



A U.S. Navy Manufacturing
Technology Center of Excellence

IMAST

Q U A R T E R L Y

2006 No. 3

Successful Coatings Workshop Convenes

An International workshop on "Advanced Materials and Coating Technologies for Extreme Environments" was held at Penn State University September 12 and 13. Approximately 140 participants from industry, government and academia attended the two day program. The workshop linked field experience, requirements, materials and technologies with various members of the materials community. The workshop also provided a forum to address current and future challenges facing the Department of Defense, Department of Energy, and NASA. Researchers and end-users were able to exchange information about new coating materials and technologies needed to extend the life of components under extreme environmental conditions including oxidation, erosion, corrosion, and wear.

Twenty-six distinguish speakers and 17 poster presentations were offered at the workshop. Dr. William Frazier, Chief Technology Officer and Chief Scientist for the Naval Air Systems Command opened and chaired the opening session. Dr. Frazier was followed by presentations from Dr. David Shifler, an Office of Naval Research program manager. Rounding out the opening presentations was Dr. Udaya Rao, a program manager with the National Energy Technology Laboratory, Department of Energy in Pittsburgh, PA..

The first session highlighted the gap between designed turbine system requirements and actual material performance when systems are introduced to extreme performance environments. A special session was organized to address *in situ* health monitoring of coated components under extreme environmental conditions. These presentations were headed by Dr. Jeff Eldridge (NASA Glenn Research Center), Dr. William Ellingson (Argonne National Laboratory), and Dr. Aravinda Kar (materials professor, University of Central Florida). Discussion leaders addressed some of the methods and unique techniques being investigated for increasing turbine system coating performance and reliability. Incorporation of *in situ* health monitoring of coated components was also addressed. This technology offers significant potential relative to system operational availability due to reduced machinery down time and the ability to pinpoint maintenance repairs where and when they are needed.

Dr. Robert R. Romanosky, who is manager of the Advanced Research Technology at the Department of Energy's National Energy Technology Laboratory in Morgantown, West Virginia, was guest speaker at the workshop evening dinner. Dr. Romanosky provided a comprehensive overview on "25 Years of Materials Progress for Future Energy Systems: Past, Present and Future." The overview addressed the Department of Energy's materials performance requirements for future energy systems.



**Focus On
Laser Processing
Technologies**

Continued on Page 6

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 2006		2. REPORT TYPE		3. DATES COVERED 00-00-2006 to 00-00-2006	
4. TITLE AND SUBTITLE iMAST Quarterly, 2006 Number 3				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Penn State University, Applied Research Laboratory, Institute for Manufacturing and Sustainment Technologies, State College, PA, 16804				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 8	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



iMAST

**Applied Research Laboratory
Institute for Manufacturing and
Sustainment Technologies**

**DIRECTOR, iMAST &
NAVY/MARINE CORPS REPAIR TECHNOLOGIES**

Timothy D. Bair
(814) 863-3880 tdb14@psu.edu

MATERIALS PROCESSING TECHNOLOGIES

Timothy J. Eden, Ph.D.
(814) 865-5880 tje1@psu.edu

LASER PROCESSING TECHNOLOGIES

Richard P. Martukanitz, Ph.D.
(814) 863-7282 rxm44@psu.edu

**ADVANCED COMPOSITES MATERIALS
TECHNOLOGIES**

Kevin L. Koudela, Ph.D.
(814) 863-4351 klk121@psu.edu

MANUFACTURING SYSTEMS TECHNOLOGIES

Mark T. Traband, Ph.D.
(814) 865-3608 mtt1@psu.edu

**SYSTEMS OPERATIONS AND AUTOMATION/
COMPLEX SYSTEMS MONITORING**

Eddie C. Crow
(814) 863-9887 ecc1@psu.edu

DRIVETRAIN TECHNOLOGIES

Suren Rao
(814) 865-3537 sbr1@psu.edu

iMAST ADMINISTRATOR AND EDITOR

Gregory J. Johnson
(814) 865-8207 gjj1@psu.edu

STAFF ASSISTANT

Shannon Ranio
(814) 865-3264 srr12@psu.edu

WORLD WIDE WEB

www.arl.psu.edu/capabilities/mm_imast.html

NAVY PROGRAM MANAGER

Greg Woods
(703) 696-4788
woods@onr.navy.mil

ADMINISTRATOR'S CORNER

Busy and Changing Times

As the fiscal year comes to a close, we have numerous and sundry activities underway within the Institute for Manufacturing and Sustainment



Technologies. This activity was recently intensified by the departure of our previous director, Robert Cook. In order to be closer to family, Bob made the decision to resign and move south. As of this writing he is now employed and working in the sonar community near Virginia Beach, Virginia. We wish Bob the best and will likely continue to encounter him within our various Navy-related activity efforts.

With Bob's departure we are pleased to announce iMAST's new acting director, Tim Bair. Tim comes to us from within our Materials and Manufacturing Office, where he served as a program manager within our Systems Operations and Automation Department. Tim provides continuity and a sound understanding of both the regular and repair-related Navy ManTech activities that are being addressed here at Penn State University's Applied Research Laboratory.

Prior to Tim's ARL Penn State service, he served as a senior aircraft maintenance and logistics officer with the U.S. Air Force. Air Force assignments included command, line, and staff assignments with experience in instructional-systems development, training, and education. He has extensive experience in maintenance processes at the organizational, intermediate, and depot levels and in supply-chain management, transportation, and logistics-planning functions. Tim was temporarily assigned as an investigator for the Columbia Shuttle Accident Investigation Board. A Penn State undergraduate, Tim holds an master of science degree in National Resource Strategy from the National Defense University, and a masters of science degree in logistics management from the Air Force Institute of Technology.

While Tim acclimates himself to the various ManTech programmatics, the rest of us are assisting him in preparation to attend and participate in the annual Defense Manufacturing Conference that will be held 27-30 November in Nashville, TN. If you will be attending that event, please stop by and visit us at our exhibit booth.

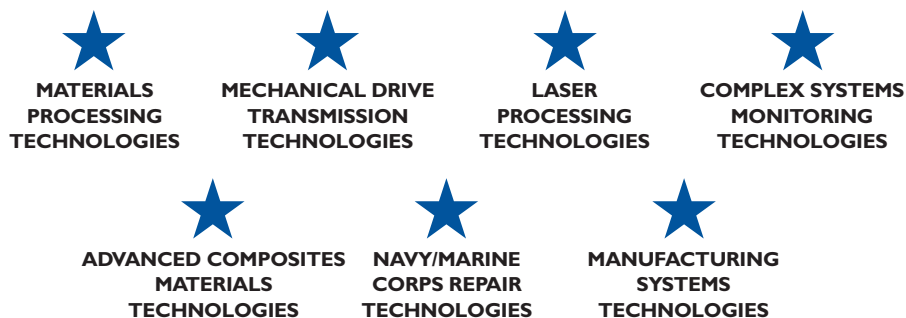
Greg Johnson

©2006. The iMAST quarterly newsletter is published by the Institute for Manufacturing and Sustainment Technologies of the Applied Research Laboratory at Penn State, University Park, Pa. iMAST is sponsored by the U.S. Navy Manufacturing Technology (ManTech) Program, Office of Naval Research, under Navy Contract N00024-02-D-6604. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the U.S. Navy. Send mail list requests or address corrections to: iMAST Administrator, ARL Penn State, P.O. Box 30, State College, PA 16804-0030 or e-mail: srr12@psu.edu. Parcel delivery address (UPS, FedEx, USPS): N. Atherton St. Rear; Research Building West, State College, PA 16804.

Penn State is an equal opportunity/affirmative action university.
This publication can be made available in alternative media on request.
U.Ed.ARL 06-05

IN THIS QUARTERLY

Feature Article	3
Institute Notes.....	7
Calendar of Events.....	8



Light Weight, Low Total Ownership Cost Are Benefits of New Surface Ship Watertight Door

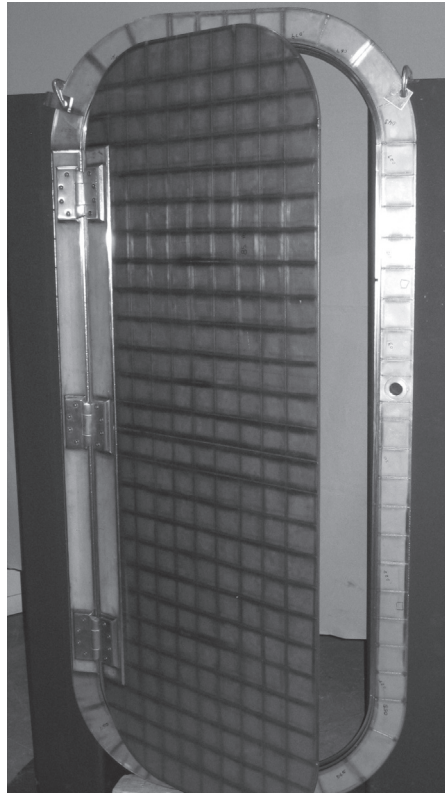
by Stephen Copley, Ph.D.

Introduction

Designed in the 1950s to be watertight during flooding and airtight under normal operating conditions, the Navy Standard Watertight Door (NSWD), actually a family of doors varying in size and pressure specifications, is both a wonder and a source of frustration. Inexpensive to manufacture but expensive to install and maintain, approximately 32,000 NSWDs are currently in-service aboard amphibians and combatants across the fleet¹.

Figure 1 (on page 4) is an assembly drawing showing the interior side of a 26 in x 66 in NSWD². Ninety percent of in-service doors fall into this size classification. The panel is a dimpled, low carbon steel (A-36) sheet reinforced by externally welded stiffeners. It is attached to the frame by two hinges and eight latches called “dogs” located on the exterior side of the door. A complex linkage system, which includes four latches mounted at the top and bottom of the door, translates the closing motion of the handle into rotating motion of the dogs pressing them against wedges mounted on the panel (Figure 1). The wedging action presses the rim of the panel containing a flat silicon rubber gasket against the knife edge of the frame to produce the seal. The frame is lap-welded to the interior surface of the bulkhead.

The cost of manufacturing the NSWD shown in Figure 1 is surprisingly low, about \$3000 per door. Installation costs are estimated to be about \$7500, so the acquisition



cost is \$10,500 per door. Annual maintenance costs are estimated to range from \$330 to \$660 depending on the condition of the door¹. The main cause of high installation and maintenance costs is distortion of the knife edge resulting from lap-welding the frame to the bulkhead, which is not flat. Owing to this distortion, high

forces are required to seat the frame's knife edge on the panel's gasket leading to gasket and dog wedge wear during operation of the door. Also, NSWDs require frequent repainting, because low carbon steel lacks corrosion resistance in the marine environment adding to the high maintenance cost. An additional problem of the NSWD is its weight; by today's needs, it is too heavy. The door shown in Figure 1 weighs about 290 lbs.

There have been many advances in manufacturing technology since the 1950s. One of the most significant is the increasing use by industry of lasers for a wide variety of manufacturing processes including welding, cladding, cutting, surface transformation hardening and modification creation of near-net-shape components, coating removal and remediation of hazardous materials. In 1985, the Laser Processing Division of ARL was established by direction of the Navy's Manufacturing Technology Office to improve the affordability and effectiveness of manufactured components for the Department of Defense and U.S. Industry. In 1995, the Navy recognized the



PROFILE

Stephen Copley is a senior scientist in the Laser Processing Division of ARL Penn State's Materials and Manufacturing Office. He was awarded a B.A. in Physics and an M.S. and Ph.D. in Engineering Science, all from the University of California at Berkeley. Prior to ARL, Dr. Copley served as Vice Provost and dean of engineering and science at Illinois Institute of Technology. Dr. Copley's current responsibilities include developing and conducting programs related to advanced processes and materials and the application of various laser processing technologies. He can be reached at (814) 863-7140, or by e-mail at <scopley@psu.edu>.

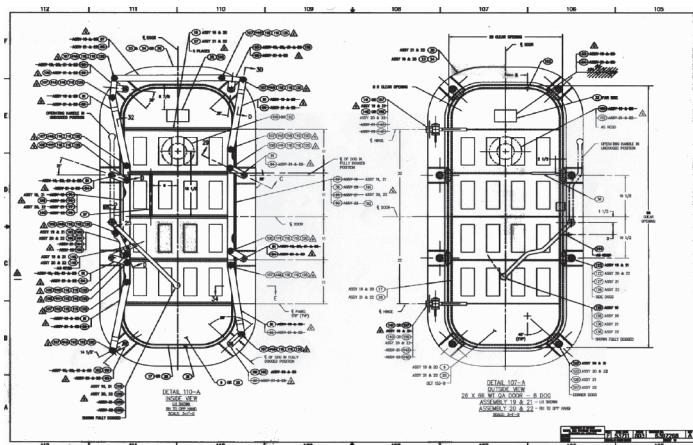


Figure 1. Assembly drawing of 26 in x 66 in quick acting, 8 dog, 10 psi Navy Standard Watertight Door.

Division's outstanding capabilities by designating it as the Navy Laser Applications Research Center-of-Excellence, which, today, continues as part of the Navy's Institute for Manufacturing Sustainment Technologies (iMAST).

In June 2004, the ARL's Laser Processing Division in collaboration with Naval Surface Weapons Center Carderock Division, Ship Systems Engineering Station (NSWCCD-SSSES, Code 9782) and Northrop Grumman Corporation Newport News under sponsorship of ONR ManTech/iMAST and the Program Executive Office, Aircraft Carriers, CVN-21 (PMS-378) initiated a new program with the objective of specifying for manufacture a new interior watertight door for CVN-21 featuring improvements over the NSWSD and candidates for its replacement.

ADVANCED WATERTIGHT DOOR

Assessment of the needs of a watertight door design for use on the CVN-21 led to the following set of requirements: (1) reduce weight by 25%; (2) acquisition cost neutral; (3) reduced total ownership cost = acquisition cost + maintenance cost (TOC); (4) satisfy performance constraints; and (5) secure qualified

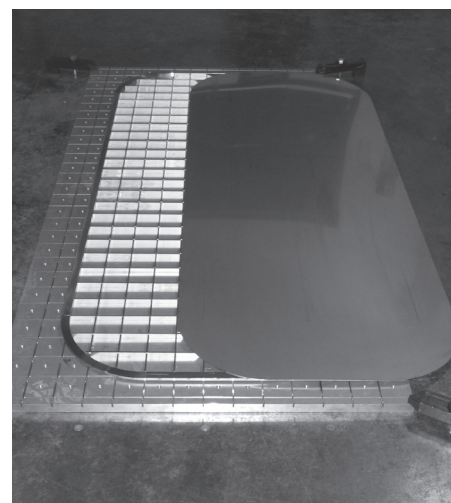
domestic manufacturing base to ensure a competitive environment. The following describes important features of the new design and progress towards implementing it to date.

CELLULAR STRUCTURE

The new door has a cellular sandwich panel structure developed under Navy sponsorship, LASCELL™ (patent pending).³ For example, the door panel consists of two thin face sheets separated by a square honeycomb core of stiffeners as illustrated in Figure 2. The face sheets and stiffeners are laser cut from sheet metal of standard thicknesses. The stiffeners, which are slotted and mechanically interlocked, are attached to the face sheets by autogeneous laser welds (without filler metal) passing through the face sheets into the stiffeners. The stiffeners are neither welded to each other nor to the rims. The resulting structure is very efficient in resisting bending loads because much of its weight is concentrated in the face sheets, which are displaced from the neutral axis to produce a large moment of inertia, and because of beneficial pre-stressing induced by the laser welding^{4, 5}. The door is made from an austenitic stainless steel (304), a much more corrosion resistant material than that used in the NSWSD.



Current ship enclosures require costly manpower-intensive maintenance.



Internal cell structure prior to cover sheet welding.

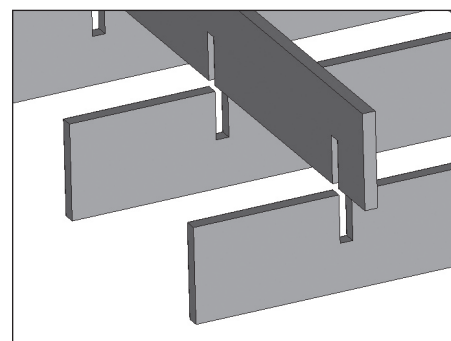


Figure 2. Schematic drawing showing design of square honeycomb core sandwich panel.

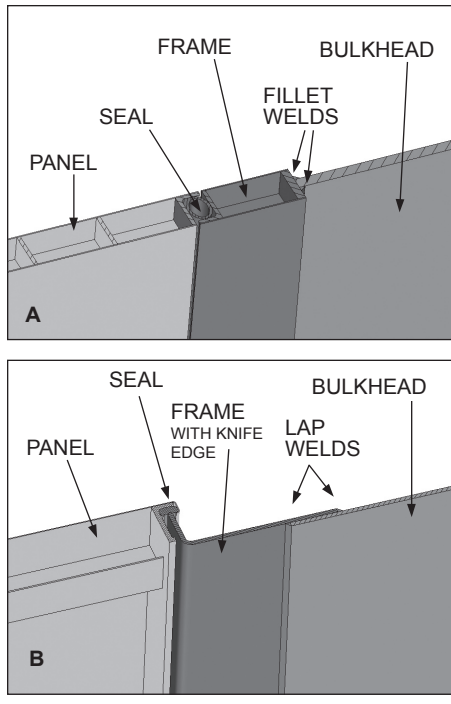
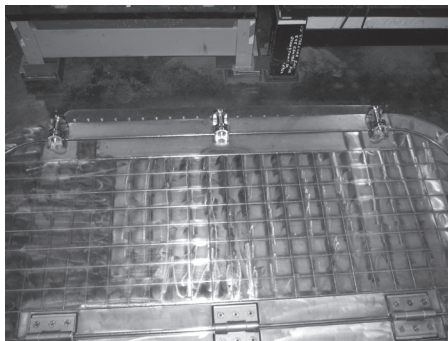


Figure 3. Comparison of welding methods for attaching new door and NSW to bulkhead: (a) plug-in-hole concept; (b) lap welded frame



Fully welded door with all hardware mounted shown on welding table.

PLUG-IN-HOLE INSTALLATION

Figure 3 compares installation of the NSW to that of the new door. The NSW is lap welded to the bulkhead, which is not flat, distorting the knife edge. The new door fits inside the bulkhead hole and need not conform to the bulkhead surface. It is fastened by two fillet welds.

HYDROSTATICALLY ACTUATED SEAL

In the new design, load is transferred from the panel through the hinges and latches to the frame. Only three

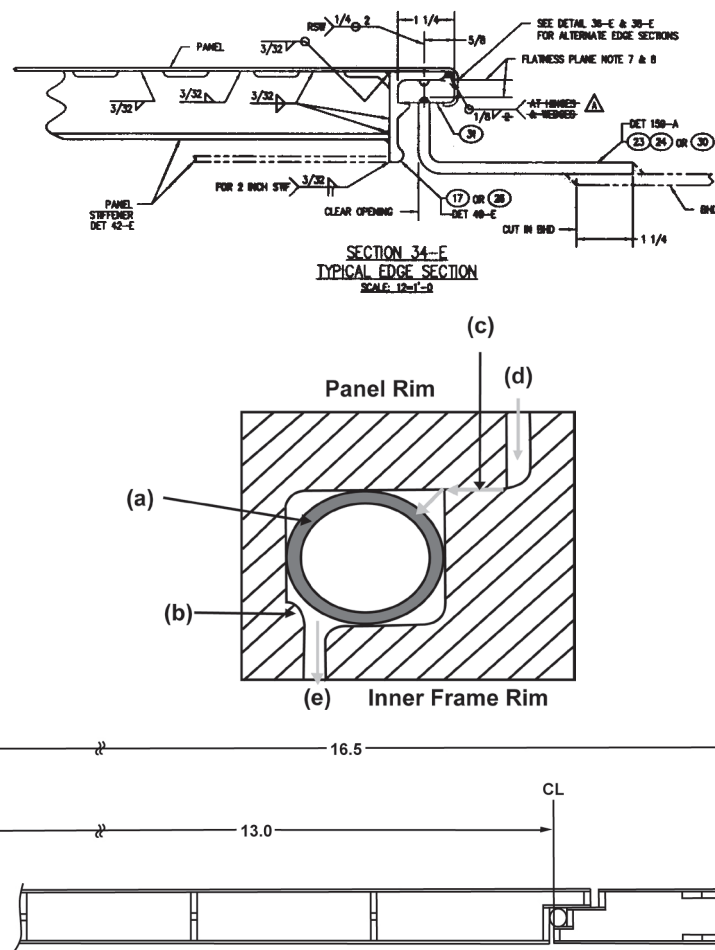


Figure 4. Hydraulically actuated gasket concept.

hinges and three latches mounted on the sides of the panel and frame are employed in the new design compared to two hinges and eight latches in the NSW. Although distorting slightly under load, the gasket cavity remains essentially as shown in Figure 4. Although, the exact shape of the gasket and its cavity are still under development, it will function like the hollow cylinder illustrated in Figure 4. Under normal operation it will be slightly compressed producing an air-tight seal. If flooded from the exterior side, it is forced by the pressure against the passageway leading to the interior side, and vice versa. The gasket can be designed by adjusting the wall thickness so that only a small force need be applied by the latches to produce the airtight seal. Since only

a small force is needed the latch assembly can be less robust and hence lighter than that used for the NSW.

CURRENT STATUS

Two full scale prototype door panels, frames and hinge assemblies have been designed and fabricated. The first has been shown at the Navy League Sea-Air-Space Expo, April 4-6, 2006 in Washington, D.C., Figure 5, and the Showcase for Commerce, May 31-June 2, in Johnstown, PA, Figure 6. A prototype latch assembly will be installed on this door and it will be used for future displays. The second has been mounted on a hydrostatic test tank and shipped to Seal Science, Inc., for a gasket design and test program to be completed in August 2006. Design of a latching system has been completed.

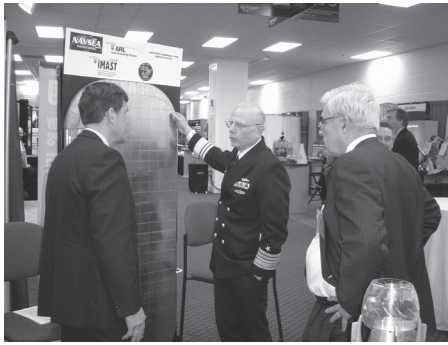


Figure 5. VAdm Paul Sullivan views prototype watertight door at Navy League Sea-Air-Space Expo in Washington, D.C..

Engineering drawings of a second generation design have been completed. Finite element analysis (FEA) has validated its use to 10 psi pressure, both directions. Computer simulated shock analysis (DDAM) is in progress; preliminary results are promising.

The weight reduction of the new door will exceed the 25% goal. Material and laser cutting

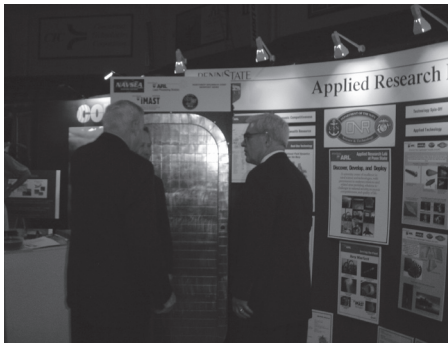


Figure 6. ARL Director, Dr. Ed Liszka, and Congressman John Murtha discuss door at Johnstown Showcase for Commerce.

costs for face sheets and stiffeners of the prototype doors was less than \$2000. Material and forming costs for the rims have been quoted at about \$1200 for 100 or more orders. Investigation of the welding cost and the cost of the latch system is in progress. A program is being initiated with Northrop Grumman Corporation Newport News to investigate methods of reducing installation costs including in situ automated welding.

A request for proposal to provide ten doors for a test program that will include hydrostatic, shock, vibration, cyclic, and installation tests has been submitted.

ACKNOWLEDGMENT

The author wishes to express appreciation for support of this effort by the Institute for Manufacturing and Sustainment Technologies (iMAST), a U.S. Navy Center of Excellence sponsored under contract by the Navy Manufacturing Technology Program, Office of Naval Research. The author also wishes to acknowledge the contributions of the Laser Processing Division technical staff, especially Chris Sills and Dennis Wess, an associate engineer in the Manufacturing Systems Division. Any opinions, findings, conclusions and recommendations expressed in this material are those of the author and do not necessarily reflect the views of the U.S. Navy.



REFERENCES

1. Jim Burton and David Simunov, "Options for In-Service Ship Watertight Doors," Presented to PEO Ships-F Program Review, Watertight Door Technical Splinter Group, Feb. 15, 2006
2. Department of the Navy, Naval Sea Systems Command, "Doors, Watertight, Quick Acting Arrangement," Dwg. No. 803-6397268, Rev. A, Sheet 14.
3. S.M. Copley, W.G. Rhoads, C.A. Sills and E.S. Ventsel, "Autogenously Welded Metallic Cellular Structures and Methods for Forming Such Structures," Patent Pending
4. S.M. Copley, E.S. Ventsel and P. Vigna, "Laser Fabricated Metallic Cellular Sandwich Panels," ICALAO-05, Laser Institute of America (2005)
5. S.M. Copley, P. Vigna and E.S. Ventsel, "Beneficial Pre-Stress in Laser Fabricated, Metallic, Square, Cellular Sandwich Panels, accepted for publication ICALAO-06, Laser Institute of America (2006)

FEATURE ARTICLE (CONTINUED FROM FRONT COVER)

Round table discussion highlighted day two of the workshop with closing remark summaries by Drs. Frazier and Shiftler, as well as Dr. Cheruvu Sastry (Southwest Research Institute, San Antonio), Dr. Dongming Zhu (NASA), and Dr. A. Manivannan (Department of Energy).

Looking to the future, it was agreed that any future road maps need to be jointly developed in order to

address the various challenges noted by the numerous distinguished workshop speakers.

The coatings workshop was the result of various coatings projects being performed at ARL Penn State under the Institute for Manufacturing and Sustainment Technologies, a U.S. Navy Manufacturing Technology Program sponsored by the Office of Naval Research. For more information

on iMAST coating project efforts, contact Dr. Douglas Wolfe at (814) 865-0316, or by e-mail at <dew125@psu.edu>. For a CD copy of the workshop presentations, please contact the workshop organizer, Dr. Jogender Singh (Chief Scientist, Materials and Manufacturing Office). Dr. Singh can be reached at (814) 863-9898, or by e-mail at <jxs46@psu.edu>.



ONR 332/NSWC Philadelphia Visits iMAST

David Shiftler (ONR 332 Undersea Weapons and Naval Materials Division), along with Bruce Rodman (Naval Surface Warfare Center Carderock Ships Systems Engineering Station Philadelphia) visited ARL Penn State and iMAST as part of a ManTech capabilities review visit. Following presentations, the visitors were given a tour of facilities, to include laser processing, coatings, composites, gears, and materials processing.



Johnstown Showcase for Commerce

iMAST participated in the annual Johnstown Showcase for Commerce forum in Johnstown, Pennsylvania. The showcase provided an opportunity to highlight iMAST's Navy Manufacturing Technology program effort, as well as network with key industrial partners from the region. The showcase also provided an opportunity to personally share with Congressman John Murtha, various program efforts and capabilities resident within iMAST's Navy ManTech Program. iMAST featured its watertight ship enclosure project which is our featured article in this quarterly.

Joint Defense ManTech Panel

Joint Defense ManTech Panel (JDMTP) Meeting Held at iMAST

Members of the JDMTP visited iMAST where they were briefed on the following iMAST ManTech projects: S2031: Advanced Surface Ship Watertight Closures; C2142 USMC Depot Blast and Paint Lean Production Optimization; S2023 Brush Electroplating Project; S1065: Modeling & Simulation for Carrier Construction Planning and Sequencing; S2074: Optimization of Virginia Class Submarine Facility Utilization of NGNN; S2086: Shipyard Simulation-Optimization Decision Support System (DSS) for Lead Time Reduction; S2135 Austal Facility Design Analysis and Simulation; S2134 MMC-LCS Production Capacity & Facility Analysis; S2069: Aircraft Carrier Propulsion System Health Monitoring; A2138: Corrosion Resistant Coating for Magnesium Transmission Gearboxes for SH60; A2087: Erosion Resistant Coating for Stage I-Compressor Components; S1017: Hot Section Corrosion Protection for 501-K34 Gas Turbine; S1019 Collarless Construction; S2073: Hybrid Laser Beam Welding; S1064 Long Life Non-Skid Coating; S2072 Waterborne Preservation of Tanks and Void; and S1070 LASCOR CVN.

The JDMTP panel meets with iMAST once a year to review current programs. Members of the panel provide input and determine possible synergy with other service materials processing-related ManTech programs.



PMS 399 Visits iMAST

Members of PMS 399 (Special Operations Forces Undersea Mobility Program Office) visited iMAST to discuss program efforts incorporating ARL's conceptual design environment tool. The visit included presentations, followed by tours of iMAST/ ARL's various facilities. The conceptual design tool explores design trade-offs and the complex design space of an engineering product.

iMAST's Kevin Koudela describes specific Navy ManTech program projects to PMS 399 visitors.

CALENDAR OF EVENTS

2006

9–11 Oct.	AUSA Expo		Washington, D.C.
16 Oct.	Penn State Center for Space Research Programs Workshop "State of Space Business"		University Park, PA
23–26 Oct.	Expeditionary Warfare Conference		Panama City, FL
23–26 Oct.	DoD Maintenance Conference		Reno, NV
24–25 Oct.	Materials and Manufacturing Advisory Board Meeting (Aerospace)		State College, PA
27–30 Nov.	DMC 2006	★★★★★★ visit the iMAST booth	Nashville, TN

2007

9–11 Jan.	Surface Navy Association Symposium	★★★★★★ visit the iMAST booth	Crystal City, VA
3–5 April	Navy League Sea-Air-Space Expo	★★★★★★ visit the iMAST booth	Washington, D.C.
1–3 May	American Helicopter Society Forum 63	★★★★★★ visit the iMAST booth	Virginia Beach, VA

Quotable

"The only constant in the Navy's future is change."
— Admiral Michael G. Mullen, USN

PENNSTATE



Applied Research Laboratory
P.O. Box 30
State College, PA 16804–0030

Nonprofit Org.

U.S. Postage
PAID
University Park, PA
Permit No. 1

ADDRESS CORRECTION REQUESTED