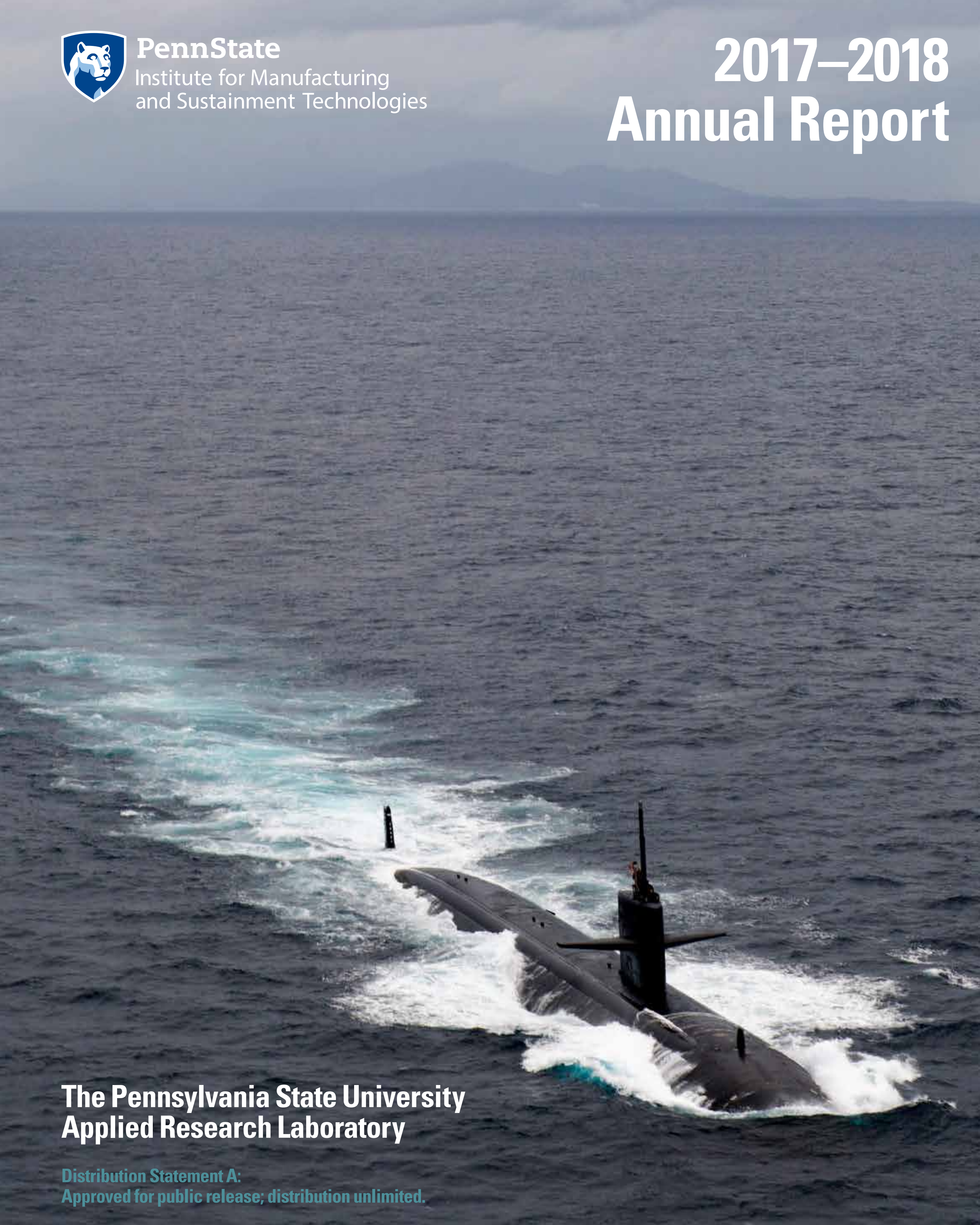
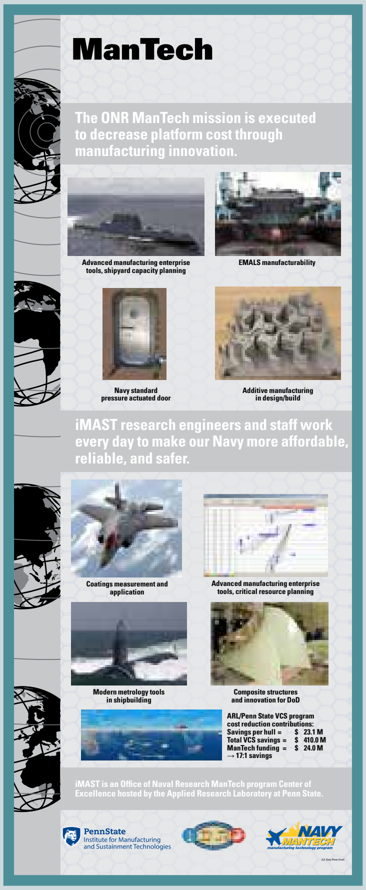
PennState
Institute for Manufacturing
and Sustainment Technologies

2017–2018 Annual Report



The Pennsylvania State University
Applied Research Laboratory



On the Cover:
USS *Key West* (SSN 722), U.S. Navy released photo

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Director's Message

Timothy Bair
iMAST Director

The best part about being the director of the Institute for Manufacturing and Sustainment Technologies at ARL/Penn State is the mission and the opportunity to see the impact our project teams can have on Navy readiness. The projects iMAST executes for the Navy ManTech program have the potential to make our major acquisition programs cheaper and more reliable throughout the life cycle. The secondary benefit is the effect our work has on sustaining a competitive industry base for support of the DoD. Thanks to the iMAST staff and the men and women of ARL, our program continues to earn its way on board the ONR ManTech program every year by supporting the U.S. Navy-Marine Corps Team, as well as the Department of Defense in general.

The summary of support expounded in this report reflects a concerted effort to support the Navy ManTech Investment Plan espoused by the Office of Naval Research. Thanks to the Office of Naval Research and the Navy ManTech program, iMAST has continued to fund projects and implement the results across the Department of the Navy's missions and commands. iMAST has invested in the DDG, Carrier, VCS/CLB, JSF, and CH-53K programs with projects aimed at streamlining the manufacturing process, as well as cutting labor hours. As you peel back the layers of implication, it is clear this is not an easy task. We continue to push forward with respect to current and future challenges facing the naval services and the Department of Defense. ManTech is focused on cutting the cost of these major systems, and iMAST is making a huge contribution.

Many of our projects are nearing completion and undergoing testing at outside facilities. That Navy and Marine Corps program offices are willing to let us take on the risk and cost of testing new technologies speaks well for the technical promise of the projects, not to mention the confidence in our engineers. But this is not the time to rest on our laurels, so we continue to look at the future of manufacturing and repair technologies. Ten years ago Additive Manufacturing, as well as Advance Manufacturing Enterprise tools, was just starting to evolve. Industry has now embraced those tools, and they are being put in place. These leading edge insertion opportunities could not come into play without the dedication being put forth by our engineers and their supporting staff.

In concert with our efforts, I am enjoined to also restate (in particular) the value the iMAST's repair technology program brings to the table. As you may know, iMAST is leading the Navy-Marine Corps team's repair, overhaul, and sustainment initiative through our Repair Technology ("RepTech") program. The RepTech program is chartered to reduce the cost of maintaining the fleet and improve reliability. While the number of ships, aircraft, and vehicles has decreased over the years, the age of the remaining assets has risen. With increased operating tempos, the need to reduce the costs and time spent in the depots and shipyards is ever more critical. Given the limited funding available for Repair Technology, we have judiciously selected projects that maximize benefits to the fleet. We will continue to concentrate on technology that can be used at multiple shipyards or depots. By using a lead depot to demonstrate the technology, then working with the systems commands to implement it across the board, we can reap the biggest benefit for the Navy.

Thank you for your time and interest in iMAST, ARL, and The Pennsylvania State University. Please feel free to contact us if you have any questions.

Tim Bair

iMAST: Serving the Navy-Marine Corps Team

The Institute for Manufacturing and Sustainment Technologies (iMAST) is a U.S. Navy Manufacturing Technology (ManTech) Center of Excellence, sponsored by the Office of Naval Research. Located at The Pennsylvania State University's Applied Research Laboratory in State College, Pennsylvania, the institute was formally established in 1995. The institute is comprised of seven technical thrust areas:

- Repair Technology
- Laser Processing Technologies
- Manufacturing Systems
- Composites Technologies
- Materials Processing Technologies
- Mechanical Drive Transmission Technologies
- Systems Operations and Automation

As noted, iMAST is resident within Penn State's Applied Research Laboratory, which serves as a DoD University Affiliated Research Center (UARC). iMAST provides a focal point for the development and transfer of new manufacturing processes and equipment in a cooperative environment with industry, academia, and the Navy. The Institute leverages the resources of the Applied Research Laboratory to develop technology and business practices that enhance the industrial sector's ability to address advanced weapon systems issues and challenges for the Department of Defense. The "reach-back" capability into Penn State's strong R&D engineering and material foundation provides significant science and technology capability which iMAST exploits in a cost-effective manner. Sponsored under Navy contract N00024-12-D-6404, iMAST provides manufacturing technology support to the systems commands of the U.S. Navy and Marine Corps.

U.S. Navy released photo

About ARL Penn State

PennState
Applied Research Laboratory

The Institute for Manufacturing and Sustainment Technologies resides within the Applied Research Laboratory (ARL) at The Pennsylvania State University (University Park campus). University Affiliated Research Centers (UARCs) are strategic United States Department of Defense (DoD) research centers associated with universities. UARCs were established by the Director of Defense Research and Engineering (DDR&E), Office of the Secretary of Defense to develop and ensure that essential engineering and technology capabilities of particular importance to the DoD are maintained. Although UARCs receive sole source funding under the authority of 10 U.S.C. Section 2304(c)(3)(B), they may also compete for science and technology work unless precluded from doing so by their DoD UARC contracts.

The Applied Research Laboratory is one of five U.S. Navy-sponsored UARCs in the country. Solving challenges for the U.S. Navy and DoD for over 70 years, ARL has demonstrated innovation and practicality in technology-based research. While serving the Navy and DoD as a technology base, it has also facilitated Penn State in becoming second among U.S. universities in industrial R&D funding.

ARL's broad-based effort is supported by a full-time complement of more than 1,100 scientists, engineers, technicians, and support staff, in addition to 200 associate members within the University. Through its affiliation with various colleges of Penn State, other universities, and consortia, it has extended capabilities to manage and perform interdisciplinary research.

The Applied Research Laboratory's charter includes and promotes technology transfer for economic competitiveness. This focus supports congressional and DoD mandates that technology from federally funded R&D be put to dual use by being transferred to the nation's commercial sector.

Core competencies within ARL enable iMAST to directly contribute to manufacturing-related activities espoused by the Office of Naval Research's Manufacturing Technology Program (Navy ManTech).

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Navy ManTech Strategic Investment Plan

The Navy Manufacturing Technology (ManTech) Program is improving the affordability of naval platforms critical to the future force. Investments are focused on manufacturing technologies to assist key acquisition program offices in achieving their respective affordability goals. ManTech has specifically identified and funded affordability initiatives for the Virginia-class and Columbia-class submarines, CVN 78-class carrier, DDG 51-class destroyers, CH-53K King Stallion, and the F-35 Lightning (Joint Strike Fighter).


U.S. Navy released photo


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2017–2018 Technology Transfer Event Participation

Attended Events

- Surface Navy Association Symposium, Crystal City, VA
- National Shipbuilding Research Program, Charleston, SC
- Navy League Sea-Air-Space Expo, National Harbor, MD
- ONR Future Force, Washington, D.C.
- Showcase for Commerce, Johnstown, PA
- RepTech Working Group Meeting, Norfolk, VA
- Defense Manufacturing Conference, Tampa, FL
- Mega Rust, Virginia Beach, VA

State College Hosted Events

- Materials and Manufacturing Board Meeting
- RepTech Working Group Meeting
- JDMP Conference

A2609-B — Primer Thickness Measurement for Seam Validation & Supply Base Quality


© Lockheed Martin

Affordability Focus Area: Coatings
Stakeholder: PEO (JSF), F-35 Joint Program Office (JPO)
Platform(s): F-35 Joint Strike Fighter (JSF)

Process improvements to meet strict F-35 primer thickness requirements.
Various fundamental elements contribute to the establishment of the F-35 as the single most advanced warfighter in aviation history. Several factors, such as an integrated airframe design and the incorporation of innovative materials, contribute to the effectiveness of the F-35. Every detail counts toward achieving the advanced performance capabilities, and tight tolerances are held at every stage of the aircraft assembly. Meeting these tight tolerances has proven to be challenging in terms of manufacturing time and cost, and finding accurate measurement technology has proven to be just as difficult. For the F-35, the combination of overly thick primer application and the absence of accurate measurement technology commonly results in failures that require many hours of unplanned rework.

This project aims to develop a method to provide painters with the ability to reduce the costs of rework caused from deficient panels. The project team will investigate multiple tools/methods capable of proving the thickness measurements of the primer coating over composite panels without damaging the primer surface or requiring additional rework. Following a down select, the preferred technology will then be further developed for implementation into F-35 production.

Payoff

Early estimates forecast a 20-percent reduction in rework activities related to primer thickness. Assuming a low-rate initial production (LRIP) 11 implementation during the first quarter of FY18, the estimated reduction correlates to a per-aircraft savings of $30.5K and total program savings of over $60.5M per F-35 JSF program. The project is anticipated to reduce the labor and costs associated with rework, improve first-pass quality, and decrease process span time. A five-year ROI of 3:1 is expected.

Implementation

This technology will be disseminated to individual part suppliers, enabling the suppliers to accurately apply and assess the primer coating on their parts prior to shipment, eliminating tedious rework during later stages of the production process. Accurate measurements of the primer coating thickness will improve first-pass quality and eliminate the mandatory rework required for out-of-tolerance panels. If the technology proves successful, Lockheed Martin anticipates implementation of the primer thickness measurement technology in FY18 during LRIP 11.

This project is a joint COE effort between Naval Shipbuilding & Advanced Manufacturing (NSAM) and the Institute for Manufacturing and Sustainment Technologies (iMAST).

PI: Timothy Eden, Ph.D.

ARL released photo

A2644 — Powder Metal Advanced Grinding

Affordability Focus Area: Metals Processing & Fabrication
Stakeholder: PEO (JSF), F-35 Joint Program Office (JPO)
Platform(s): F-35 Joint Strike Fighter (JSF)

Advanced grinding process improves machining of powder metal forgings.
Components for the Joint Strike Fighter F-135 engine are produced by machining powder metal forgings. The forgings are difficult and expensive to machine using conventional tools and processes. Hand work and hand polishing are required after the machining process to achieve the required surface finish. Preliminary work has shown that high-speed grinding has the potential to increase the material removal rate by a factor of four while meeting the required surface finish and microstructure. High-speed grinding can be applied to several different components. Additional work is needed to select the grinding wheel, develop the optimal grinding parameters, and qualify the process. Both creep and peel grinding are being evaluated during this project.

This effort is developing cost-effective grinding processes for powder metal and forged turbine components that meet all part quality requirements. To realize this objective, 10 different grinding wheels are being evaluated to determine the material removal rate, the wheel wear rate, and the quality of the grinding surface. After completing the same tests on all 10 wheels, the best one to two grinding wheels for each grinding process will be selected for optimization testing. An optimal set of parameters yielding the best combination of cost and performance will be developed and validated through laboratory testing. These grinding parameters will be transferred to Pratt & Whitney (P&W) for implementation within its F-135 production line.

Payoff

Implementation of high-speed grinding processes with increased material removal rates and improved surface finish will greatly reduce the time and cost to produce F-135 engine components. The process can be used on several different engine components. Cost savings will be identified based on reduced fabrication time and handwork. A faster production process will provide a higher throughput for the existing grinding cells and will help meet the production schedule without purchasing additional grinding cells. The ROI is 3.3:1.

Implementation

The results of this effort will be transitioned to P&W in March of 2018. P&W will evaluate the technical performance of each wheel and implement the grinding process into its component manufacturing enterprise. The design of the experimental systems is intended to be a facsimile of P&W's manufacturing cell, thereby ensuring direct scalability and ease of implementation to the P&W production process.

PI: Timothy Eden, Ph.D.

A2647 — Additive Manufacturing Repair of AV-8 LPC Seal

Affordability Focus Area: Metals Processing & Fabrication
Stakeholder: NAVAIR, PEO (T)
Platform(s): RepTech

Repair of AV-8B engine part by additive manufacturing process.
Additive Manufacturing (AM) is recognized by NAVAIR as a means to bring "…a revolution in how we sustain our systems" (VADM David Dunaway). This technology has clear potential to benefit Navy sustainment activities, including direct part replacement, repair parts fabrication, and refurbishment of worn or corroded parts. The U.S. Navy must develop and demonstrate qualification and certification procedures for targeted components before this potential can be realized for aviation components.

This project will advance AM technology for both new manufacture and repair by developing a qualification test plan, a suitable repair process, and a technical data package to support the qualification, repair, and implementation of AM repair procedures at Fleet Readiness Center (FRC) East. These procedures will address a high-priority repair need within the AV-8B F402 engine—unacceptable surface/ fretting wear on the Low Pressure Compressor (LPC) 2nd Stage Rear Seal Ring at bolted contact points to the 3rd Stage Rear Seal Ring.

Payoff

A key payoff will be the reduction in time associated with placing components and systems back into service, resulting in concomitant reductions in cost and improvements in readiness. A Supply Snapshot provided by FRC East suggested that the projected number of surplus seal rings was expected to drop below an acceptable level, which could adversely affect their ability to sustain the fleet. Moreover, lead time to get a new part manufactured or to qualify a new vendor were expected to be two years and cost approximately $100K.

The cost avoidance and operational benefit associated with the cyclical availability of resources was stressed to the project team from FRC East as motivation to aggressively pursue suitable AM repair options. The knowledge gained through this project will be leveraged by follow-on efforts to apply the benefits of AM technologies to other Navy applications.

Implementation

Transition will be achieved when: (1) a qualification test plan has been approved by the Navy (completed), (2) a repair process has been developed that enables successful execution of the qualification test plan (completed), and (3) a technical data package with information to reproduce the qualified repair process by FRC East or their designee. Other progress toward implementation includes the approval by FRC East of internal Capital Investment Plan funding to procure special equipment to produce these AM repairs in-house, as well as repairs to other components, e.g., T64 air seals (the target of anticipated next efforts) and/or identification and qualification of a private/commercial provider. Implementation is expected to occur in FY18.

PI: Stephen Brown

ARL released photos

A2686 — Electromagnetic Aircraft Launch System (EMALS) Armature Assembly Producibility Improvements

U.S. Navy released photo

Affordability Focus Area: Metals Processing & Fabrication, Coatings
Stakeholder: PMS 378, PEO (Aircraft Carriers), NAVAIR
Platform(s): CVN Class/Aircraft Carriers

Improved affordability and producibility for EMALS components.

The Electromagnetic Aircraft Launch System (EMALS) armature assembly connects to the aircraft tow bar at the tow bar interface. Electromagnetic fields accelerate the armature assembly, providing the thrust needed to launch aircraft. As the load transmission link between the EMALS and aircraft, the armature assembly is a Critical Safety Item (CSI), as are each of the components comprising the armature assembly. The armature assembly acquisition cost is a target for ManTech affordability investment. Many of the vendors supplying armature assembly components are sole- source. Sole-source supply of critical components creates technical, acquisition cost, and schedule risks. The current acquisition lead time for one armature assembly is 36 months. The five armature assemblies fabricated for CVN 78 were delivered a year after scheduled in-yard date.

The objective of this project is to reduce cost and lead time associated with acquisition of the EMALS armature assembly and is focusing on one high cost component, the Aft Bogey. The estimated Aft Bogey acquisition cost is $215K. At approximately 23 percent of the total armature cost, reducing acquisition cost of the Aft Bogey is a logical starting point to reduce cost of the armature assembly.

Payoff

Applied Research Laboratory (ARL) obtained a quote for $175K for a 4,000-lb. billet of Custom 465 stainless steel — large enough to machine an Aft Bogey. ARL identified a forging house and received quotes for Custom 465 stainless steel forgings of $93K each. This will reduce raw material cost by approximately $80K per Aft Bogey. Starting with a near-net-shape forging that weighs approximately 500 lbs. (vice a 4,000-lb. billet) will also reduce machining costs. Cost reduction of other armature assembly parts will further improve the ROI and contribute to a successful project.

Implementation

Implementation hinges on successful cost reduction of the EMALS Aft Bogey. Implementation requirements are straightforward – material requirements, incoming material inspection requirements, and part acceptance criteria already exist for this component. Potential vendors will adhere to all relevant material and first-part inspection requirements. ARL will work with vendors to ensure the necessary vendor certifications and registrations are in place. The implementation target date is January 2018.

PI: Charles Tricou

S2580 — Cold Spray Proof of Procedures for Navy Shipboard Components

U.S. Navy released photo

Affordability Focus Area: Metals Processing & Fabrication
Stakeholder: NAVSEA 04 and all Public Shipyards
Platform(s): Surface Ships and Submarines

Additive repair of ship's components.
Working with Puget Sound Naval Shipyard and the Intermediate Maintenance Facility (PSNS), a number of shipboard components were identified that either needed an improved repair process or did not have a viable repair process. Most of the components suffered from corrosion or wear of the base metal. The components included actuator bodies, valves, pump housings, electric motor housings and periscope masts. The components are made of different materials including Al-6061 T651, brass, 70/30 Cu-Ni and steel. Current repair processes for extensive corrosion damage include electroplating, epoxy patches, and welding. These repairs can be very labor and time intensive with limited degrees of success depending on the component. The Cold Spray process offers an alternative to these repair processes with the added benefits of low heat input and can be used on many materials that can't be easily welded.

The objective of this effort was to develop, validate and implement Cold Spray repairs for an Al-6061 hydraulic actuator housing, steel motor end bell housings, 70.30 CuNi valve and a bronze pump housing.

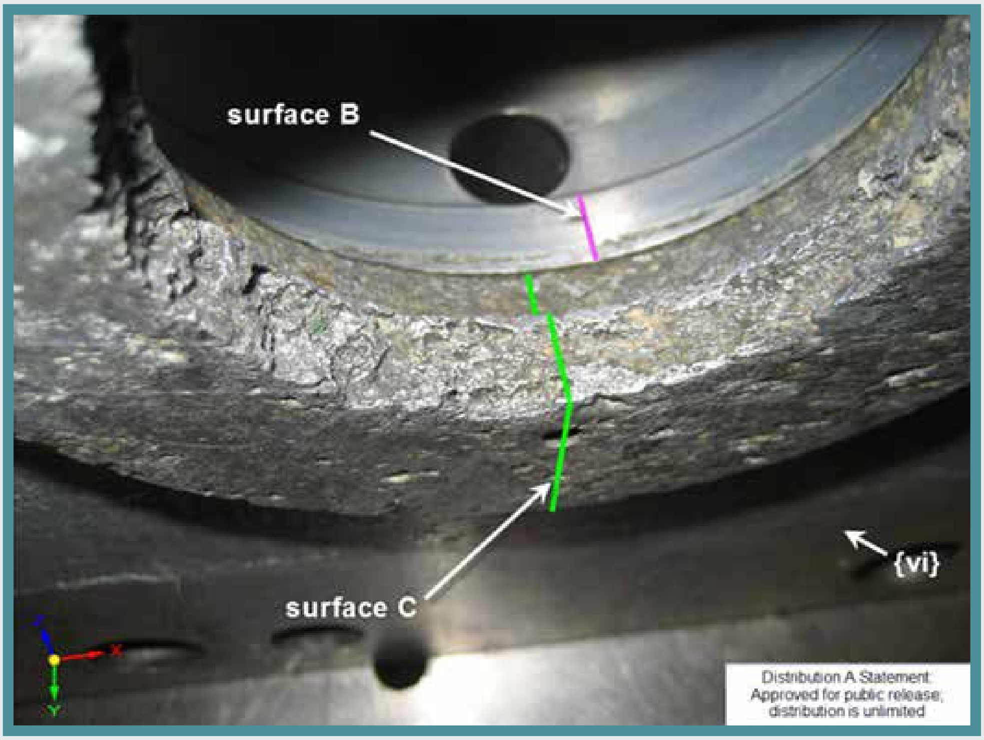
Payoff

There are several benefits that have resulted from the program: approved repair processes for submarine and aircraft carrier components; repairs that return components to service that often have to be scrapped; repair costs of less than 20% of a new component; repair times can range from one day to four weeks (depending on the component) compared to lead times as long as 24 months for new parts and the process can be applied to a wide variety of components, substrate metals and applications purpose such as repair, overhaul, upgrade or overcoat for corrosion prevention. The estimated cost avoidance for the first five years of implementation is $9M for an ROI of 15:1.

Implementation

Two hydraulic actuator bodies have been repaired and have been returned to service on a submarine with two year limited use approvals. The CVN Main Water Circulating pump has been given a four year unlimited use approval and has been returned to service. The Universal Industrial Process Instruction (UIPI) 6320-901 Cold Spray, Processes and Quality Control was developed by Puget Sound Naval Shipyard and is in the final approval process. Approval of this document will make Cold Spray an approved process for NAVSEA. Working groups have been established to support the implementation of Cold Spray at the four naval shipyards and at the intermediate maintenance facilities. Pearl Harbor Naval Shipyard has purchased a Cold Spray system and the other three shipyards are planning on having Cold Spray capability within the next two years. A Navy wide call is held every six to eight weeks to review and track Cold Spray technology in NAVSEA and NAVAIR.

PI: Timothy Eden, Ph.D.



ARL released photo

S2593-B — Critical Resource Planning

Affordability Focus Area: Advanced Manufacturing Enterprise, Product Engineering Tools
Stakeholder: PMS 450, PMS 397
Platform(s): VCS/CLB Submarines

Providing accurate information regarding the use and availability of critical resources for planning.
A tool is needed to monitor and forecast the use of critical construction resources (e.g.,-support/transportation equipment) at General Dynamics Electric Boat (GDEB). The focus of this project is to develop a software-based tool that is capable of providing accurate information to Planning regarding the use and availability of critical resources at GDEB and its partners. The tool will be capable of providing statistical data to Planning regarding the downstream effects of schedule changes, added work, or changes in a manufacturing assembly plan. The data generated within the tool can then be used to estimate the total cost of a planned/unplanned change event or evaluate the total cost of a proposed plan. The tool will track information beyond the capabilities of current spatial and capacity planning tools and ensure that sufficient quantities of each critical resource exist at all phases of construction.

Phase 1 investigated and included a thorough requirements gathering from potential end users and GDEB management, development of recommendations and the design of a prototype critical resource planning tool graphical user interface, and the inventory and prioritization of all Electric Boat critical resources. Phase 2 focuses on the development or extension of the data table to feed the critical resource planning tool, the development of a prototype graphical user interface that processes planning data and incorporates requirements as defined in Phase 1, and the development of specific use cases to be tested with initial deployments of the critical resource planning software. A thorough testing procedure will be developed and executed. After verifying full functionality of the critical resource planning software, the project team will demonstrate the tool to GDEB stakeholders as well as project sponsors.

Payoff

This technology could potentially save an estimated $478K per VIRGINIA Class submarine (VCS) hull and estimated cost avoidance not less than $1.808M for the COLUMBIA Class resulting in an estimated five-year ROI of 2.56:1.

Implementation

Implementation is expected to utilize a phased approach, where the most beneficial opportunities will be assigned higher priority and implemented first. The results of this ManTech project may be implemented in production of VCS hulls as early as 2Q FY18. However, the schedule for implementation activities is dependent on project results.

This project is a joint COE effort between Naval Shipbuilding and Advanced Manufacturing (NSAM) Center and Institute for Manufacturing and Sustainment Technologies (iMAST).

PI: Daniel Finke, Ph.D.

S2599 — UHP SHT/MIP Removal Using Dual-Track Crawler System

Affordability Focus Area: Coatings
Stakeholder: NAVSEA
Platform(s): RepTech

Ultra-high pressure water jet removal of special hull treatment using dual-track crawler system.
Removal of Special Hull Treatment (SHT) and mold in place (MIP) coatings from submarine hulls is performed using ultra-high pressure (UHP) water jet blasting. Currently, shipyards use UHP hand-lances to remove SHT. SHT removal using UHP hand-lances is slow and is a safety hazard for operators. The objective of this Institute for Manufacturing and Sustainment Technologies (iMAST) project is to design, fabricate, test, and deliver a dual-track UHP SHT removal system. The dual- track SHT removal system will be a semi-automated process. The dual-track crawler system will use higher pressure and flow rates than can be used with hand-lances. For these reasons, the dual-track crawler system will improve removal efficiency, improve safety, and reduce labor in both the blasting and waste cleanup processes.

Payoff

According to Puget Sound Naval Shipyard and Intermediate Maintenance Facility (PSNSY&IMF), an estimated 1000 person-hours were expended from April 2013 through April 2014 for SHT removal from submarines using the standard hand- lancing technique. PSNSY&IMF subject matter experts (SMEs) estimate a labor reduction of approximately 35 percent through elimination of the 60-minute operator blast-time restriction (safety requirement) and from elimination of 'trigger- off' associated with operator fatigue and poor visibility.

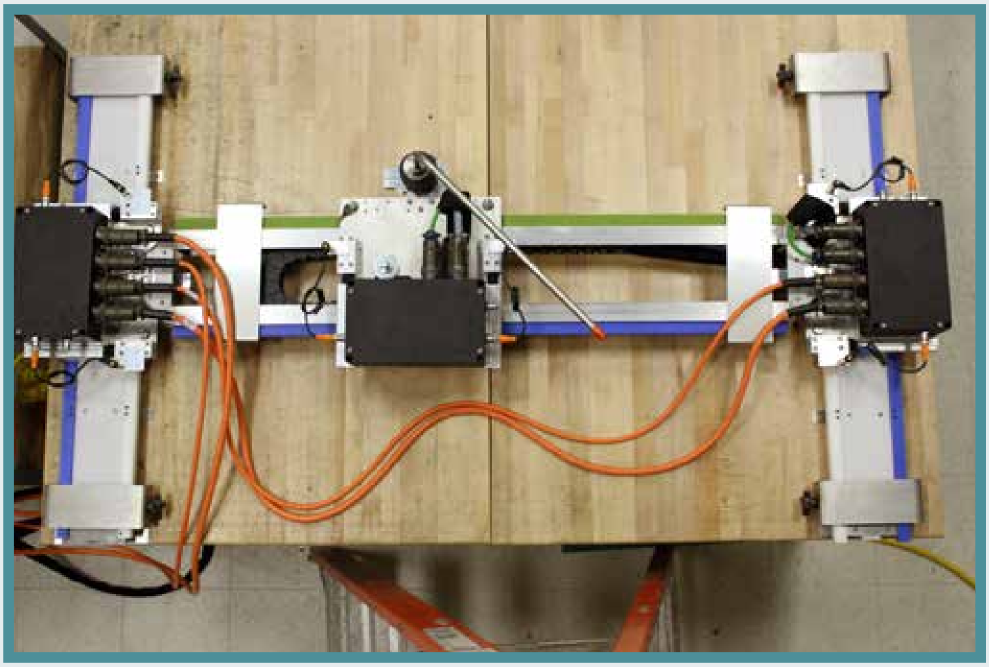
Vacuum collection is not currently feasible due to the tendency of removed SHT material to clog the vacuum collection equipment. The use of a dual-track system will enable precise control of particle size, enabling vacuum collection at point of generation. Shipyard SMEs estimate 50 percent labor reduction for cleanup. Lastly, Shipyard SMEs estimate ~35 percent labor reduction associated with edge cleanup prior to reinstallation of new tiles.

The estimated total cost savings per hull is $120K per year per yard. The estimated total annual cost savings to the Navy is $360K per year. The return on investment over five years is 3.5:1.

Implementation

The Institute for Manufacturing and Sustainment Technologies (iMAST) first demonstrated the system at PSNSY&IMF in July of 2016. iMAST conducted pre-production trials at the PSNSY&IMF July 10th – 14th at the PSNSY&IMF. PSNSY&IMF full-scale on-boat production trials occurred in August 2017. The transition path is direct technology insertion at the submarine-supporting shipyards. Implementation target is for submarine hull-coating repair and maintenance operations.

PI: Charles Tricou



ARL released photo

S2600 — Shipyard Capacity Planning Tools at BIW

Affordability Focus Area: Automated Tools, Advanced Manufacturing Enterprise
Stakeholder: PMS 400D, PMS 500
Platform(s): DDG 51/DDG 1000

Capacity planning tools transitioned to BIW.
Capacity planning is the process of ensuring that production capacity is matched to demand. Capacity planning enables facilities to meet critical delivery schedules. Bath Iron Works (BIW) has legacy production information systems that can be used to facilitate more robust capacity planning analyses. However, the capabilities of these tools are not fully exercised. The tools analysis capabilities are limited due to significant upfront customization of the systems to meet initial implementation requirements. In addition, planners often employ a plethora of "tools" (spreadsheets, databases, etc.) to understand the demands on resources such as labor, machines, fixtures, or space under their control. Therefore, there are increased chances of disparate plans being developed that are not efficiently synchronized to the master production schedule.

The objective of this Navy ManTech Institute for Manufacturing and Sustainment Technologies (iMAST) project was to develop a shipyard-wide capacity planning system that enables the BIW planning organization and construction management personnel to conduct both long-term, shipyard-wide and short-term, shop-level capacity planning for critical shipyard resources in support of their DDG 51 and DDG 1000 shipbuilding programs. Specifically, this project developed a central data system, long-range and shop-level capacity planning tools, and integrated the previously transitioned Spatial Scheduling Tool into the system.

Payoff

The implementation of the capacity planning tools at BIW is expected to result in a reduction of overtime trade-labor hours and a reduction of labor hours for production planning and control personnel. The Capacity Planning System speeds up the time to develop capacity plans enabling rapid mitigation when existing plans require modification. BIW projects the savings for production and planning personnel to be an estimated $921K per hull (5 hulls), resulting in a five-year ROI of 6.36:1.

In addition to the quantitative benefits, qualitative benefits are expected to include improved visibility of potential space conflicts in advance of production, reduced non-value-added product movement, and completion of work in preferred work locations.

Implementation

The Spatial Scheduling, Long-Range, and Shop-Level Capacity Planning tools were transitioned and implemented in production at BIW; where immediate savings in planning development time and improvements in planning fidelity have been anecdotally reported by the planning organization. The final full-scale Capacity Planning System software that was released in spring 2017 included the Shop-Level Capacity Planning Tool, which has been undergoing early implementation testing at BIW.

PI: Daniel Finke, Ph.D.

S2643 — Acoustical Sensing through Energized Electrical Enclosures

Affordability Focus Area: RepTech
Stakeholder: PMS 378, PMS 379
Platform(s): CVN Class/Aircraft Carriers

Acoustical sensing provides safe, cost effective, and early fault warning inspection of energized electrical enclosure.

An electrical fault diagnostic technology has been identified for energized shipboard electrical equipment and distribution panels. Early detection of electrical faults (e.g. loose connections inside the panels) will allow corrective actions prior to catastrophic failure (i.e., arcing, explosion, fire, etc.). Existing inspection procedures using Infrared Imaging Thermographic cameras require direct line-of-sight of energized components and electrical connections. This inspection technique presents electrical safety hazards to personnel as typical distribution panels operate at voltages of 450 VAC up to 13,800 VAC. Even if the enclosures are opened, obstructions and internal structures may block visual direct line-of-sight inspection of all energized components. A reliable, non-intrusive inspection technology is desired to provide electrical fault sensing of all energized equipment through closed panels. High frequency acoustic inspection technology can provide a means of early electrical fault detection and location, enabling planning of corrective maintenance actions, improved sailor safety, and increased asset availability. The objective of this Navy ManTech project, performed by the Institute for Manufacturing and Sustainment Technologies (iMAST) at the Applied Research Laboratory at The Pennsylvania State University, was to evaluate and establish the feasibility of using high frequency acoustic sensing technology for application to shipboard electrical panel connections monitoring and maintenance. The technology has already been successfully implemented in land- based power systems distribution systems and networks.

Payoff

The new inspection technology allows for easy and frequent inspections that can be performed through closed panels and under operational power loading thus enabling the early detection of electrical faults. This inspection technology allows for proactive planning of corrective maintenance actions. Many electrical faults (loose connections/ replaceable components) can be corrected with minor maintenance and minimal mission interruption. Acoustic inspection technology is applicable to all electrical distribution panels on all ship classes. This project is expected to result in an estimated $10M per year cost avoidance.

Implementation

Evaluation of the hand-held acoustic sensing device has been completed on laboratory scale components and shore-based, full-scale switch-gear panels (KEMA Labs.). Follow-on ship-board trials have been performed on numerous electrical distribution components to provide an initial acoustic signature database. Findings will be presented to the Technical Warrant Holder for review; and implementation will be funded through platform maintenance activities. Trial introduction of this new technology is anticipated by late 2017.

PI: Clark Moose

ARL released photo

S2649 — VIRGINIA-Class Submarine Alternative Coating and Surface Preparation Solutions for Ball Valves

U.S. Navy released photo

Affordability Focus Area: Coatings
Stakeholder: PMS 450, PMS 397
Platform(s): VCS/CLB Submarines

Alternative coating and surface preparation solutions for Teflon®-coated ball valves.
Currently, green Teflon® coatings are used as a solid film lubricant to reduce the operating torque of the ball in the valve assemblies. The coating on the air-system ball valves (ASBV) peels and wears after a low number of cycles (new production testing), potentially causing an increase in seal wear and operating torque. Teflon® peeling in ball valves has increased inspection rejections, which increases re-work costs.

The project is identifying, testing/evaluating, and implementing potential alternative coating systems, coating deposition processes, and/or surface modification processes that improve the performance and extend the life cycle of ASBV. The project will identify the root cause failure mechanism. This will assist in identifying coating properties/surface modifications that meet the minimum performance requirements. The coated ASBV/seating material interaction will also be evaluated as a system. Currently, four potential solution sets exist: improvements in the Teflon® coating manufacturing process, improved seat/ball materials, superfinishing, and advanced coating materials.

Payoff

There is almost a 100 percent rejection rate of the Teflon®-coated ball valves (size dependent) during acquisition. An improved coating system will eliminate the need to rework the ASBV and save approximately 50 percent of the total acquisition cost. Material savings of $100K per ship and planning and engineering savings of $334K per ship are anticipated for a total acquisition savings of $434K per ship. Over five years, at two ships per year, this correlates to $4,340K in savings, which gives a ROI of approximately 3.85:1. There is a potential acquisition savings of $755K per VIRGINIA Payload Module and $2,127K per COLUMBIA Class ship due to the increased number of ASBV assemblies. Reduced life-cycle costs are anticipated that will benefit other submarine and ships classes.

Implementation

This project will be implemented in late FY 2019 on new construction VIRGINIA Class submarines and existing hulls on an attrition basis. Electric Boat and NAVSEA are committed to this project as a means to reduce acquisition costs and total ownership costs for the VIRGINIA and COLUMBIA Class submarines. The project's results will significantly reduce source inspection rejections and unplanned maintenance. Implementation will be accomplished through drawing changes and will require successful coating or surface modification development by iMAST to be qualified and certified by NAVSEA technical authorities.

PI: Douglas Wolfe, Ph.D.

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S2682 — Low Loss Launch Valve Plug Maintainability Improvement

Affordability Focus Area: Metals Processing & Fabrication
Stakeholder: PMS 378, NAVAIR
Platform(s): RepTech

Low loss launch valve improvement.

The improved Low Loss Launch Valve (LLLV) is a component within the steam catapults and are deployed on CVN 68 through CVN 77. Each catapult has a LLLV which precisely meters the proper flow of steam to the power cylinders for aircraft launch. The plug-type valve rotates to control the flow of steam. The LLLV plug is exposed to high temperature steam, condensate, graphite, and grease. A coating is applied to the area on the plug shaft just below the steam plug valve to increase wear and corrosion resistance. The coating system has a bond coat that provides adhesion to the plug and a ceramic top coating that provides wear resistance. During refurbishment of the LLLV, the coating and a thin layer of base metal must be machined from the shaft to remove any material affected by the coating process. This process can remove enough material to reduce the diameter of the shaft to below the minimum acceptable diameter. Increasing the thickness of the bond coat can restore the LLLV shaft to the required diameter. There is occasionally, some evidence of corrosion in the damaged coatings. Therefore, an alternative sealant with higher temperature capabilities is being examined to improve the corrosion performance.

The objective of this Navy ManTech Institute for Manufacturing and Sustainment Technologies (iMAST) effort was to increase the thickness of the coating system while meeting the adhesion strength requirements and to improve the corrosion resistance. Initial efforts have shown that the adhesion strength decreases with increasing bond coat thickness. However, doubling of the bond coat thickness resulted in an adhesion strength that was still above the required adhesion strength. Adhesion, microstructural analysis, and corrosion tests were performed. A high temperature sealant was produced and evaluated and other coating systems and processes were examined as needed. Representative hardware will be developed to validate the repairs. Improvements to the plasma spray process will also be investigated.

Payoff

The payoff includes a process that can be used to restore undersized LLLV plug shafts to the required diameter, increased corrosion and wear resistance, and improved the plasma spray process for applying the coatings. The cost of a new LLLV plug is $100K. Eight plugs are repaired annually. The cost savings for repairing the shafts over purchasing new plugs and for increasing the life of the ILLLV plug shaft is $500K per year. An additional benefit includes extended time between repairs. An improved plasma spray process could be used on other Navy platforms as well.

Implementation

Implementation of the repair processes will be through Naval Air Warfare Center Aircraft Division - Lakehurst and the plasma spray vendor. Implementation will include test methods to validate the performance of the thicker plasma coatings. Final implementation is expected to occur in FY18.

PI: Timothy Eden, Ph.D.

U.S. Navy released photo

S2714 — PSNS&IMF Submarine Factory Simulation and Capacity Planning

U.S. Navy released photo

Affordability Focus Area: Advanced Manufacturing Enterprise
Stakeholder: PMS 392, PMS 371
Platform(s): VCS/CLB Submarines

Computer simulation improves workload planning in the Submarine Factory at Puget Sound Naval Shipyard. The Submarine Factory at Puget Sound Naval Shipyard (PSNS) is responsible for operating the Navy's Inactivation, Reactor Compartment Disposal, Recycle (IRR) Program on SSN 688 class submarines. Because of resource constraints and inefficiencies in the current workload planning process, the Submarine Factory has had trouble managing the workload of 688 class submarines that have come into the shipyard for IRR. PSNS has limited space available to store submarines that are waiting in the queue for IRR. At the current submarine arrival rate and IRR processing rate, the shipyard will reach its storage limit of 30 submarines by the year 2030. Managing the allocation of manpower is also a problem in the Submarine Factory. Resources are sometimes reassigned to higher priority work at the shipyard, causing disruptions to the Submarine Factory's schedule and making it necessary to replan and reschedule. Scheduled work cannot be completed on time if the resources that were allocated to the work become unavailable. The shipyard would like to make targeted investments in planning resources and processes to mitigate these disruptions, but do not have a good tool for identifying the most cost-effective investments and changes.

This project will develop a simulation-based capacity planning system to improve the PSNS Submarine Factory's ability to schedule its IRR workload and to allocate resources while minimizing costs. The capacity planning interface will have an underlying simulation model that accurately and statistically represents the tasks and resources that comprise the Submarine Factory's IRR process. The capacity planning system will be integrated with the simulation model so that shipyard personnel can effectively use it without modeling experience.

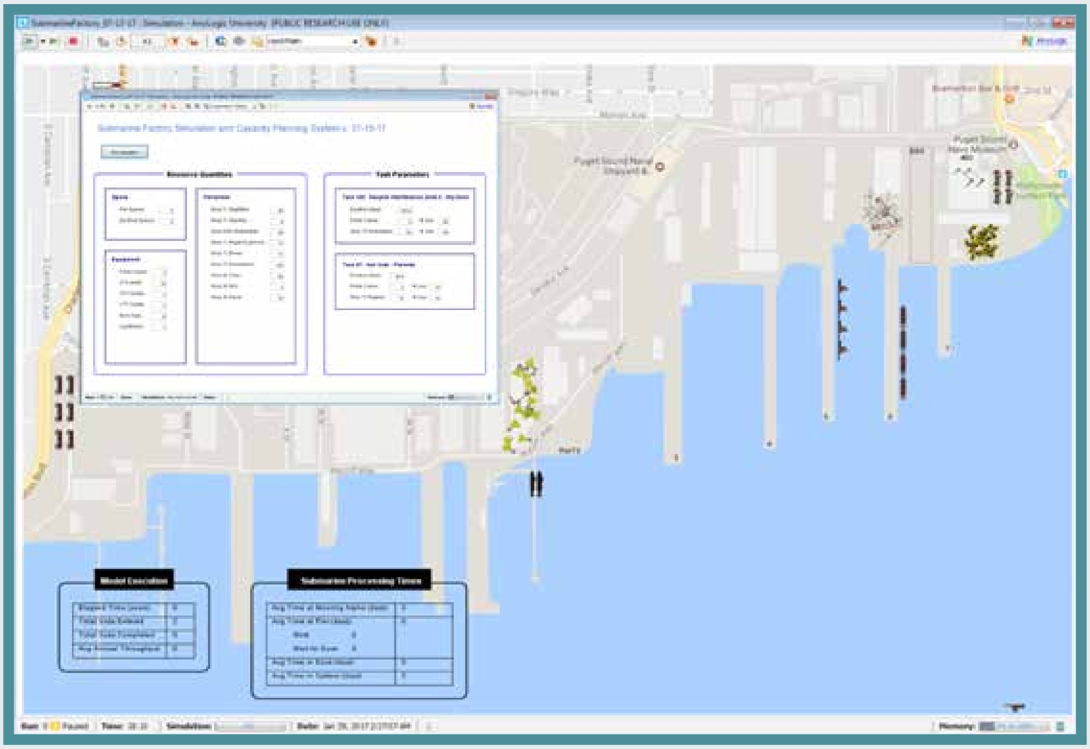
Payoff

The system is expected to improve the utilization of resources and increase the throughput of dismantled/recycled submarines. PSNS expects a savings of $3.9M per submarine resulting from a 15 percent decrease in the total cost to dismantle and recycle a submarine. With an expected workload of two submarines per year, the savings over five years (10 submarines) would be $39M. The return on investment for the project over the five-year period would be 64:1.

Implementation

The simulation-based capacity planning system will be implemented in the Submarine Factory at Puget Sound Naval Shipyard in April 2018. At that time the capacity planning system, along with its integrated simulation model, will be handed off to PSNS personnel for use at the shipyard. PSNS will also take over responsibility for maintenance of the software and updates to the model. Applied Research Laboratory Penn State/iMAST will provide training and user documentation to PSNS personnel at the time the software transitions to PSNS ownership.

PI: Daniel Finke, Ph.D./Christopher Ligetti



2017–2018 Portfolio of Projects

S2723-A — False Deck Panel Improvement

U.S. Navy released photo

Affordability Focus Area: Composite Processing & Fabrication
Stakeholder: PEO (Ships), PMS 500
Platform(s): DDG 51

Down-selection of new material and/or streamline false deck panel.

False Decking is used throughout electronic spaces on DDG-51's and other surface ships, where inspection and access to electrical and HVAC systems is necessary. This lightweight composite decking is a structural sandwich panel with a honeycomb core, requiring a multi-step edge treatment when cuts are made to fit around objects during installation to ensure a watertight seal. The DDG-51 Class destroyer outfits approximately 8,000 square feet of decking, consisting of approximately 1,600 panel pieces. The DDG-51 Program Office would like to address the complexities of cutting, edge preparation and installation procedures with a possible deck panel redesign or edge preparation alternative. These modifications could meet current design specifications, reduce labor-intensive fabrication and installation costs, reduce delamination of the panel during installation and removal operations, and reduce acquisition and life-cycle costs. Additionally, the project team will evaluate the potential of modern metrology tools to accelerate the fit and install time for this task. Bath Iron Works will work directly with both ManTech groups, iMAST, and CMTC.

Payoff

Projected cost reduction will result by increasing productivity and throughput, by eliminating shop time for cutting and edge treatment steps, and facilitate the transfer of the cutting and fitting tasks to the panel installation team to perform on the ship. Moving all installation activities to the ship should reduce panel fabrication time by as much as 75%. Expected benefits are streamlining the installation process and reduction of maintenance burden on the ship's crew, which will translate into lower installation and ownership costs. The total funding requirement is $1.11M ($500k from iMAST, $600k from CMTC, $10k for training from Bath Iron Works). The per hull cost savings, per year, is estimated at $428k; therefore, the five year savings is $2.140k, yielding a five year ROI of 1.93.

Implementation

The final ManTech deliverable for Phase 0 will be a Requirements Document that will define material and performance characteristics requirements, to be delivered three months after CMTC is funded. This document will be reviewed with the Technical Warrant Holder to ensure acceptance. Another final deliverable will include a phase 0 Go/No Go Milestone Report that will consist of documentation of project steps, product, and materials evaluation findings, six months after CMTC is awarded. This report will prioritize recommendations with saving estimates in accordance with Phase 0 objectives that can be utilized during the follow-on Phase 1 effort.

Phase 1 will subsequently demonstrate, via critical element and full-scale prototype design, fabrication and testing, that the proposed critical design meets acceptance requirements and constitutes a viable solution to support false deck development, ship integration, and certification. Tasking will demonstrate the cost-benefits of the core technologies and metrology capabilities for all stakeholders. Documentation, in the form of a summary report, will be issued upon completion of phase 1, 21 months after CMTC is awarded.

PI: Terri Merdes

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S2727 — Advanced Steel Production Facility – Industrial Modeling and Simulation

U.S. Navy released photo

Affordability Focus Area: Modeling and Simulation, Advanced Manufacturing Enterprise
Stakeholder: PMS 378, PMS 379
Platform(s): CVN Class/Aircraft Carriers

Industrial modeling and simulation allow modifications in current factory configuration.
The Institute for Manfacturing and Sustainment Technology (iMAST) at the Penn State Applied Research Laboratory (ARL) will develop a stochastic Discrete Event Simulation model of the entire fabrication process for the products created by Newport News Shipbuilding's (NNS) Steel Production Facility. The model, with included front-end user interface, shall provide a means that will allow NNS to assess alternatives and modifications in the current factory configuration to obtain productivity increases.

NNS is proposing a radical shift in manufacturing of these products in the Advanced Steel Production Facility (ASPF). This model will allow productivity changes to be assessed globally and down to the station-level, which allows departures and variants in productivity to be determined and, by extension, technology gaps to be identified. In follow-on efforts, alternative equipment, process flow configurations, and new manufacturing stations will be "modeled." Modules representing these stations are to be inserted into this baseline model, creating new models of alternative scenarios. New analytical results will allow analysis of concepts to be conducted and evaluated.

Payoff

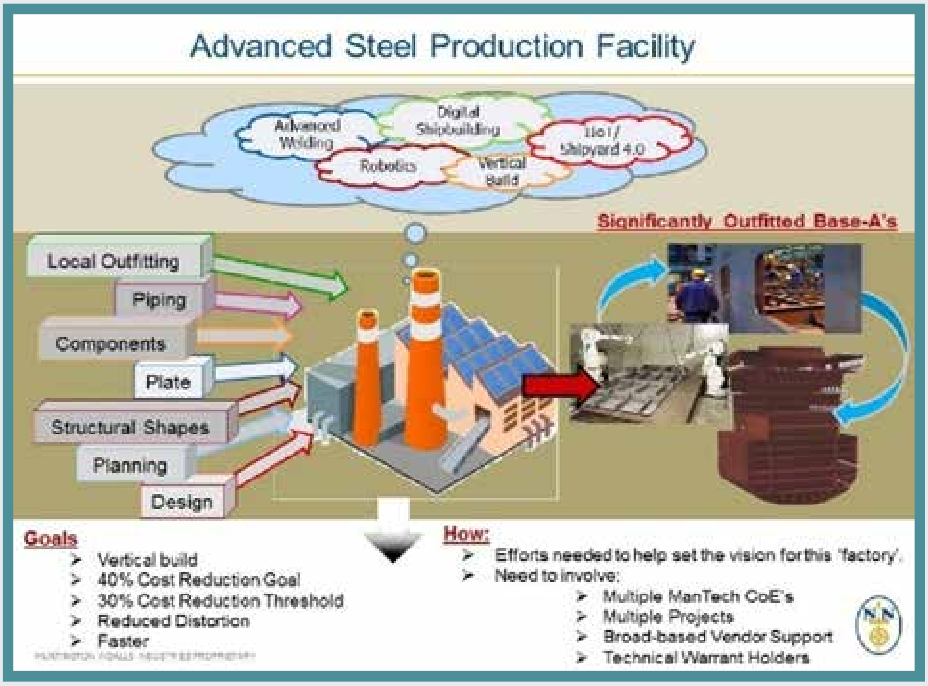
While no benefits may be estimated until the actual completion of the ASPF concept, the concept itself may be assessed on a global scale. The following EROM savings (based on ASPF model only) may be obtained:

- Products that are currently removed from the legacy panel line due to weight, depth, or access may be assembled on a new production line. This may include items currently statically built and have a high level of manual operations. Currently this potential is estimated at approximately 400,000 labor-hours per hull. If this can be fabricated using an assembly line method, it is estimated that 40 percent reduction can be achieved (approximately $17.2M savings per CVN).
- Products currently assembled on the panel line are to be assembled, joined, and undergo early outfitting more effectively. This is to include a more completed final product with a goal of completing the majority of hot work either on the line or in the shop. It has been estimated that an increase in productivity can be achieved resulting in approximately 20 percent savings. With 1.8M labor-hours assigned per hull to ASPF for panel line completion, this equates to a savings of 360,000 labor-hours per hull (approximately $38.6M per CVN).

Implementation

Upon completion of this project, and acceptance of the technology and associated business case by the acquisition Program Office (PMS 379), the model and all associated software applications and source code will be transitioned to NNS. The technology will be implemented at NNS through use in follow-on research and development efforts expected to be funded to support the ASPF concept. Post-project technology insertion should be limited to full-scale deployment of piloted technologies/improvements during the project; however, implementation investments are expected to be minimal given NNS's cost share commitments throughout the model development phase.

PI: Daniel Finke, Ph.D./Christopher Ligetti



S2744 — Hatchable Cold Spray Technology for Naval Shipyards and Marine Corps Depots

ARL released photo

Affordability Focus Area: Metals Processing & Fabrication
Stakeholder: NAVSEA 04, Public Shipyards, USMC LOGCOM
Platform(s): Other Sea Platforms

Innovative In-Situ Repair for Ships.

The successful completion of project S2580, Cold Spray Proof of Procedure for Navy Shipboard Components, led to the identification of several additional components that could be repaired using Cold Spray technology. Being able to repair these components on board would result in significant time and cost savings associated with eliminating the necessity to remove them from the ship or submarine to facilitate repair. Additional components were identified that could be repaired pier side which will result in significant cost savings also. A new high pressure cold spray system will be designed that can be transported throughout ships' spaces to enable in-situ repair and save extensive labor hours required to remove and replace ships systems. Supporting technology also has to be developed and integrated with the Cold Spray system such as dust collection, personal protective equipment (PPE), operator feedback, in process quality assurance and motion control. This project leverages other ongoing cold spray efforts and will include applications for the NAVSEA Command and the U.S. Marines.

The objectives of this effort are to develop and deliver a high-pressure hatchable cold spray system, commensurate support equipment and operation procedures, to include on-board ship, and develop and validate shipboard repairs of specifically selected components.

Payoff

Benefits that will result from this project are: (1) development of a man portable high pressure cold spray system and supporting technology that can be used to perform shipboard, pier side and field repairs; (2) approved repair processes for submarine and aircraft carrier components; (3) repairs that return components to service that previously had to be scrapped; (4) repair costs of less than 20 percent of the cost of a new component; (5) reduced repair times (lead times taking as long as 24 months will now take one day to four weeks - depending on the component); and (6) an improved process to identify additional candidate components for repair by the shipyard or depot personnel. The estimated cost voidance for the first five years of implementation is $8M for a ROI of 13:1.

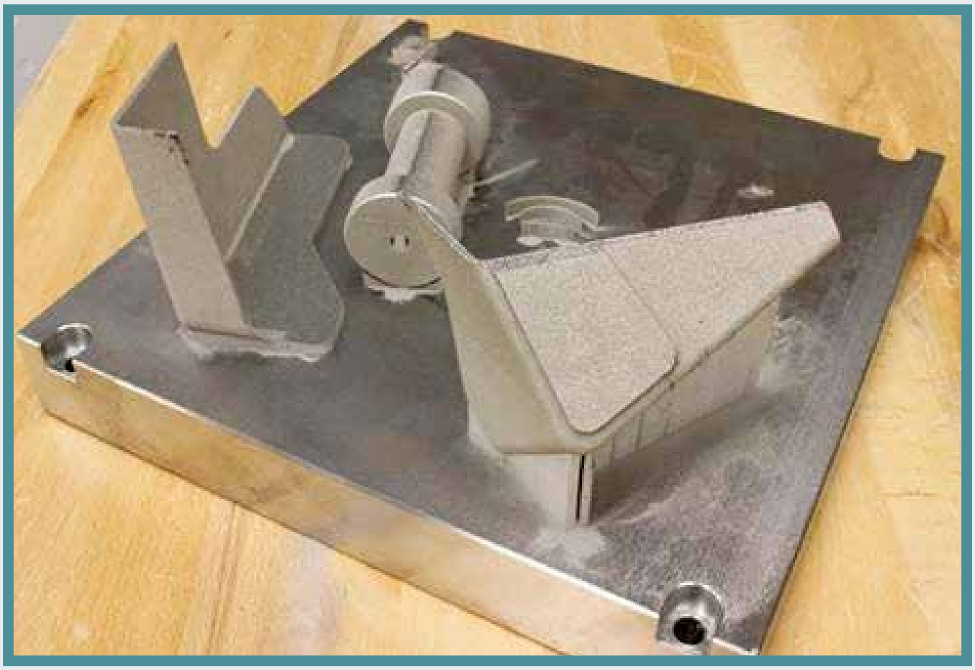
Implementation

The hatchable cold spray systems will be implemented first at IMF Bangor and Puget Sound Naval Shipyard in late 2018. Approved repairs are expected to be implemented early 2018. The repair process will be governed by Uniform Industrial Process Instruction (UIPI). Information specific to the hatchable repairs will be developed as required by the UIPI. Other implementation sites include Navy shipyards, (IMFs) and the Marine Depot at Albany, GA. The system will also be made available to NAVAIR facilities.

PI: Timothy Eden, Ph.D.

ARL released photo

T2716 — Development of Additive Manufacturing Processes for Corrosion Resistant Alloys



ARL released photo

Affordability Focus Area: Metals Processing & Fabrication
Stakeholder: NAVSEA, Other Ships
Platform(s): Other Sea Platforms

Additive manufacturing R&D in support of the Navy's fight against corrosion.
The Navy utilizes several corrosion-resistant alloys, such as Monel® K-400 and K-500 and Corrosion-Resistant Steels (CRES) in a range of turbomachinery and structural applications. Common product forms, such as bar, plate, or rod, provide limited geometries and frequently require significant levels of post-processing to produce the desired component geometries. These limited geometries and post-processing requirements result in long lead times and limited availability for critical components. However, additive manufacturing (AM) offers significant promise for the on- demand fabrication of parts of varying sizes and complexities. In AM technologies, components are built up in a layer-by-layer manner using either powder bed fusion or directed energy deposition processes. No concerted effort to analyze the impact of AM processes on the properties of corrosion-resistant materials of interest to the Navy has occurred. In this project, two categories of materials systems will be investigated. These materials systems include the Ni-Cu-based Monel® alloys and CRES alloys. Each of these systems has unique characteristics that can potentially make the AM processing of these alloys challenging.

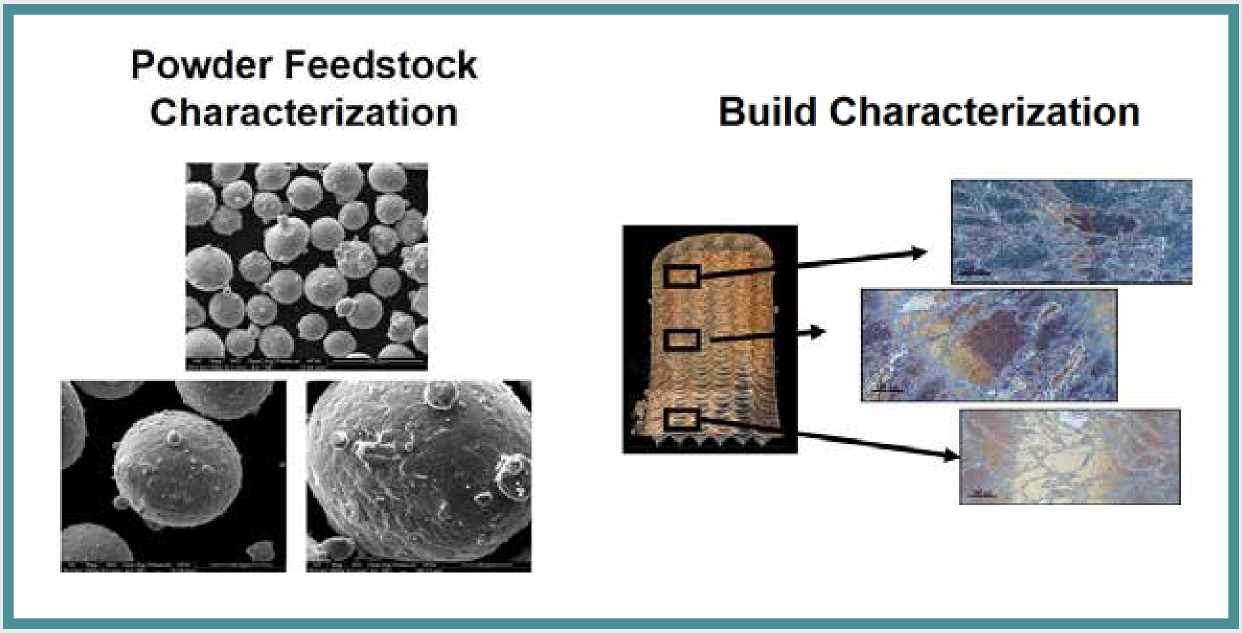
Payoff

The Navy will significantly benefit from the fabrication of corrosion-resistant structural components using directed energy deposition AM processes. For applications common to the Naval Sea Systems Command (NAVSEA), component size and materials of interest fall outside the ranges typical for powder bed fusion processes. On the other hand, directed energy deposition processes can be adapted to a much wider range of material and product sizes, making it an attractive option for larger structural components. When combined with its ability to work with multiple materials, this AM process shows promise for addressing the size and diversity of components common to NAVSEA applications. This project will offer the opportunity to investigate the impact of AM on these classes of materials and to provide a sound scientific foundation for developing a fundamental understanding of the governing process-structure-property relationships. This project will also serve as a test bed for the application of data analytics and data capture for important processing and property conditions.

Implementation

Each of the materials classes noted above have significant applicability to naval systems but also present a range of challenges before they can be successfully processed using AM. Efforts will be directed at understanding the processing challenges and building a knowledge base for how a small range of processing conditions can impact the resulting structure and properties for important naval materials. As part of the process development work, a preliminary process and property database will be developed for these material systems. At the completion of the project, the technology basis for the AM fabrication of a range of different components using these materials systems will be developed and applicable to the near-term qualification and insertion of AM components into service. The iMAST team hopes to transition this knowledge to specific parts applications on ships within the FY19-FY20 time frame.

PI: Jayme Keist, Ph.D.



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Repair Technology

Timothy Bair
Technology Leader

Sustainment has never been as critical to the Navy-Marine Corps team as it is today. The fiscal realities facing the naval services have significantly increased the need to find or create cost-cutting measures that can reduce life cycle cost as well as enhance operational availability. The ONR ManTech, Repair Technology (RepTech) program, managed by iMAST, carries as its prime mission the drive to cut sustainment cost through advanced technology as well as mature technology applied in innovative ways. RepTech has the potential to create significant dollar savings (or cost avoidance), while concurrently enhancing operational readiness—especially at this critical juncture in time. This mission is especially critical as it directly impacts the support our Sailors and Marines need and deserve. iMAST is grateful to be entrusted with this vital program.

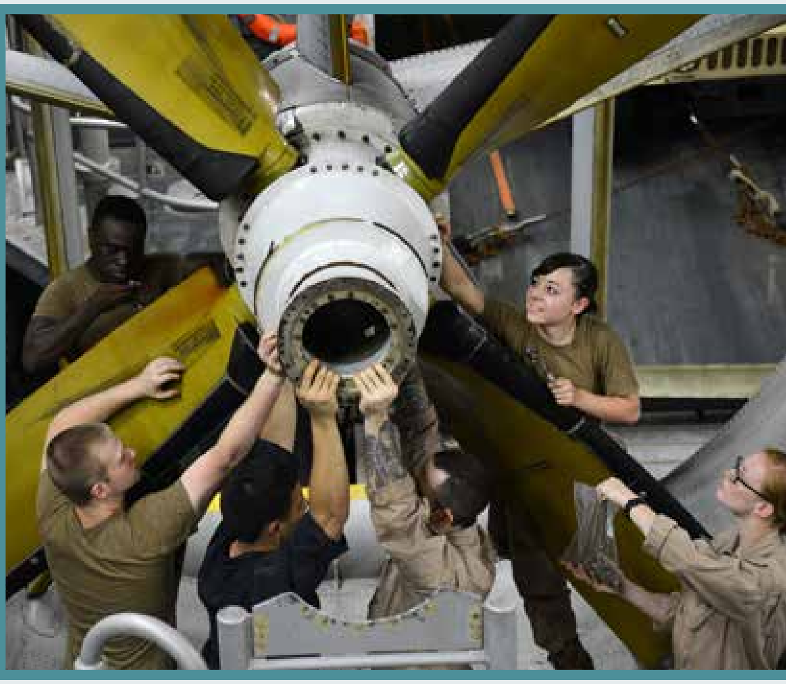
Mission

Designated by the Navy as the resident coordinating center for the repair technology effort, RepTech's charter includes:

- Apply emerging technologies to improve the capabilities of the repair community.
- Improve repair processes and the affordability of repair facilities.
- Execute S&T projects which directly affect depot-level maintenance.
- Execute projects under the direction of the RepTech Working Group.
- Communicate innovation to implementation agents across DoD by all means available.
- Reduce duplication of effort in RepTech-related R&D.
- Leverage program funding with funds from other programs and agencies.

Management Structure

Oversight for the RepTech program is facilitated by the RepTech Working Group (RWG), which is chaired by ONR (Mr. Eric Oller) and consists of one technology integration management representative from NAVSEA, NAVAIR and MARCOR. The RWG meets semi-annually at ARL-Penn State in the fall and at a shipyard or depot in late winter to review all current projects as well as discuss new potential efforts. The RWG was created to develop a coordinated approach to executing and identifying the RepTech needs across the Navy sustainment enterprise; surface, subsurface, air and ground combat forces.



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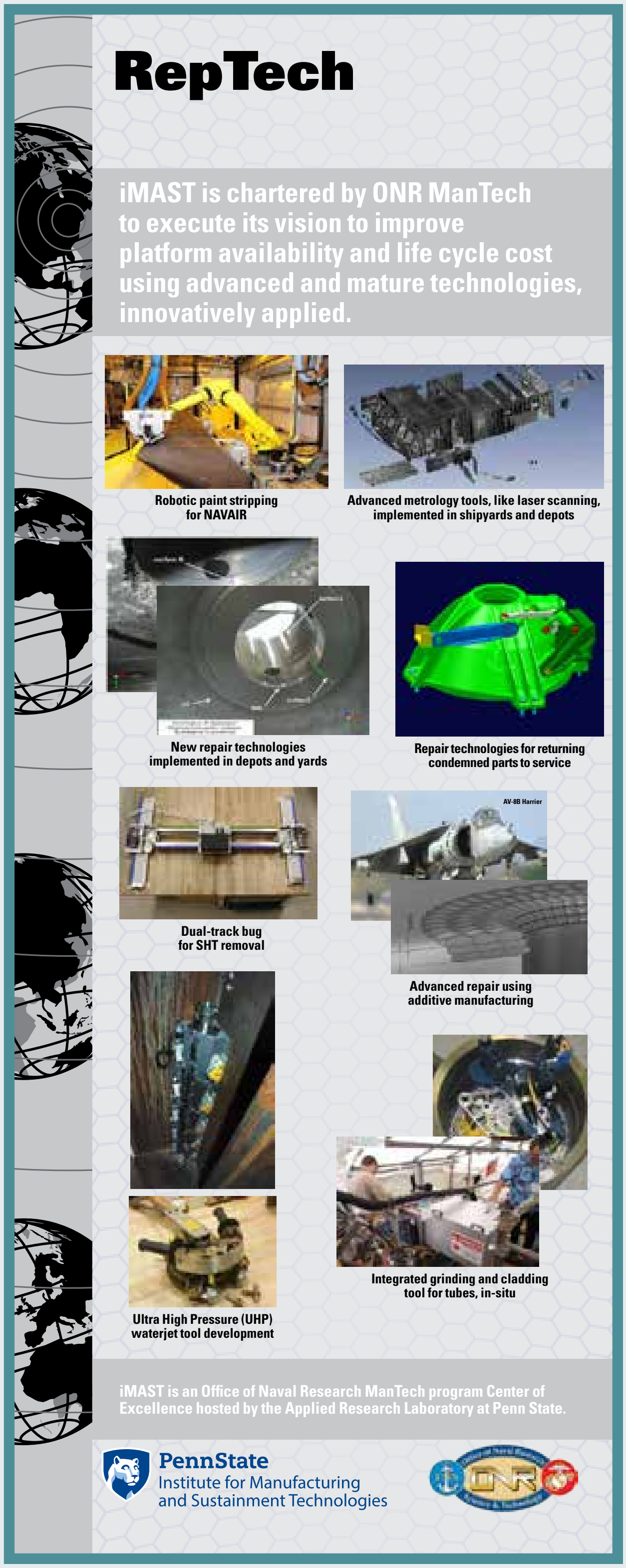
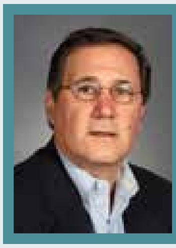
iMAST-funded projects are performed in cooperation with and directly support these DoD activities:





Laser Processing Technologies

Richard Martukanitz, Ph.D.
Technology Leader

Mission

The primary mission of ARL's Laser Processing Division is to develop and implement advanced laser processing technology for improving affordability through reduced acquisition and life-cycle costs, maintaining readiness and increasing performance of Navy and Marine Corps platforms. The secondary goal of the division is to ensure that advanced laser processing technology is available to meet the growing demand for efficiency and innovation while maintaining a national repository of laser technology for use by the U.S. industrial base in its efforts to preserve international competitiveness.

Facilities and Unique Capabilities:

Commercial Lasers

The wide range of laser processing capabilities includes complete laboratories for microprocessing (Q-switched Nd:YAG lasers operating at the fundamental frequency, second harmonic, third harmonic, and fourth harmonic, Nd:VO4 laser operating at the third harmonic, and an excimer laser capable of operation in any one of four ultraviolet wavelengths) and macroprocessing (12 kW ytterbium fiber laser with two fiber deliveries, 5 kW diode-pumped Nd:YAG laser with three fiber deliveries, and a fast axial flow CO2 laser, all operating in the far infrared regime). This resource includes:

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- Extensive array of direct digital manufacturing systems for repair or remanufacturing.
- Range of beam manipulation, data acquisition, and sensing capabilities.
- Extensive materials preparation and characterization capabilities.
- Laser processing educational programs.
- Eight full-time multi-disciplinary engineers (including 5 Ph.D. and 3 M.S. in materials science and mechanical engineering), 2 full-time laboratory technologists, and 1 administrative support staff.

Macro Processing

- 12.0 kW ytterbium fiber laser (1070 nm)
- 5.0 kW CO2 with enhanced pulsing (10,600 nm)
- 5.0 kW Nd:YAG CW (1064 nm)
- 3.0 kW Nd:YAG CW (1064 nm)

Micro Processing

- 500 W single mode ytterbium fiber laser (1070 nm)
- 400 W (avg.) pulsed Nd:YAG (1064 nm)
- 1 J/Pulse Q-Switched Nd:YAG (1064 nm)
- Nd:VO4 at 3rd Harmonic (355 nm)
- Nd:YAG at 2nd, 3rd, and 4th Harmonic (532, 355, and 266 nm)
- 0.5 J/Pulse Excimer (193-351 nm)

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Work Cells

- Two 6-Axis Robotic Systems (ABB and Kuka)
- Large 5-Axis gantry system (3.4 m by 3.4 m)
- 5-Axis motion system (3 linear and 2 rotational)
- Various micro processing systems
- Optomec Corporation laser additive manufacturing cell

Technology Transfer Facility

- Support equipment (e.g., robotic, linear and rotary workstations, etc.)
- 4 kW Ytterbium fiber laser at Pearl Harbor Naval Shipyard with portable processing capabilities
- 2.4 kW cw Nd:YAG and robotic manipulator at Norfolk Naval Shipyard's Foundry and Propeller Center (Philadelphia, Pa.)
- 3.0 kW cw Nd:YAG laser at Naval Underwater Warfare Center, Keyport, Washington.
- 25 kW cw CO2 laser at ATS Corporation, Samford, Maine, with 7.3 m gantry

UNIQUE CAPABILITY

Applied Laser Laboratory

ARL's Laser Processing Division encompasses one of the largest collections of commercial lasers for applied laser research in the United States. A fully staffed facility with an impressive array of capabilities, both in terms of equipment and expertise, provides support to the Department of Defense and the U.S. Navy.

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UNIQUE CAPABILITY

Additive Manufacturing (AM)

The Laser Processing Division has developed a leadership role in establishing a University-wide initiative in additive manufacturing under the Center for Innovative Materials Processing through Direct Digital Deposition (CIMP-3D) with the goal of establishing a world-class resource for Direct Digital Manufacturing (DDM) for critical applications. With a broad mission to advance and deploy DDM technology of metallic and advanced material systems to industry, CIMP-3D seeks to:

– advance enabling technologies required to successfully implement DDM technology for critical components and structures

– provide technical assistance to industry through selection, demonstration, and validation of DDM technology as an “honest broker”, and promote the potential of DDM technology through training, education and dissemination of information


CIMP-3D Facility

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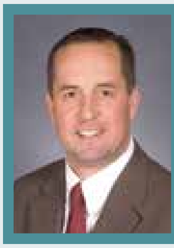


Manufacturing Systems Technologies

Mark Traband, Ph.D.
Technology Leader

Mission

To be a leader in the development, application and transition of advanced design, manufacturing, and repair systems and tools. To apply advanced information systems technology to product and process design, enabling engineers to explore a wider set of design options, resulting in more robust system designs, with shortened development lead times, and reduced lifecycle costs.

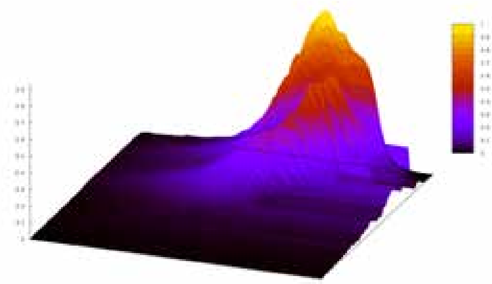
Facilities and Unique Capabilities:

Environmental Technology Laboratory

Conducts sampling and testing of air emissions from new and modified manufacturing processes for a wide range of airborne environmental contaminants including volatile organic compounds, toxic industrial chemicals, particulates, emission factors and opacity, and evaluates new sensors and analyzers for these measurements.

UNIQUE CAPABILITY

Enhanced Inspection Tools for Hydrocarbons



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Enhanced inspection toolscan detect contamination on steel surfaces that can adversely affect coating performance. The current methods of visual inspection used to ensure SSPC – SP1 “oil-free” surfaces are little more than a crude go/no-go gauge, even with the use of black-light illumination. Current detection methods for oil & grease are inadequate to prevent hydrocarbon-contamination-related coating failures. For the first time, ARL has developed tools that provide a means to ensure compliance with SSPC-SP1 “oil-free” inspection requirements. The tools work by enhancing the extent of the fluorescent response of common hydrocarbon contaminants while simultaneously improving the ability of inspectors to see the fluorescent response. The lights used do not contain mercury and are safe for onboard use. The enhanced detection goggles meet the requirements for PPE and improve upon the safety of conventional eyewear used during UV-inspection.

Polymer Coatings Laboratory

addresses application, removal, inspection, formulation and testing of organic coatings. The lab also supports the development of surface preparation and cleaning processes and the development and testing of new tooling. particulates, emission factors and opacity, and evaluates new sensors and analyzers for these measurements.

UNIQUE CAPABILITY

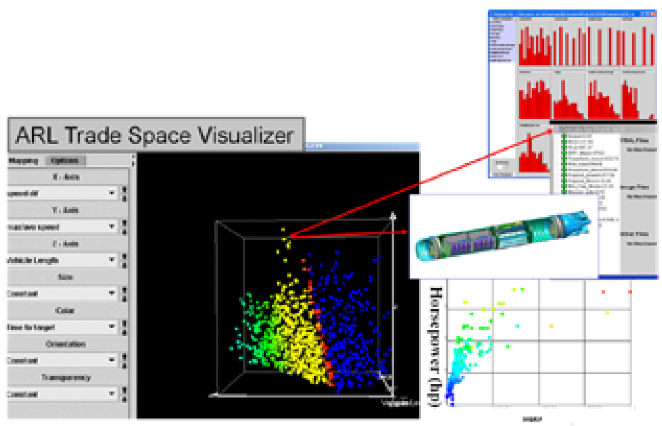
High-Pressure (HP) and Ultra-High Pressure (UHP) Equipment and Processes

U.S. Navy released photo

This equipment provides dramatic productivity improvement in shipyards. ARL has become a leader in the design, development and implementation of safe, innovative, High-Pressure (HP) and Ultra-High Pressure (UHP) waterjet tools and processes to solve some of the Navy's most challenging preservation problems. Mechanical methods of surface preparation such as abrasive blast cleaning are ineffective at removing oil and grease contamination. UHP water jet blasting is effective at removing oil, grease, soluble salts and other contaminants from steel surfaces. ARL has developed and implemented HP and UHP tools and processes for surface preparation for applications and in areas not previously believed possible. Examples include: oil, grease and salt removal within the confined spaces of Normal Fuel Oil (NFO) and Sanitary (SAN) tanks on submarines, and nonskid removal from sensitive substrates.

Distributed Engineering Center (DEC)

A collaborative U.S. Navy facility that supports a Navy surface ship defense engineering program effort. Since 2002, this facility has facilitated cost-effective information exchanges across government, university and industry teams developing specific projects. This facility extends similar support to other Navy programs requiring collaborative engineering services.



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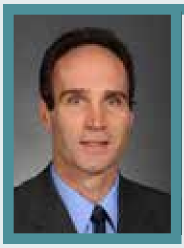
UNIQUE CAPABILITY

Rapid Design Space Exploration

For both product and process design, if performed early in the lifecycle of a product, can result in tremendous downstream benefits in both performance increases and cost reduction. By increasing the number of options considered, a more robust design and associated manufacturing process can result. ARL combines trade space exploration, multidisciplinary design optimization, advanced visualization tools, and process simulation to achieve the robust product and process designs. Key to this process is presenting large amounts of information in an easy to understand way. The ARL Trade Space Visualizer (ATSV) is a multi-dimensional visualization tool that is used to explore the relationships captured in the design data. It has the ability to explore multi-dimensional data, dynamically apply constraints and preferences, determine sensitivities for a selected design, and visualize design uncertainty.



Composites Technologies

Kevin Koudela, Ph.D.
Technology Leader

Mission

Conducts basic and applied research in composite materials and structures for DoD and commercial applications with emphasis on performance, reliability, affordability and technology transfer. Research and development efforts focus on critical composite design, quality assurance and manufacturing technology gaps that preclude composite material implementation. After successful demonstration, these next generation technologies are implemented according to critical warfighter needs. The Composites Division's core competencies are identified below.

Facilities and Unique Capabilities:

Fabrication

Fabrication facilities include; a 3' diameter x 7' Baron autoclave with computer control to 250 psi maximum pressure and 825°F maximum temperature processing limits; meter/mix equipment with 2 component/solvent flush, heated pots/delivery lines, vacuum degassing and static mixer used for RTM and VARTM processing; a McClean Anderson filament winder with Compositrak control, 4 programmable axes suitable for both prepreg tow and wet winding; a 6' x 6' x 10' curing oven (500°F); a hydraulic mandrel extractor and a 150 ton press. In addition ARL-Penn State maintains a machine shop with 38 stations that include six 5-axis, three 4-axis and four 3-axis CNC machining stations. ARL also has access to 0°F walk-in freezers and standalone chest freezers.

ARL released photo

UNIQUE CAPABILITY

Critical Element Design, and Analysis and Testing

CMD has a proven track record and unique capability in the design, analysis, fabrication and test of critical elements to facilitate rapid implementation of advanced material structures for DoD applications. The full-spectrum of finite element and boundary element tools provides the capability to conduct both global and detailed structural analysis. This allows design of subscale or ‘Critical Element’ test articles that are used to duplicate salient in-service structural demands. Candidate manufacturing technologies are then used to fabricate these test articles that are instrumented and tested to capture data that can be used to verify and/or refine developed numerical models. While such individual capabilities exist in other organizations, the division has streamlined the Critical Element approach to rapid development of advanced material solutions to a unique extent. A true concurrent engineering protocol has allowed execution of ‘paper to prototype’ development and implementation of mission critical hardware in timescales on the order of 6 months to a year. Without uniquely integrated development and test capability of this type, such rapid turnarounds would not be possible.

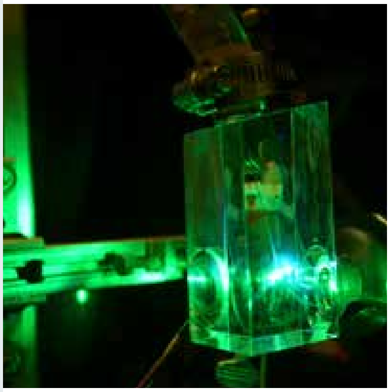
Material Property Characterization

CMD possesses extensive test and evaluation facilities including a full microscopy laboratory and several test frames. Among these are two 33 Kip electro-mechanical test frames with a temperature controlled test chamber, five 5 Kip high speed test machines with 10 Hz maximum cyclic rate, one 220 Kip (4 post), one 110 Kip (4 Post) and three 22 Kip servo hydraulic test frames, and a drop-weight impact tester. An 8-channel acoustic emission system supports both sub-element and full-scale structural testing. Fiber volume fraction determination is routinely performed using acid digestion techniques. A high fidelity sand bath is resident for high temperature component heating tests.

Design and Analysis

CMD possesses state of the art design and analysis capabilities. Structural design and optimization is normally completed using commercial as well as internally developed finite element, boundary element, micromechanical, and three-dimensional lamination analysis programs. Tool and component design is typically conducted using a broad suite of CAE and CAM tools including ANSYS, ABAQUS, Nastran, LS-DYNA, PAM Crash, Unigraphics, IDEAS and ProE.

Composites



ARL released photo

UNIQUE CAPABILITY

Nondestructive Inspection

CMD and Manufacturing Systems Division are jointly developing cutting edge capabilities in non-destructive evaluation of structural polymer materials through fluorescence response techniques. The divisions have assembled unique test hardware to monitor high resolution spectral response changes applicable to thermal degradation and curing of polymer matrix composites. In collaboration with the NAVAIR Patuxent River, the divisions have led the unique application of direct fluorescence excitation of polymer matrix materials and high sensitivity spectrometers. Using well defined collection optics, the determination of spectral responses are independent of the matrix surface area fraction and are correlated to the measured structural response through chemometric analysis. All hardware components were selected for integration into field portable units and transition is currently underway. This non-contact inspection approach offers the capability to track and correlate thermal degradation of numerous composite matrix materials to structural degradation and provide monitoring of polymer matrix material cure regardless of environmental conditions to ensure required structural integrity.

A large scale vibration isolated 6' x 6' x 5' Coordinate Measurement Machine (CMM) is used to verify component tolerances down to 0.0005". Additionally, ARL Penn State possesses unique fiber volume fraction mapping software that allows fiber volume distributions to be determined from tag-end or sample sections. High sensitivity part quality measurements have been successful using broad band ultrasonic scanning. Ultrasonic waveform conditioning and signal analysis has provided sensitive technology that has the capability to determine both large scale (delamination or adhesive failure) and small scale (voids and porosity) defect distributions in complex structures. Additional capabilities are available to apply thermography, shearography, laser measurement and other techniques as appropriate to particular component scales and complexities.

ARL released photo

UNIQUE CAPABILITY

Split Hopkinson Pressure Bar (SHPB) Test Facility

CMD has a custom designed SHPB facility that provides the unique capability to determine high rate material responses for low stiffness elastomers, engineering polymers, advanced composites, as well as high performance metallic systems and ceramics. CMD is in the process of using this capability to develop a database to facilitate the parameterization of new multi-scale material models used to evaluate candidate material systems capable of mitigating Traumatic Brain Injury (TBI) in personnel subjected to blast events.

UNIQUE CAPABILITY

High-Rate Fatigue Test and Evaluation

A new high-rate composite fatigue test method has been developed which reduces 1E8 cycle test times from nearly a year to less than 1 month. A corresponding model method has been developed to predict component fatigue performance for defined transient operating spectrums. Tests to date have been successfully completed up to 1E7 cycles with total test time reduced by an order of magnitude versus conventional testing. The new model method uses the high rate test data in conjunction with ply-by-ply failure criteria combined with a rainfall method which provides fatigue life thresholds using a finite element analysis (FEA) model subjected to an unsteady transient load profile.

Long duration (1E7-1E8) fatigue test data are critical for quantifying material degradation and component performance for composite material systems.

To predict fatigue failure thresholds of composite components, a new fatigue prediction method has been developed. The combined testing and model method development technologies provide a new method for obtaining reliable composite material fatigue test data in a timely fashion and applying those test results to predictions of operational thresholds of full scale composite components. The test and model method development efforts are complete, and are recommended for follow-on validation testing and implementation.

In-air Testing

In-water Testing

ARL released photos

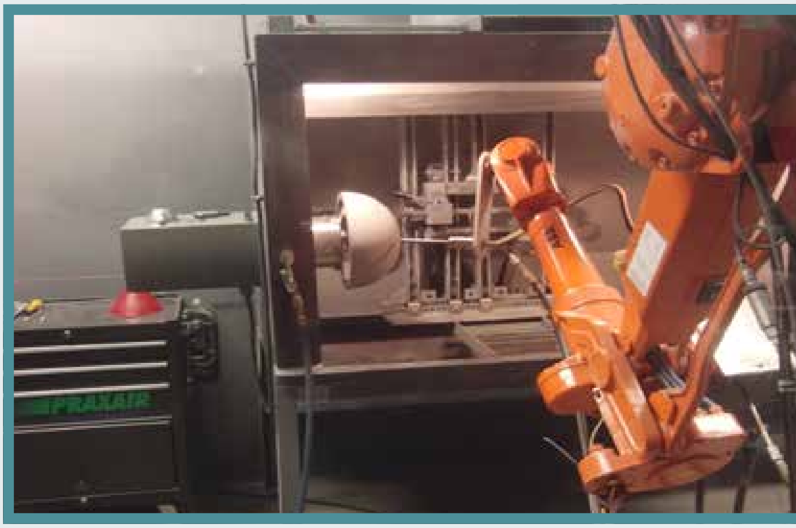
Materials Processing Technologies

Tim Eden, Ph.D.
Technology Leader

Mission

To perform basic and applied research in a broad range of materials and material processing in support of the DoD and the U.S. industrial base. The Materials Processing Division develops and transitions innovative materials and material process technologies to solve critical technical challenges, address manufacturing and sustainment challenges, improve component and system performance and reduce procurement and life cycle costs. The division provides leadership in the fields of coatings, material testing and characterization, electronic materials, devices and sensors, and metal and ceramic processing. The materials processing thrust is organized into four departments:

- Metals and Ceramic Processing
- Advanced Coatings
- Electronic Materials and Devices
- Mechanical Drivetrain Transmission Technologies



ARL released photo

The unique combination of experienced faculty and staff and extensive materials processing and characterization facilities allow the division to quickly develop, validate and implement complete solutions to a wide range of technical challenges. The division has transitioned a number technologies and specific solutions to the DoD and industry. Specific areas of expertise include Cold Spray and Vapor Deposition technologies for corrosion resistance, wear resistance, thermal barriers, environmental barriers, electronic materials, electronic devices, antimicrobial and medical implants. Multifunctional nanograined materials and functional tailored coatings and laminated structures have been developed for improved erosion resistance, armor and cutting tools. Alloy development and processing include ultrahigh temperature and ultrahigh strength aluminum alloys for armor and engine applications, fragmenting steels, thermomechanical processing, failure analysis and modeling, as well as development and production of bulk and thin film crystals. Design and fabrication of electronic devices and sensors. Material characterization capabilities include corrosion, wear, erosion, mechanical properties, chemical and phase composition, surface properties, hot corrosion/high temperature oxidation, failure analysis, electrical characterization and microstructural analysis.

Facilities and Unique Capabilities:

MATERIAL CONSOLIDATION

Cold Spray
- High pressure and portable cold spray systems
- Additive-Subtractive High pressure cold spray system (1000 psi, 900°C) coupled with a multiaxis machining station
- Cold Spray Characterization Lab – adhesion, corrosion, porosity, composition, hardness, wear

Vacuum Hot Pressing
- 100 ton press with 5 inch diameter ram
- Maximum temperature 1900°C
- Vacuum level 10-4 Torr or controlled atmosphere up to 2 psi

Hot Isostatic Press (HIP)
- Maximum pressure 30,000 psi (207 mPa), Maximum temperature 2200°C (3992°F)
- Vessel interior diameter 10 inch

High Pressure Laboratory
- Cold Isostatic Pressing (CIP)
- 60 inch diameter x 165 inch - Max pressure 16,000 psi
- 18 inch diameter x 168 inch - Max pressure 20,000 psi
- 24 inch diameter x 60 inch - Max pressure 2,000 psi
- Simulation of deep sea pressure and temperature environments

Nanophase Material Facilities
- Vacuum and controlled atmosphere hot press
- Nanoparticle handling capabilities

Powder Processing and Handling
- Ball milling
- Cryogenic milling

ADVANCED COATINGS

Industrial Prototype Electron Beam Physical Vapor Deposition (EB-PVD)
- Industrial scale unit, six 45kW guns
- Capable of continuously feeding 3 ingots individually or simultaneously for the synthesis of complex compounds through co-evaporation processes
- Chamber is approximately 90cm in length, 90cm in width, and 90cm in height for accommodating large components
- Evaporation rates range from 0.5nm to 100μm per minute depending on the material

Lab Scale Electron Beam Physical Vapor Deposition (EB-PVD)
- One EB gun (8 kW), 4 – 25cc hearths allows up to 4 different materials to be deposited
- Cold cathode ionization source with chamber size of 66cm x 60cm x 100cm
- Multilayered coatings, direct evaporation, reactive evaporation and IBAD processes

Sputter Deposition
- Two 6" OrbiTorr sources (Sloan) for DC Magnetron or R.F. sputtering
- One 6" TriMag source (L.M. Simard)
- R.F. sputter cleaning of substrates
- DC biasing of substrates
- Six 7.5" diameter sample mounts with planetary rotation and variable source to substrate
- Substrate heating to 200°C

Ion Beam Assisted Deposition
- Penn State also has the capability of ion beam sputter deposition, ion cleaning, and microstructural enhancement with either 8cm gridded (Kaufman) or gridless (end hall) ion sources
- Both ion sources can be used to pre-clean samples prior to deposition to facilitate coating adhesion
- When used during deposition, microstructure, crystallographic orientation, residual stress, and properties can be tailored

Cathodic Arc Deposition

- The unit contains a minimum of three 2.5" arc sources
- The chamber size is approximately 20" x 20" x 20"
- Coating zone of 10" in diameter by 10" tall
- Radiant heaters and alternate surface conditioning capabilities (plasma cleaning)
- Infrared temperature sensing capabilities and gas flow metering (nitrogen, argon, acetylene, and hydrogen) for depositing metallic, nitride, boride, and carbide materials in monolithic, multilayer or functional graded structures

Surface Technologies

- Pin on disc and reciprocating wear tests
- Erosive wear testers
- Seal test rigs
- Controlled-environment test rigs
- High pressure hydro-static equipment

High Temperature Cyclic Oxidation and Humidity Testing

- Four high temperature furnaces capable of thermal cyclic testing up to 1300°C in atmosphere and two controlled environments such as saturated water vapor (humidity-controlled)
- Additional furnace available for conversion to corrosion testing depending on the test set-up

Dean Rig Hot Corrosion Testing Facility

- Provides comparable hot corrosion results to burner rig testing at a fraction of the cost and time
- Testing/evaluation of materials under Type I (900°C) hot corrosion environments
- Testing/evaluation of materials under Type II (700°C) hot corrosion environments
- Type of salt corrosion easily changed as well as sulfur-oxygen ratio for aggressive testing

Corrosion Testing

- Cyclic Corrosion Chamber
- Equipment: Singleton CCT-10
- Accelerated testing (weeks, months) in a simulated aggressive corrosive environment
- ASTM B117 Salt Fog, ASTM G44 Alternate Immersion GM 9540P, SAE J2334, others
- Stress corrosion cracking
- Electrochemical (DC & AC)
- Gamry PC4 Potentiostat, EG&G 273A Potentiostat (for high current applications)
- Electrochemical polarization, corrosion rate, galvanic corrosion, pitting resistance, and Electrochemical

Impedance Spectroscopy (EIS)

- ASTM G71 –Galvanic, ASTM G34 – Exfoliation, ASTM G78 – Crevice
- High impedance voltmeter (Z=1013 Ω)
- Conductivity/pH meter
- Crevice corrosion test cells
- Micro probe reference electrodes (50 micron)

Bulk and Thin Film Deposition and Characterization Lithography

- Electron Beam
- Vistec EBPG5200 electron beam lithography
- Photo
- GCA 8000 i-line Stepper
- GCA 8500 i-line Stepper
- Karl Suss MA/BA6 contact aligner

Etch

- High Density Reactive Ion
- Tegal 6540 HRe-CCP
- Plasma-Therm Versalock 700 ICP
- Magnetically Enhanced Reactive Ion Etch
- Applied Material Cluster MERIE
- Plasma Etch
- Metroline M4L Plasma Etcher (Litho descum, suface modification)
- Reactive Ion
- Plasma-Therm 720 RIE

Characterization
- Electrical
- Four Point Probe sheet resistance
- Micromanipulator 6000 Probe State and C-V/I-V test equipment

Microscopy
- Leitz Optical Microscopes
- Leo 1530 Field Emission Scanning Electron Microscope
- Nikon L200ND Optical Microscope
- Sputter Coater of gold & platinum for SEM/FESEM imaging
- FEI NanoSEM 630

Deposition
- Chemical Vapor
- Cambridge Savannah ALD

Evaporation
- Kurl Lesker e-gun & thermal evaporator
- Kurt Lesker Lab-18 E-gun & thermal evaporator
- Semicore e-gun & thermal evaporator

Process
- KLA-Tencor Alphastep 500 profilometer

Rapid Thermal Processing
- Alwin 21 AG610 Rapid Thermal Processing

Electronic Materials and Devices
- Material Synthesis Processes
- Chemical Vapor Deposition (CVD)
- Bridgman, Czochralski, SSR
- MPCVD
- Sublimation Synthesis, PVT
- Textured Electro-ceramic Processing
- Materials
- Silicon Carbide Bulk/Epitaxy
- Graphene, MoS2, 2D Materials
- GaN, AlGaN
- Bulk Oxides
- Diamond
- Thin Film Nitrides/Oxides
- Crystal Growth
- Nanofabrication Lab
- Materials Characterization
- Electrical (IV, CV, Resistivity)
- Structural/Microstructure (XRD, TEM)
- Surface characterization (AFM, Zygo)
- Device & Sensor Fabrication
- Piezoelectric Transducer Elements
- RF Transistors, Phototransistors
- SiC, GaN Diodes, PCS Switches
- Interdigitated Capacitors
- Radiation Detectors –IR, Neutron, Gamma


ARL released photos

Mechanical Drivetrain Transmission Technologies

Mission

To assist in the enhancement, revitalization, and resurgence of the transmission industrial-base sector of the United States. It is essential that the drive system industrial base remain viable, competitive, and robust in order to effectively address U.S. Navy, Marine Corps, and DoD modernization and surge requirements.

This industrial sector is also critical to the national transportation infrastructure; therefore, it must remain responsive and competitive in order to address national interests. To achieve these stated objectives, with guidance from the Office of Naval Research, we continue to build our reputation as a national resource. The broad technological objectives driving our research and development agenda are driven by the following DoD-stated goals:

- Reduce transmission weight by at least 25 percent.
- Reduce vibration and noise by at least 10 dB.
- Increase Mean-Time-Between-Removals (MTBR) by 20 percent.
- Reduce procurement and operating costs (affordability).


USMC released photo

The influx of industrial dual-use sponsored research has been a prominent feature of the Drivetrain Technology Center. These mechanical- and material-related projects are an indirect result of prior Navy-sponsored S&T investments. Coupled with a robust gear metrology facility, the Drivetrain Technology Center provides a direct resource for the Navy relative to gear, transmission, material and metrology-related challenges impacting Navy and Marine Corps mechanical drive systems

The Drivetrain Technology Center (DTC) began looking into an effort to optimize and implement an advanced grinding process for machining forged nickel alloys. This would replace current fabrication methods, likely reducing manufacturing time and cost, while increasing parts quality.

The DTC continued its efforts to transition the ausform gear finishing technology for dual-use high-volume ground vehicle application. Ausform gear finishing technology, developed through a previous Navy ManTech program effort, shows potential for high-strength powder metal gear application for ground combat vehicles. This and other related projects leveraged by prior Navy ManTech activities demonstrate new gear manufacturing processes have the ability to replace conventional gear finish grinding for service support vehicles.

Leveraging previous unique Navy ManTech-sponsored efforts, core competencies remain online to address an array of gear fatigue performance studies of interest to the Navy, Marine Corps and Army, as well as the aerospace and wind turbine industries.Some of the ongoing and recently completed gear fatigue performance studies at the Drivetrain Center leveraging prior Navy ManTech efforts.

Facilities and Unique Capabilities:

Advanced Manufacturing Facility

- Provides equipment, tooling, processing, and inspection equipment to enhance industrial manufacturing process technology
- Permits affordable gains in component performance
- Reduces life-cycle costs
- Equipment: Ausform gear finishing machine Drivetrain Performance Testing Facility
- Permits comparative evaluation of new technologies to facilitate implementation
- Develops advanced materials technology databases for high-performance mechanical drive components
- Validates predicted gear performance behavior in terms of vibration/noise characteristics
- Equipment:
  - Gear tooth bending fatigue machines (3)
  - Gear tooth impact testing machine
  - Rolling/sliding contact fatigue testing machines (5)
  - Power circulating gear surface fatigue testing machines (2)
  - Power circulating gear bending fatigue testing machines (2)
  - Gear tooth scoring resistance testing machine (3)
  - Testek high speed power circulating gear testing machines (2)

UNIQUE CAPABILITY

Ausform Finishing

ARL possesses one of the few production-capable double die ausform finishing machines in the country. This process entails heating case-hardened steel specimens to a red-hot temperature, followed by quenching it to a working temperature that allows rolling to maximize strength and geometry.

ARL released photo

Prognostics Development and Testing Facility

Provides model-based testing and evaluation methods for in-service prediction of remaining useful life in material elements, components, subsystems, systems, and weapon systems platforms.

- Equipment: Power circulating gear box testing equipment

Dimensional Inspection Facility

- U.S. Navy's Gear Metrology Laboratory
- DoD neutral testing site for verifying measurement accuracies related to gear specifications
- On-call advance notice capability for emergency gear repair analysis

ARL released photo

UNIQUE CAPABILITY

Drive System Component Materials

ARL has one of the most comprehensive and unique collections of gear testing equipment in the United States. Both Rolling Contact Fatigue (RCF) and Single Tooth Fatigue (STF) testing can be conducted at temperatures of up to 400°F. Variable power circulating testing under load can be conducted from as low as 900 rpm to as high as 10,000 rpm at up to 1,400 hp. Testing is an essential requirement to validate process qualification in support of high-performance transmission technology. RCF testers for simulating gear tooth contact, STF testers for evaluating bending fatigue, and PC testers for contact fatigue testing on gears are essential equipment.

Materials Characterization

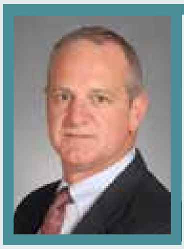
- Micro-hardness testing
- Failure analysis via optical and scanning electron microscopy
- Micro-structural analysis
- In-situ surface roughness characterization via replica fabrication and optical interferometric analysis
- Steel cleanliness evaluation via energy dispersive spectroscopy and element mapping.

UNIQUE CAPABILITY

Navy Metrology Laboratory

ARL's Drivetrain Technology Center is host to resident U.S. Navy provided gear metrology equipment (with supporting artifacts). The center serves as a neutral or "honest broker" testing site for verifying measurement accuracies related to gear specifications. This capability is fundamental and basic for the advancement of mechanical drive transmission manufacturing science and technology. iMAST provides the Navy with an on-call resident resource for addressing gear metrology technical issues related to naval weapon system platforms.

ARL released photo



Systems Operations and Automation

Ed Crow
Technology Leader

Mission

U.S. Navy released photo

The Systems Operations and Automation (SOA) Division develops, demonstrates, inserts and transfers new technologies to monitor and control the health and operation of mechanical, electrical, and electrochemical systems to DoD and other government and industrial customers. Within SOA, the Complex Systems Monitoring department applies a systems engineering approach for analyzing customer challenges. It then identifies applicable technologies and formulates an engineering implementation plan to solve the issue. The SOA division further develops solutions that implement a continuous information thread for complex systems from sensor data through actionable information in a commercial Enterprise Resource Planning system. The division has been historically focused on the science and technology of systems health monitoring. Finding its technology roots in embedded sensing, signal process and data fusion, the division is pioneering much of the technology, techniques and practices for engineers to apply condition based maintenance. In the early years, smart sensor development, coupled with improved processing power provided by digital electronics allowed rapid advancements in the ability to affordably and practical instrument equipment and achieve health and systems status monitoring. Under sponsorship from Navy and Army sources, the Systems and Automation (SOA) Division conducted many demonstrations of system health monitoring aboard ships, aircraft, rotorcraft, fixed facility and ground tactical vehicles. Along with maturing technology, the SOA Division was instrumental in the development and advocacy of standards pertaining to condition based maintenance information. And, as a leading academic institution nationally and internationally, we developed and taught the principals of reliability centered maintenance, condition based maintenance and systems health monitoring and management. More recently we have also assisted in the cost benefits analysis and analyses of alternatives as the various program managers within DoD are building condition based maintenance into their weapon platforms to realize the benefits of lower life cycle costs and increased operational availability.

Facilities

Robotic Technology Laboratory

The Robotic Tech Lab contains remotely controlled air and ground vehicle platform assets. This facilitates the integration of robotic sensors, power storage and management of health care technologies, which provide operational support of specified DoD tactical and logistics operations. The Mechanical Diagnostic Test Bed was specifically designed and built by ARL Penn State to conduct run-to-failure testing on representative mechanical systems including gear train components and pumps. The testing capability provides the ability to generate discrete fault evolution data for the training and testing of advanced diagnostic, predictive and prognostic algorithms that can be applied and validated on full scale platforms such as gas turbine generators and ground combat system transportation assets loaned to ARL Penn State by the Navy, Marine Corps, and Army.

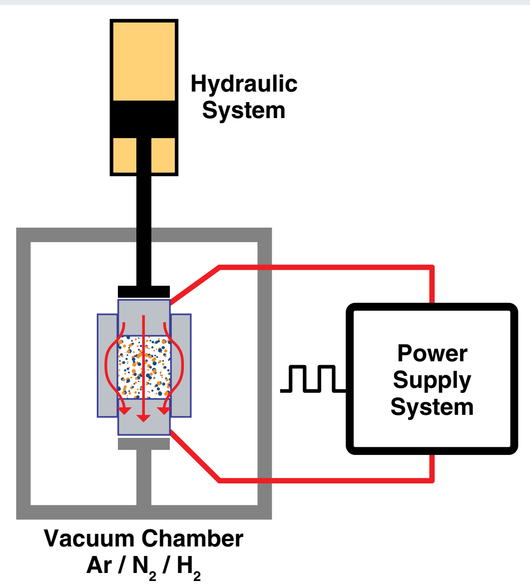
Field Assisted Sintering Technology (FAST) Center of Excellence

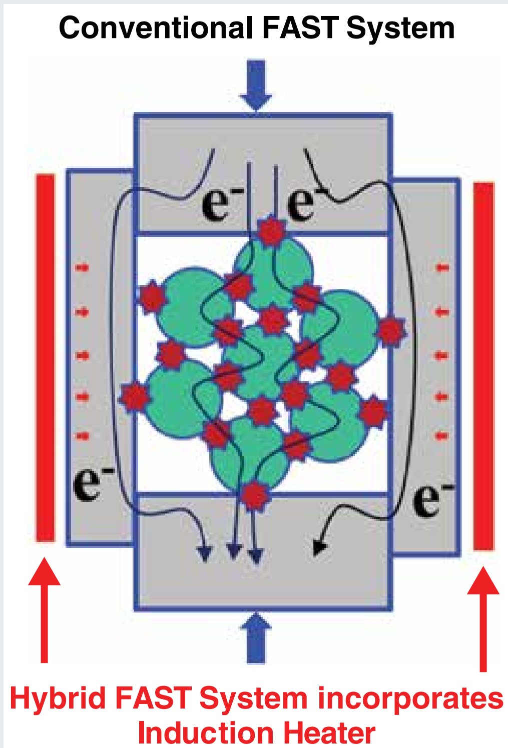
Jogender Singh, Ph.D.
Technology Leader

Field Assisted Sintering Technology (FAST) is an emerging manufacturing technology process having a significant impact on sintering and densification of various ceramic, metallic, and composite materials. Also known as Spark Plasma Sintering (SPS), this process offers higher heating rates and lower sintering times than conventional consolidation processes. It has several advantages including fast process times, reduced grain growth (retention of nanoscale features in nanomaterials), high density, and superior physical properties. FAST can be used to rapidly sinter metals, ceramics, and both metal and ceramic composites. Penn State has three systems that have a maximum operating temperature of 2400°C and can use vacuum, nitrogen, argon or hydrogen (maximum up to 1400°C). The HP D 25 has a 25 ton load capacity and an 80 mm maximum sample diameter and the HP D 250 has a 250 ton load capacity and a 200 mm maximum sample diameter. The hybrid 325 ton unit is the only one at a research facility in the U.S. and capable of manufacturing components up to 350 mm diameter (10.5" x 8.5" rectangle). The system is capable of sintering materials in various environments. It has been used to produce net-shaped components of ceramic, metal, and composite materials for a wide range of applications including ceramic armor, high thermal conductivity materials, blanks for cutting tools, sputtering and x-ray targets, rocket nozzles, heat sinks, and turbine and hypersonic components.

Benefits

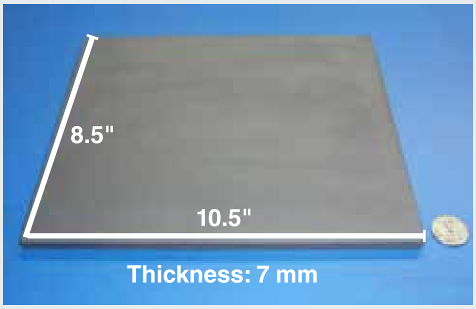
- Manufacture porous materials to high density products (~100%)
- Lower sintering temperature than conventional methods
- Processing cycle time: 60–80 times faster than conventional method
- Retain sub-grained structure
- Compositional graded structures
- Significant energy savings: 20–35%
- Joining of dissimilar materials (metals and ceramics)





Potential Materials

- Polymers: High molecular weight polymer based composites
- Metals: Al, Cu, Ti, Ni, Re, Ta, W, and their alloys
- Ceramics (carbides, nitrides, oxides): SiC, B_4C, Si_3N_4, TaC, HfC, Al_2O_3
- Composites: SiC_f-SiC_m, C_f-SiC_m, SiC_p /Al_m, W_p /Cu_m, C_{flakes} /Al_m



Ceramic plate

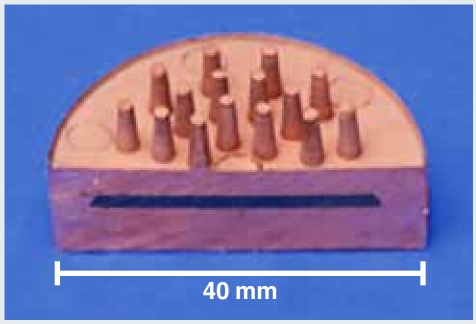
Applications

- Aerospace Industry and Hypersonic Vehicles
- Cutting Tools
- Energy Harvesting and Thermo-electric Materials
- Human Protection
- Medical and Bio-medical
- Nuclear Energy
- Optical Windows and Mirrors
- Sensors-MEMS
- Thermal Management Materials

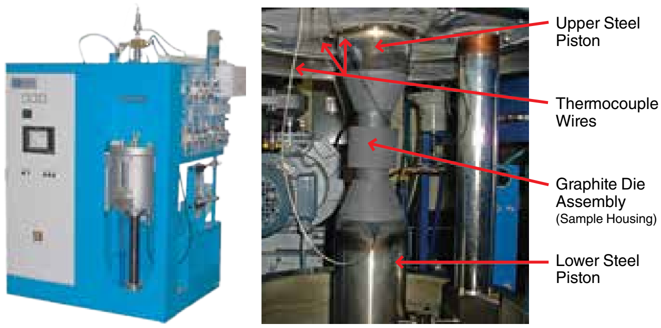
Hollow cone

Machine Capability

- Component size: Up to 14-inch diameter and 10-inch height
- Temperature: Up to 2400˚C



Hybrid heat sink with fins



25 ton

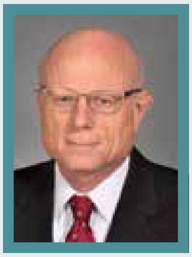
250 ton

Hybrid 325 ton

Applied Research Laboratory

Staff Profiles

PennState
Applied Research Laboratory



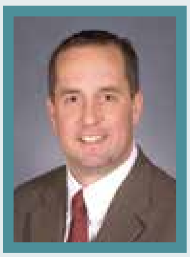
Paul E. Sullivan

Director, Applied Research Laboratory
The Pennsylvania State University

B.S., Mathematics, United States Naval Academy
M.S., Naval Architecture, Massachusetts Institute of Technology
Ocean Engineer, Massachusetts Institute of Technology

The 9th director of Penn State's Applied Research Laboratory, Paul Sullivan is the chief academic administrator of the Laboratory. He is responsible for directing the Laboratory's efforts in concurrence with Penn State's and the U.S. Navy's goal of being a naval technology base. As the largest of 10 interdisciplinary laboratories, centers and institutes under the University's Vice President for Research, ARL performs 150 million dollars' worth of research and development in the areas of undersea weapons guidance and control systems, advanced closed-cycle thermal propulsion for undersea weapons guidance and control systems, advanced closed-cycle thermal propulsion for undersea weapons, propulsor technology, hydrodynamics for undersea vehicles and weapons, and materials manufacturing science for a wide-range of other sea-air-ground combat systems. Prior to assuming directorship of ARL, Paul Sullivan served as Commander, Naval Sea Systems Command, culminating a distinguished 31 year career (1974–2005) as a Vice Admiral with service including both surface and submarine warfare officer experience. Additional career Navy highlights include service as program manager of the Seawolf-class Submarine Program (PMS 350) and the Virginia-class Submarine Program (PMS 450). Upon selection to flag rank, VADM Sullivan served as Deputy Commander for Ship Design Integration and Engineering, Naval Sea Systems Command.

Following retirement from the U.S. Navy, Admiral Sullivan joined USEC Inc, a global energy corporation, where he served as Vice President and Chief Engineer of the American Centrifuge Project, which is the only centrifuge uranium enrichment technology program based in America. Paul Sullivan has also served as Vice President of the American Society of Naval Engineers (ASNE).



Mark T. Traband

Associate Director, Materials and Manufacturing
Applied Research Laboratory, The Pennsylvania State University

B.S., Industrial Engineering and Operations Research, Virginia Polytechnic Institute and State Univ.
M.S., Industrial Engineering, The Pennsylvania State University
Ph.D., Industrial Engineering, The Pennsylvania State University

Dr. Traband is the Associate Director for Materials and Manufacturing at ARL/Penn State. He oversees the applied research and development efforts of 220 faculty and staff engineers and students in Composite Materials, Additive Manufacturing, Electro-Optics and Directed Energy, Manufacturing Systems, Materials Science, Condition-Based Maintenance, Supply Chain, and Logistics. MMO serves the ONR Navy Mantech Program, managing two Mantech Centers of Excellence: the Electro-Optics Center (EOC) and the Institute for Manufacturing and Sustainment Technologies (iMAST).

Dr. Traband is an affiliate professor in the Department of Industrial and Manufacturing Engineering at Penn State with over 28 years of experience in advanced manufacturing system development for DoD enterprises, including government and contractor manufacturing and repair facilities. He was selected as an Office of Naval Research Graduate Fellow and is a certified Project Management Professional.

Timothy D. Bair

Director, Institute for Manufacturing and Sustainment Technologies
Applied Research Laboratory, The Pennsylvania State University

B.S., Biology, The Pennsylvania State University
M.S., Logistics Management, Air Force Institute of Technology
M.S., National Resource Strategy, ICAF

Mr. Bair is the director of ARL's Institute for Manufacturing and Sustainment Technologies. The iMAST mission is to support the U.S. Navy ManTech program as a focal point for the development and transfer of new manufacturing processes and equipment in a cooperative environment with industry, academia, and Navy acquisition and sustainment programs. Before assuming his current assignment, Mr. Bair was working to extend ARL's reach into Autonomic Logistics, condition-based maintenance applications, advanced repair technology, and space-based sustainment programs.

Mr. Bair has more than 26 years of logistics and program management experience as a senior officer in the U.S. Air Force. Mr. Bair's previous logistics experience includes flightline maintenance officer, wing maintenance operations officer, maintenance supervisor, maintenance squadron commander, Air Combat Command F-16 branch chief, operations group deputy commander, and logistics group commander. Prior to his Air Force retirement, Mr. Bair was the deputy director, Directorate of Logistics Management, Ogden Air Logistics Center, Hill Air Force Base, Utah.

Melissa L. Klingenberg

Technical Director, Institute for Manufacturing and Sustainment Technologies
Applied Research Laboratory, The Pennsylvania State University

B.S., Chemistry, University of Pittsburgh at Johnstown
M.S., Manufacturing Systems Engineering, University of Pittsburgh
Ph.D., Materials Engineering, The Pennsylvania State University

Dr. Klingenberg is the iMAST Technical Director and provides technical leadership and management support at the program level. Her primary duties are in direct support of principal investigators in project identification, qualification, execution, and completion. Prior to joining ARL, she was an advisory engineer for the Chief Technology Officer, Concurrent Technologies Corporation where she spent 23 years in engineering research, development, and test and evaluation for the Department of Defense. Her research focused on the improvement of materials and manufacturing systems for the sustainment of weapons systems. She brings expertise in program management, coatings development, laser processing, manufacturing/repair processes for improved environmental compliance and functionality, and alternative energy.

Brenda E. Kephart

Education Program Associate
Applied Research Laboratory, The Pennsylvania State University

A.S., Business Administration, The Pennsylvania State University
B.A., Letters, Arts and Sciences with a minor in Labor Industrial Relations
The Pennsylvania State University

Ms. Kephart is the financial and administrative coordinator for ARL's Institute for Manufacturing and Sustainment Technologies at Penn State. A focal point for the development and transfer of new manufacturing processes within iMAST's Center of Excellence, Ms. Kephart plays an essential role in the program's implementation effort. Prior to joining iMAST, Ms. Kephart served in ARL's Undersea Weapons Office.

Tina S. Ludwig

Business Manager
Applied Research Laboratory, The Pennsylvania State University

A.S., Business Administration, The Pennsylvania State University
B.S., Finance, The Pennsylvania State University

Ms. Ludwig is the Office Business Manager for the Materials and Manufacturing Office (MMO) at ARL, Penn State. Her duties include monitoring, analyzing and reporting the financial status of the five technical divisions and 2 technology centers (which includes iMAST) that fall within ARL Penn State's MMO. She is also the liaison between the MMO and ARL's Business Office.

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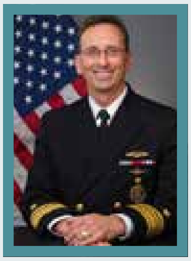


Rear Admiral David J. Hahn USN

Chief of Naval Research

Rear Admiral David J. Hahn recently assumed leadership of the Office of Naval Research, becoming the 26th Chief of Naval Research with concurrent flag responsibilities as Director, Innovation Technology Requirements, and Test & Evaluation (N84). Admiral Hahn succeeds Rear Admiral Mathias W. Winter who has assumed duty as deputy director, Joint Strike Fighter Program, Under Secretary of Defense for Acquisition, Technology and Logistics. The admiral arrives at the Office of Naval Research following duty as special assistant to the Deputy Chief of Naval Operations for Information Warfare.

A 1985 honor graduate of the United States Naval Academy, Admiral Hahn earned his Dolphin pin and served aboard the USS Casimir Pulaski (SSBN 633), USS William H. Bates (SSN 680) and USS Springfield (SSN 761), deploying to the North Atlantic and Western Pacific, conducting multiple strategic deterrent patrols. Ashore, Admiral Hahn served as flag lieutenant to Superintendent, U.S. Naval Academy; squadron engineer, Submarine Development Squadron 12; action officer, Joint Staff in the Command, Control, Communications and Computers(C4) Directorate; and legislative fellow on the staff of U.S. Senator John Warner. Admiral Hahn commanded the USS Pittsburgh (SSN 720) from September 2003 to January 2007. In command, Admiral Hahn deployed to the Caribbean Sea and Pacific Ocean, and conducted an Engineering Overhaul in Portsmouth, New Hampshire.

Since becoming an acquisition professional in 2007, he has served as Joint Test and Evaluation test director and program manager, Advanced Submarine Research and Development. He has also served as major program manager, Submarine Combat and Weapon Control Systems program. In addition to his Bachelor of Science degree in mechanical engineering from the U.S. Naval Academy, Admiral Hahn holds a Master of Business Administration degree from George Mason University and has completed the Massachusetts Institute of Technology Seminar XXI program in International Security Affairs.

Admiral Hahn's personal awards include Defense Superior Service Medal, Legion of Merit, Defense Meritorious Service Medal, the Meritorious Service Medal (three awards), the Navy and Marine Corps Commendation Medal (four awards), the Navy and Marine Corps Achievement Medal and various campaign and sea service awards.

Brigadier General Julian D. Alford USMC

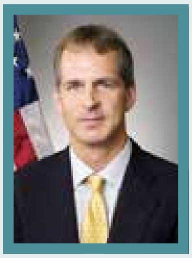
Vice Chief of Naval Research
Commanding General, Marine Corps Warfighting Laboratory

Brigadier General Alford attended West Georgia College and, as a sophomore, enlisted in the Marine Corps Reserves in 1985. Following graduation from college he was commissioned as a Second Lieutenant of Marines in December of 1987.

Brigadier General Alford's commands include rifle Platoon Commander, 3d Battalion, 6th Marine Regiment, 2d Marine Division during Operation Just Cause in the Republic of Panama and 81's Platoon Commander during Operations Desert Shield and Desert Storm; Light Armored Infantry Detachment Commander, 2d Battalion, 4th Marine Regiment, 24th Marine Expeditionary Unit (Special Operations Capable). As a Captain; Series Commander, Company Commander, 3d Recruit Training Battalion, MCRD Parris Island; Company Commander, 3d Battalion, 8th Marines, 2d Marine Division during Operation Assured Response in the U.S. Embassy, Monrovia, Liberia; As a Major; he commanded Recruiting Station, Nashville, Tennessee. As a Lieutenant Colonel; he commanded 3d Battalion 6th Marine Regiment, 2d Marine Division during Operation Enduring Freedom Afghanistan and during Operation Iraqi Freedom. As a Colonel: he commanded The Basic School, Quantico, Virginia.

Brigadier General Alford's staff assignments: As a Captain; Operations Officer, 3d Recruit Training Battalion, MCRD Parris Island. As a Major; Operations Officer, 3d Battalion, 8th Marine Regiment, 2d Marine Division; Executive Officer, 2d Battalion, 8th Marine Regiment, 2d Marine Division during Operation Iraqi Freedom; As a Lieutenant Colonel; Operations Officer, 6th Marine Regiment, 2d Marine Division, Faculty Advisor at the Marine Corps Command and Staff College. As a Colonel; Joint Operations Analysis Officer, Institute for Defense Analyses, during this assignment he deployed to Afghanistan and served as the Director of Strategic Effects, ISAF HQ, Kabul; Military Fellow, Council on Foreign Relations, New York City; Branch Head, Current and Future Operation, PP&O, HQMC. As a Brigadier General; he served as the Chief of Staff, CENTCOM, Joint Force Land Component Command, Kuwait.

Brigadier General Alford has attended The Basic School, the Infantry Officers Course, the Amphibious Warfare School, the Marine Corps Command and Staff College, and the Marine Corps War College.



John U. Carney

Director, Navy ManTech Program
U.S. Navy Industrial and Corporate Program Department
Office of Naval Research

Mr. Carney is the director of the U.S. Navy Manufacturing Technology (ManTech) Program. As director, Mr. Carney provides for the development of enabling manufacturing technologies, as well as the transition of this technology for the production and sustainment of Navy weapon systems to support the Fleet. Navy ManTech is currently focused on shipbuilding affordability. Reducing the acquisition cost of current and future platforms is a critical goal of the Navy, and ManTech aids in achieving this goal by developing and transitioning key manufacturing technology.

Mr. Carney received a B.S. degree in industrial engineering and operations management, as well as an M.S. degree in engineering management, both from Virginia Tech. Mr. Carney's technical interests include shipbuilding technology.

Points of Contact

ARL released photos

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PennState
Institute for Manufacturing
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The iMAST World Wide Web site provides an overview of the Institute and its technical thrust areas, facilities, and newsletters.

www.arl.psu.edu/content/institute-manufacturing-sustainment-technologies

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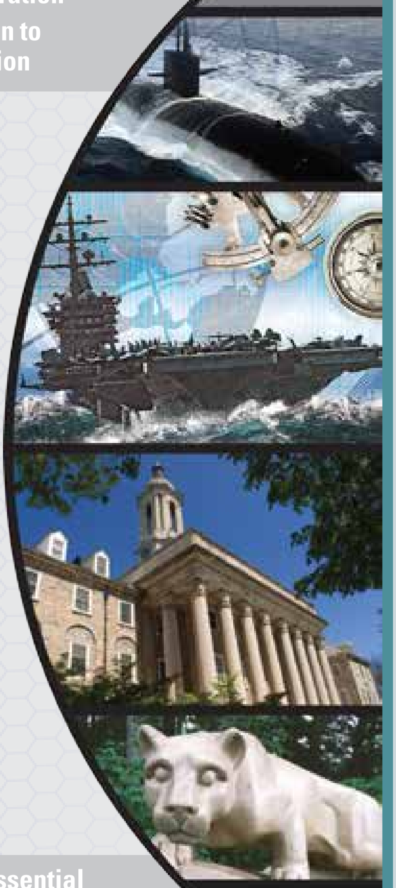

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