlation discrimination that can be incorporated in future radar warning receiver upgrade programs.

Project Engineer—
Owen O'Neill [USA, Communications-Electronics Research Development and Engineering Center (CERDEC)]

S-06-02 Affordable Laser IRCM Survivability System (ALISS)

The ALISS project is developing and testing a prototype affordable laser IRCM architecture that is lightweight, reliable, and affordable. The prototype will be suitable for all modes of testing including limited flight test on operational aircraft. JASP funding is for demonstration of a semiconductor transceiver, development of an automatic pod alignment procedure, and environmental testing.

Project Engineer—
Lt Aaron Boesch (USAF, AFRL)

S-06-03 Ground Fire Detection, Classification, and Location

This project is developing algorithms for existing sensor systems that enable detection of ground fire events and then extend the algorithms to include ground fire identification friend or foe and classification. The project goal is to improve algorithms of selected sensors to achieve a goal of 80 percent average correct detection/classification with no individual detection/classification category below 60 percent.

Project Engineer—
Vince Cassella (USN, NRL)

S-07-01 Rotorcraft Aircraft Survivability Equipment (ASE) Effectiveness against MANPADS

This project is quantifying the engagement effects when multiple ASE CMs are used in combination against MANPADS. The project will employ Army and Navy HITL simulators to determine average miss percentages for a variety of MANPADS and aircraft operating conditions.

Project Engineers—
Terry Dougherty (USN, NAVAIR) and Mark Sevachko (USA, ARL)

S-07-02 Low-Slow Aircraft Active Protection

This project will investigate the feasibility of developing a hard-kill active protection system (APS) for low, slow flying aircraft. Principal objectives include defining timelines for threat declaration and engagement, determining performance requirements for successful threat neutralization, identifying promising technologies, and assessing the feasibility of applying these technologies to transport and rotary wing aircraft.

Project Engineers—
John Bennett (USN, NSWC) and Don Lovelace (USA, AMRDEC)

S-07-03 Developed Common Exciter Advanced Suppressor Exercise and Demonstration (Deceased)

This project will develop and test electronic attack (EA) techniques for the JASP developed Common Service Exciter (Project No. S-04-01) to demonstrate a jamming capability against coherent radars that are agile in frequency, pulse duration, pulse repetition frequency, and pulse coding.

Project Engineers—
Chris Moss (USN, NRL) and Anthony White (USAF, AFRL)

S-07-04 Missile Fly-Out Considerations for IRCM

This project will quantify the impact of missile fly-outs on expendable IRCM effectiveness testing. Of particular interest are the effects of missile-to-aircraft closure on CM performance.

Project Engineer—
Terry Dougherty (USN, NAVAIR)

S-07-05 Utility of Real-Time Ozone Data for Missile Warning Systems (MWS)

This project will quantify the benefit of integrating real-time ozone-level data into MWS adaptive detection and declaration algorithms. This 1-year effort will provide an assessment of the potential for real-time ozone data to improve MWS effectiveness.

Project Engineer—
Mike Cannizzaro (USA, CERDEC)

S-07-06 Spectral IRCM Effectiveness

This project will evaluate through analysis the effectiveness of spectral decoy flares in protecting U.S. platforms.

Project Engineer—
Mark Anderson (USN, NSWC)

S-07-07 MMW Electronic Attack Transmitter

This project will assemble and test (laboratory and ground field test) a prototype MMW transmitter-jammer against modern MMW radars.

Project Engineer—Chris Moss (USN, NRL)

S-07-08 Susceptibility Reduction Technology Development Roadmap

This project will enhance overall aircraft survivability by providing a comprehensive, strategic view of aircraft susceptibility reduction requirements and provide recommendations for JASP future susceptibility reduction efforts.

Project Engineer—Robert Lyons (JASPO)

S-07-09 Rotorcraft Visual Jury Test

This 1-year project will conduct a visual jury test to evaluate the effectiveness of rotorcraft color paint schemes against desert and sky backgrounds. This project directly supports U.S. Army and Navy efforts to improve rotorcraft survivability in current operations.

Project Engineer—
Mac Dinning [USA, Aviation Applied Technology Directorate (AATD)]

Vulnerability Reduction

V-04-07 MANPADS Damage Effects on Large Aircraft Engine

This project will predict MANPADS damage effects on a CF-6 engine using LS-DYNA modeling techniques. The effort will validate the accuracy of the prediction model and process through correlation with joint live fire-air tests in 2007.

Project Engineer—
Greg Czarnecki (USAF, 780 TS)

V-05-01 RPG Characterization Testing and Model Support

This project is conducting tests to collect previously unavailable data to support development of finite element (LSDyna) RPG threat models for application to high-fidelity dynamic structural modeling of threat and aircraft structure interaction.

Project Engineer—
Karen McNab (USA, ARL)

V-05-04 Fuel Tank Ullage Vulnerability

This project is providing data on the limiting oxygen concentration (LOC) required for safe JP-8 fuel tank inerting under realistic fuel tank conditions for projectile incendiary and tracer ignition sources.

Project Engineer—
Dr. Peter Disimile (USAF, 780 TS)

V-06-01 Multifunctional Structures for Ballistic Protection

This project will demonstrate an affordable multifunctional integral armor solution for a helicopter floor that provides improved ballistic protection and significant weight reduction, as compared with current parasitic approaches. The project is endorsed by Technology Applications Program Office (TAPO) and the Systems Integration and Management Office (SIMO).

Project Engineer—
Dr. Mark Robeson (USA, AATD)

V-06-03 Spaced Armor for Rotorcraft
This project is working with an armor manufacturer to design, model, fabricate, and demonstrate a spaced armor system for rotorcraft that will yield, at a minimum, a 30 percent weight reduction compared with appliqué steel systems for a given armor-piercing projectile threat.

Project Engineer—
Dr. Marc Portanova (USA, AATD)

V-06-04 Hydrodynamic Ram (HRAM) Mitigation through Pressure Wave Interaction
This 3-year project will investigate a proof-of-concept strategy for an HRAM mitigation system using pressure wave interaction with a goal of producing a 60–80 percent reduction in overpressure and providing a significant reduction in associated fuel tank failures.

Project Engineer—
Dr. Peter Disimile (USAF, 780 TS)

V-06-05 Intumescent Coatings "Instant Firewall" for Passive Dry Bay Fire Protection
This project is demonstrating and optimizing intumescent technology to form an "instant firewall" in mid- and small-wing dry bays to mitigate, extinguish, or contain a ballistically initiated fire.

Project Engineer—
Peggy Wagner (USAF, 780 TS)

V-06-07 Spaced Armor for Rotorcraft II
This project is working with a rotorcraft manufacturer to design, model, fabricate, and demonstrate a spaced armor system for rotorcraft that will yield at least a 30 percent weight reduction compared with appliqué steel systems for a given threat.

Project Engineer—
John Crocco (USA, AATD)

V-07-01 Development of Transparent Armor Systems
This project demonstrates transparent armor concepts for rotorcraft that yield a 30 percent weight reduction over current systems while lowering manufacturing costs and substantially improving multiple hit performance.

Project Engineer—
Dr. Marc Portanova (USA, AATD)

V-07-02 Cavitation Peening of Ceramic Armor
This project demonstrates the effect of cavitation peening, a novel method of inducing deep residual compressive stresses in components to enhance fatigue life and improve damage tolerance, on ceramic armor materials to improve ballistic protection.

Project Engineer—
Dr. Marc Portanova (USA, AATD)

V-07-03 Flammable Fluid Line Fire Protection
This project will develop and demonstrate potential low-cost, lightweight technologies to reduce the vulnerability of flammable fluid lines to ballistic projectile impacts.

Project Engineer—
Patrick O'Connell (USAF, 780 TS)

V-07-04 Survivable Engine Control Algorithm Development (SECAD) Turboshaft Engine Application
Using SECAD design methodology, this project will develop engine gas path damage detection and mitigation algorithms for turboshaft engines and integrate the algorithms into a T700 engine full authority digital engine control (FADEC) for bench-level testing.

Project Engineer—
Charles Frankenberger (USN, NAVAIR)

V-07-05 Fragment Penetration and Flash with Graphite-Epoxy (Gr/Ep) Composites
This project will quantify the flash intensities and penetration characteristics of steel fragments impacting Gr/Ep composite panels at various obliquities and fragment orientations. This information will support improvements in fire prediction methodologies for aircraft.

Project Engineer—
Patrick O'Connell (USAF, 780 TS)

V-07-06 HRAM Simulator
This program will develop a low-cost test facility for evaluating HRAM and blast effects on aircraft materials and components. The project will provide a significant improvement over the capability and precision of the first generation HRAM simulator.

Project Engineer—
Greg Czarnecki (USAF, 780 TS)

V-07-07 MANPADS Miss Distance Assessment (Phase II)
This project will analyze 90 Gigabits of video and radar missile-position data collected at multiple test events in 2006 to evaluate the miss distance effectiveness of several MANPADS with respect to type, range, and environmental conditions.

Project Engineer—
Greg Czarnecki (USAF, 780 TS) ■

About the Author

Dennis Lindell is the Joint Aircraft Survivability Program Office (JASPO) Manager. Mr. Lindell has been a member of the JASPO Staff since 2003. Prior to his current position, Mr. Lindell was the Deputy Program Manager for Vulnerability Reduction. He may be reached *via* phone at 703/604-1104 or *via* email at E_GGM_GS_jasnewsletter@bah.com.

Battle Damage Assessment and Repair (BDAR) Largely Neglected

■ by William (Rocky) Tipps

When asked to write an article on battle damage assessment and repair (BDAR), I reviewed the *Aircraft Survivability* magazine and discovered that all of the articles seemed to be technical. At that point, it became more difficult to determine how to write this article, because BDAR is personal and there is more to BDAR than facts and figures. BDAR is personal because as training specialists at the U.S. Army Aviation Logistics School (USAALS) responsible for the training of BDAR, we see first-hand how the BDAR system can and should be improved and how long it takes from a "need" to "fielded" to the warfighters.

In the relatively short history of combat aviation, there has never been a greater need to develop the science of assessing and repairing battle damaged aircraft than now. Just as our tactics, techniques, and procedures for fighting the Taliban in Afghanistan and insurgents in Iraq are developing, so must our methods of assessing damaged aircraft and repairing them as far forward as possible. Numerous stories of damaged aircraft having to be evacuated from Afghanistan and Iraq for repairs point to a greater need for improvements to the BDAR system.

With more work needed in the areas of vulnerability, susceptibility, and survivability (we have lost seven aircraft as of 22 March 2007) for our aircraft and the fact that they are being damaged daily, we are left with maintainability. Everything that is damaged that is not attrition has to be repaired. Now the need is even greater that we keep pace with maintainability. With aircraft being damaged every day, it becomes imperative that BDAR receive a higher priority and not be neglected.

The Live Fire Program, which is mandated by Congress through a series of amendments to Title 10, requires that new or improved aircraft be live fire tested. Live fire testing can provide the control environment to design, test, develop, and get approved BDAR procedures that can be fielded during peacetime; however, in the Live Fire Programs, BDAR is just a check in the block. The BDAR repairs that are completed for the live fire test are performed to keep the test article working for the next test. No time or money is set aside to follow up on the repair to determine whether it can be used as a BDAR repair or could be a new permanent repair. Live fire testing would be the best place to follow up on the repair, but that is not the case. The trend is to replace instead of repair, which puts a strain on the supply system and requires units to have larger logistics.

"BDAR needs to be continually developed or it will not be effective in wartime. It has to have just as much emphasis in peacetime as it does in wartime if we are going to keep pace with all of the changes and innovations."

BDAR needs to be continually developed or it will not be effective in wartime. It has to have just as much emphasis in peacetime as it does in wartime if we are going to keep pace with all of the changes and innovations.

Some modest improvements for BDAR have been made, including a redesign of the Army BDAR kits. The fluid repair kit now includes a Permaswege capability, which allows for an expedient way to repair hydraulic tubing and is also a permanent repair. The fuel cell repair kit was redesigned by USAALS, which had to secure funding for the test, part of which came from the Joint Aircraft Survivability Program (JASP). This new kit gives the line units the option of fixing the fuel cell and continuing to use it for 30 days or 100 flight hours before it needs to be replaced. The fuel cell repair kit was designed and tested with the help of the UH-60 live fire test engineer in Aberdeen, MD. A 3M representative provided the materials and helped design the new

Figure 1. Army Borescope Kit

Figure 2. Army Low Pressure Fluid Line Kit

kits. Aviation and Missile Research Development and Engineering Center (AMRDEC) provided oversight of the test and had final approval on the safety of flight for the repair. The test included a slosh test, performed by Engineering Fabric Company, one of the manufacturers of the fuel tanks. The tests and final approval required more than 2 years. The Army is working on the next generation of the BDAR system, which will include a fiber optic repair kit and a composite repair kit. This will result in constant improvement in the currently fielded kits.

To quote, a 1996 Assessment that was prepared by Dale Atkinson, Jerry Walick, and Sam Cockerham of Logistics Management Institute (LMI): "Our findings indicate that, except for a few pockets of interest at field level, where warfighters are required to keep weapon systems combat ready, Battle Damage Repair remains largely neglected, and prospects are bleak for improving the situation in the future." A new assessment was performed in 2006. To be a part of a new assessment 10 years later and find out nothing has changed is a little disheartening.

BDAR is personal because with more emphasis by key people, the shortcomings in the BDAR system could be overcome, enabling us to provide the best training on the equipment that the warfighters need, which is our mission here at Fort Eustis. ■

About the Author

Mr. William (Rocky) Tipps is a training specialist and BDAR project officer for USAALS. Mr Tipps sits on numerous aircraft live fire integrated product teams (IPT) as the BDAR subject matter expert. Mr Tipps hold a BS in Professional Aeronautical from Embry Riddle Aeronautical University. He may be reached at rocky.tipps@us.army.mil.

Jim O'Bryon Receives 2007 Hollis Award for Lifetime Achievement in Test and Evaluation

■ by Eric Edwards

On 13 March, the National Defense Industrial Association's (NDIA) Test and Evaluation Division presented Mr. Jim O'Bryon with its 2007 Walter W. Hollis Award for lifetime achievement in defense test and evaluation. The award was presented by last year's recipient, RADM Charles "Bert" Johnston, USN (Ret), at the organization's 23rd Annual National Test and Evaluation Conference in Hilton Head Island, SC.

The selection was particularly surprising to Mr. O'Bryon because he chairs not only the Test and Evaluation Division but also its 19-member Executive Committee, whose responsibilities include coordinating with Mr. Hollis to choose each year's recipient.

"I was getting kind of frustrated," Mr. O'Bryon said, "because the deadline for nominations was getting closer and closer, and I couldn't get any of the members to submit any names. What I didn't know was that the committee had secretly met without me, and the name they had chosen was mine."

But the choice was no surprise to those familiar with Mr. O'Bryon's career. Now serving as President of The O'Bryon Group and consultant on national defense and security issues to numerous government and contractor organizations, Mr. O'Bryon has more than 40 years of experience in test and evaluation, weapons technology, combat casualty assessment, and system survivability, with more than 25 of those years serving in key test and evaluation leadership roles.

A native of Schenectady, NY, Mr. O'Bryon began his career in defense 6 months after he completed his bachelor's degree in mathematics from The King's College in 1964 and was drafted into the Army. After basic training, he was sent to work at the Ballistic Research Laboratory (BRL) at Aberdeen Proving Ground, MD. His 2 years in uniform during the early Vietnam buildup gave him an appreciation for the combat troops he would spend the rest of his career supporting. Over the next two decades, Mr. O'Bryon served in various research, development, test, and evaluation positions at BRL (now ARL) and the Army Materiel Systems Analysis Activity at Aberdeen. During this time, he also earned graduate degrees in operations research/systems analysis from The George Washington University and in electrical engineering from MIT.

Figure 1. An Emotional Jim O'Bryon Accepts the 2007 Hollis Award.

"The award means a lot to me. It's special to be recognized by your peers for what you've been able to accomplish (with the help of others). And it also means a lot because of Walt Hollis and all that he stands for. "

In 1986, Mr. O'Bryon was selected for the Senior Executive Service and began a 15-year period of commuting from his home in northern Maryland to the Pentagon to serve as the first Assistant Deputy Undersecretary of Defense, Live Fire Testing, a position created by Congress. During his tenure in Washington (and under the administrations of seven different Secretaries of Defense), he also served in the Office of the Secretary of Defense as Deputy Director, Test and Evaluation; Director, Live Fire Testing; Deputy Director, Operational Test and Evaluation (DOT&E); and Deputy Assistant Secretary of Defense. In these roles, he had oversight of nearly 100 major weapons acquisition programs with a purchase price of more than $600 billion.

Since retiring from Government service in 2001, Mr. O'Bryon has continued his efforts in survivability and weapon effects. He provides independent oversight and consultation on test and evaluation activities for the Transportation Security Administration and the Department of Homeland Security. In addition, as previously mentioned, he is Chairman of the NDIA Test and Evaluation Division (chairing more than 30 national conferences), as well as the National Academy of Sciences' Panel on Transportation Security Technology and the National Research Council's Committee on Assessment of Technologies Deployed to Improve Aviation Security. He also has memberships in the International Test and Evaluation Association, the Heritage Foundation, and the American Institute of Aeronautics and Astronautics.

In addition, Mr. O'Bryon continues to spread his test and evaluation message through extensive writing and speaking. He has authored or co-authored more than 100 technical reports, open-literature articles, and other publications, including a recently published 800-page book entitled *Lessons Learned from Live Fire Testing: Insights into Designing, Testing, and Operating U.S. Air, Land, and Sea Combat Systems for Improved Survivability and Lethality*. Moreover, he has spoken at more than 100 technical conferences, graduate schools, and other organizations across the United States (and in eight other countries) and has served as Distinguished Lecturer at the Defense Acquisition University and Invited Lecturer at the Industrial College of the Armed Forces in Washington and the Center for Professional Development at the University of Texas. He has also developed and teaches a short course on live fire test and evaluation and system survivability.

But despite all of his public speaking experience, on the night of 13 March, Mr. O'Bryon found himself at a loss for words as he approached the lectern to receive the Hollis Award plaque.

"As everyone knows, I'm usually very talkative and willing to share my thoughts," he said, "but that night, I was unable to speak. The award means a lot to me. It's special to be recognized by your peers for what you've been able to accomplish (with the help of others). And it also means a lot because of Walt Hollis and all that he stands for. He's the dean of defense T&E."

In presenting the Hollis Award, RADM Johnston detailed the highlights of Mr. O'Bryon's distinguished career and recalled a personal account of an early morning they shared at a desert test range in China Lake, CA, several years earlier.

"It was 4 a.m.," Johnston said, "and we were waiting to shoot an F-14, mounted on a pole with the engines turning, with a shoulder-fired anti-aircraft missile. Jim was there because he took such great interest in the outcome of tests and what we could learn. After talking a short time, what became crystal clear was how much Jim supported our men and women who go in harm's way on our behalf. There was nothing that was more important—not political pressure, not service loyalty, not program manager or contractor premises. What mattered to Jim was how well our systems worked in the most realistic conditions we could create."

Mr. O'Bryon was joined at the award ceremony by his wife, Adina, and their daughter, Kera, an accomplished vocalist and actress (and 2007 Emmy nominee), who sang the *Star-Spangled Banner* to open the conference session earlier in the day. Mr. O'Bryon's previous honors have included gold medals from the American Defense Preparedness Association (ADPA) and the NDIA; listings in Who's Who in America and Who's Who in the World; election into the Sigma Xi Scientific Research Society, and selection for two Meritorious Civilian Service Awards as well as the Arthur Stein Award for Outstanding Achievement and Service in Live Fire Testing.

Figure 2. 2007 Hollis Award Winner Jim O'Bryon with daughter Kera at the 23rd Annual T&E Conference.

As far as his non-test and evaluation interests go, Mr. O'Bryon serves on various educational and charitable boards, including the MIT Education Council, School Ministries, Inc., the Advisory Board of the New York Evangelical Seminary, and the International Bible Society Foundation Board. In addition, he's a longtime music songwriter, instrumentalist, and vocalist (with four published recordings to his name) and is a conference speaker on mathematics, education, music, and the patent/copyright system. He also recently published his first nontechnical book, a 500-page collection of inspirational, political, humorous, and other thoughts entitled *I Fail to Miss Your Point*.

Prior to Mr. O'Bryon's selection, the Hollis Award was given to seven other individuals. They include Walt Hollis himself (2000); the Hon. Philip Coyle III, DOT&E (2001); Mr. G. Thomas Castino, Underwriters Laboratories (2002); Mr. James Fasig, Aberdeen Test Center (2003); Dr. Marion Williams, Headquarters, Air Force Operational Test and Evaluation Center (AFOTEC) (2004); the Hon. Thomas Christie, DOT&E (2005); and, as previously mentioned, RADM Bert Johnston, USN (Ret.), Wyle Laboratories (2006). As the 2007 recipient, O'Bryon will be the presenter of the 2008 Hollis Award at the Test and Evaluation Conference next February in Palm Springs, CA. ■

About the Author

Eric Edwards is a technical writer and editor for the SURVICE Engineering Company in Belcamp, MD. He has supported ARL and other Defense organizations for more than 18 years, editing numerous technical reports, articles, and books, including *Ballisticians in War and Peace, Volume III; Lessons Learned From Live Fire Testing*; and *Fundamentals of Ground Combat System Ballistic Vulnerability*. Mr. Edwards has a BA in print journalism from Bob Jones University and an MS in professional writing from Towson University.

Calendar of Events

JUN

12–14, McLean, VA
MSS National Symposium on Sensors and Data Fusion
http://iac.dtic.mil/sensiac

12–15, Las Vegas, NV
Military Laser Principles and Applications
http://iac.dtic.mil/sensiac

19–21, Colorado Springs, CO
JASP Model Users Meeting (JMUM)
jeng_paul@bah.com

25–28, Charleston, SC
NDIA National Live Fire Test and Evaluation (LFT&E) Conference
MGeary@ndia.org

AUG

6–9, Washington, DC
AUVSI's Unmanned Systems North America 2007

21–24, Atlanta, GA
Infrared/Visible Signature Suppression
http://iac.dtic.mil/sensiac

29–31, Pax River, MD
International Specialists' Meeting on Vertical Lift Aircraft Research, Development, Test, and Evaluation
http://www.vtol.org

SEP

11–13, Nellis AFB, NCV
JASP Annual Program Review
Darnell Marbury: 703/604-0817

16–19, New Orleans, LA
44th Annual AOC Symposium
http://www.crows.org

17–19, Montreal, Canada
AHS International Helicopter Safety Symposium
http://www.ihst.org
http://www.vtol.org

OCT

29 Oct–1 Nov, Atlantic City, NJ
Fifth Triennial International Aircraft Fire and Cabin Safety Research Conference
http://www.fire.tc.faa.gov

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

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