PennState
Institute for Manufacturing
and Sustainment Technologies

2019–2020 Annual Report

The Pennsylvania State University
Applied Research Laboratory

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DCN # 43-5952-19

On the Cover:

ARL Penn State's Large Format Additive Manufacturing Test System

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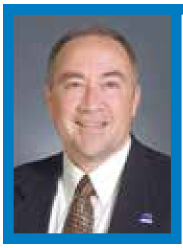


Director's Message

Timothy Bair
iMAST Director

This iMAST annual report is a summary of our contribution to the Navy ManTech mission over the past year, as well as an overview of ARL's capabilities in the materials and manufacturing technology domains. The mission of iMAST is simple, support the goals established by the Chief of Naval Research, RADM Hahn, and as defined by the ONR ManTech Director, Mr. John Carney. Specifically, iMAST identifies, defines, and executes projects in support of the major acquisition programs with the primary measure of excellence being cost reduction as a function of ManTech funds invested. Additionally, iMAST has enthusiastically executed the newest ManTech project category, Accelerated Capability projects, which supports the CNR's drive to decrease the development to fielding timeline for new warfighter tools and systems. Finally, iMAST executes the Navy's Repair Technology program, which is described in detail on page 37.

Within each of the three ManTech mission areas, iMAST has assembled an impressive portfolio of projects focused on affordability, availability, and improved capability. Under the ManTech program, ARL/Penn State investigators are contributing to the Navy's drive for an affordable and larger fleet, and in support of the Virginia Class and Columbia Class programs, as well as the Ford and Burke Class programs. The rally cry for the Repair Technology program is improved availability through the introduction of advanced and innovative technologies. This year, iMAST lead the way with the first two Accelerated Capability projects focused on improved combat capability for our subsurface and special warfare fleets.

The projects iMAST oversaw for ONR this past year cover a wide variety of technologies, all resident at the Applied Research Laboratory at Penn State. Examples include: advanced composites materials and manufacturing, industrial laser applications, additive manufacturing of metals, Advanced Manufacturing Enterprise focused modeling and simulation applications, Condition Based Maintenance, Industrial process improvement tools and technologies, coatings applications and removal, materials processing technologies such as Cold Spray and innovative functional coatings, and multi-spectrum technologies focused on improved or sustained warfighter superiority.

As the director of the Institute for Manufacturing and Sustainment Technologies at ARL/ Penn State, I get 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. If you would like to explore a future opportunity to work with us in support of the Department of the Navy, please feel free to contact us.

On behalf of our dedicated staff, engineers, and scientists, thank you for your time and interest in iMAST, ARL, and The Pennsylvania State University.

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 and 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. ARL enjoys a "reach-back" capability into Penn State's strong R&D engineering and material foundation, which provides significant science and technology capability that iMAST can exploit in a cost-effective manner. Sponsored under Navy contract N00024-18-D-6401, iMAST provides manufacturing technology support to the systems commands of the U.S. Navy and Marine Corps.

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. Solving challenges for the U.S. Navy and DoD for over 74 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 first among U.S. universities in materials research and second in industrial R&D funding.

ARL's broad-based effort is supported by a full-time complement of more than 1,300 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, ARL 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 with the limitations of International Traffic in Arms Regulations.

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

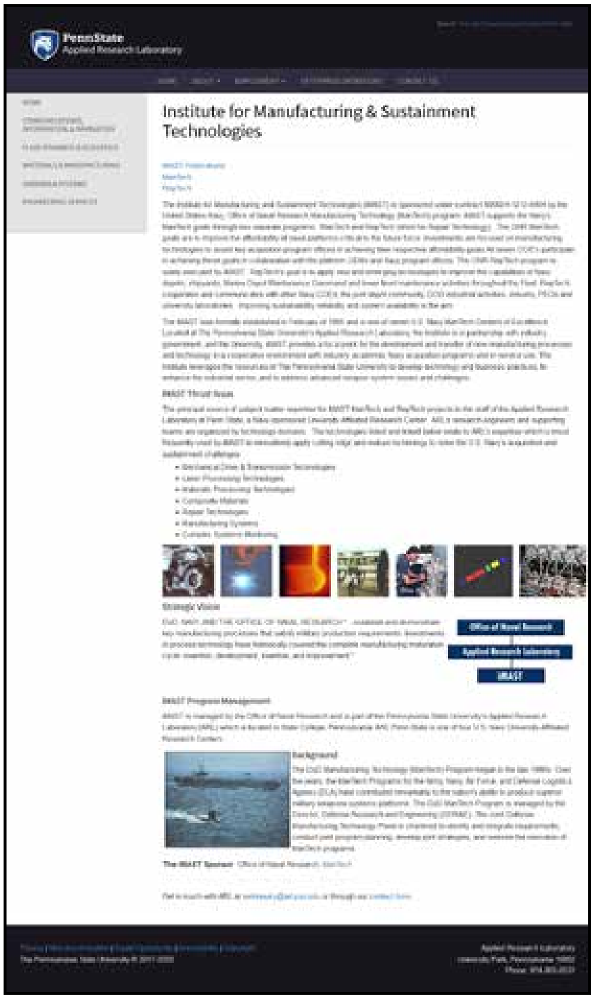
Navy ManTech Strategic Investment Plan

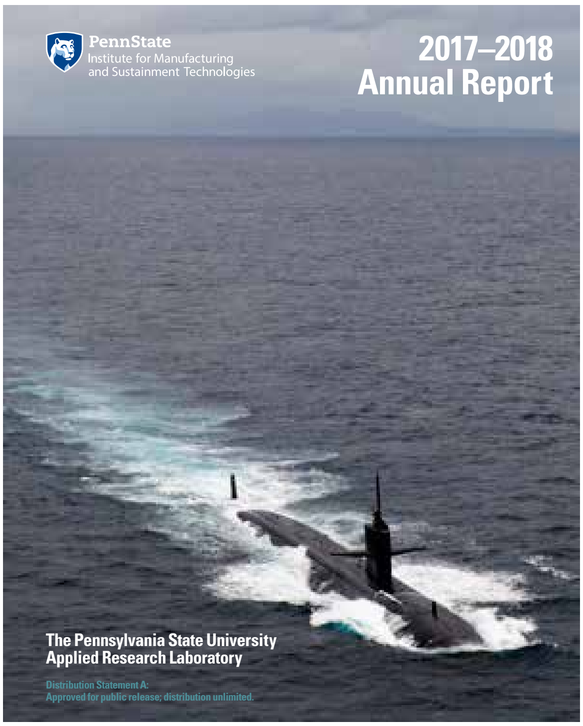
The Navy Manufacturing Technology (ManTech) Program's mission is to improve the affordability of naval platforms critical to the future force, accelerate new capabilities to the warfighter, and maximize the availability of those platforms and systems. Investments are focused on manufacturing technologies 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 F-35 Lightning (Joint Strike Fighter). Fleet availability being improved as a goal of the RepTech program is discussed later in this report.

2019–2020 Technology Transfer Event Participation

State College Hosted Events

– Materials and Manufacturing (MMO) Board Meeting
– RepTech Working Group Meeting
– Joint Defense ManTech Panel (JDMTP) Meeting





RT2769 — Corrosion Repair of Missile Decoy Systems

Affordability Focus Area(s): Sustainment
Stakeholder(s): Naval Surface Warfare Center – Crane Division COM
Platform(s): RepTech

Innovative Repair for Legacy Missile Decoy Systems

The successful completion of this project provided repair processes for Decoy Launching Systems; the components were fabricated from Al-6061 and suffered from corrosion damage during use. Furthermore, the components were expensive to repair and required long lead times to replace. Many of the repairs had to be performed outside of the United States. An efficient and economical repair process greatly reduced operating costs, increased system availability, and reduced repair times.

The objective of this Institute for Manufacturing and Sustainment Technologies (iMAST) project was to develop and transition cold spray repair processes to the Department of the Navy (DoN), Naval Surface Warfare Center, Crane, and its support contractor to repair decoy launching systems.

Payoff
Cold spray technology is rapidly growing in Department of Defense (DoD) applications. The DoN has been proactively and successfully implementing this technology in innovative applications as a repair for components that could not previously be returned to service. Benefits that resulted from this project include: reduced repair time and cost, improved readiness, and a repair process that can be used on similar Al-6061 components. The estimated cost avoidance for the first five years of implementation is $4.6M for a return on investment of 21:1.

Implementation
The repair process developed through this project will be implemented through a Crane-selected cold spray vendor or the Norfolk Naval Shipyard (NNSY) in collaboration with the Mid-Atlantic Regional Maintenance Center. A Cold Spray system has been installed at NNSY. Detailed repair processes and qualifications have been developed following Uniform Industrial Process Instruction (UIPI) 6320-901. Implementation is expected in FY20.

PI: Timothy Eden, Ph.D.

RT2770 — Marine Corps Depot Workflow Modeling

Affordability Focus Area(s): Sustainment
Stakeholder(s): Marine Corps Logistics Command (LOGCOM)
Platform(s): RepTech

Marine Corps Depot Uses Simulation to Improve Resource Planning and Reduce Costs

The U.S. Marine Corps depot performs maintenance on all types of Marine Corps vehicles and needs to accomplish this mission in a timely, cost-effective manner. On a regular basis, the depot has to contend with fluctuating workloads, increasing costs, resource constraints, unpredictable lead times for repair parts, and pressure to decrease costs and turnaround times for vehicles that come in for maintenance. Given these issues, the depot needs to be proficient at determining the resources needed to support its workload. "Resources" at a depot consist of three things: space, equipment, and personnel. The challenge of determining the optimal combination of resources to support a forecasted workload is complicated by the variation and uncertainty that is inherent in a depot maintenance environment. Variation and uncertainty in tasks and task durations make it difficult to determine what resources are needed, when they are needed, and for how long they are needed. Additional complications include variations in workload forecasts, changing workload priorities, uncertainty in the condition of incoming vehicles, high employee turnover, long lead times for spare parts, and uncertain funding availability.

The Institute for Manufacturing and Sustainment Technologies (iMAST) is developing a "Workflow Analysis & Resource Planning System," that can enable the depot to quickly estimate the resource levels needed to meet specified workload levels. The software tool will measure the depot's capacity, evaluate its material flow, identify its bottleneck operations, calculate resource utilizations, determine throughput, and assess overall efficiency. With this tool, depot management will be able to run different experiments to test the impact of changes in operations, workload, schedules, layouts, or routings, and make strategic decisions based on the outcomes that will improve operational performance and cost.

Payoff

The Workflow Analysis & Resource Planning System will identify and eliminate bottlenecks in depot operations. This will reduce excess material handling and waiting, and improve the utilization of resources. These improvements are expected to result in a 2% decrease in annual labor costs, or $1.4M per year. With a project cost of $525K and an estimated implementation cost of $100K, this yields a five-year return on investment of 10:1.

Implementation

The Workflow Analysis & Resource Planning System software application will be implemented at the Marine Corps depot in January 2020. The Marine Depot Maintenance Command (MDMC), supported by the Marine Corps Logistics Command (LOGCOM), will be responsible for installing and using the system. Preparations for implementation have already begun, with LOGCOM selecting Arena® simulation modeling software and submitting it for cybersecurity approval by the Marine Corps. iMAST has conducted several training classes on simulation modeling with Arena for MDMC and LOGCOM personnel and has developed an Arena User's Guide to assist the Marine Corps engineers who will support the system.

PI: Rick Tillotson

RT2810 — AN/SPS-67(V)3/5 Radar Radome Surface Restoration Project

Affordability Focus Area(s): Sustainment
Stakeholder(s): PEO-IWS 2.0
Platform(s): Arleigh Burke Class Destroyers up to DDG118

Improved Radome Restoration for Reliability and Reduction in Cost

There are 67 AN/SPS-67(V)3/5 radar systems in-service within the Navy fleet. The antennae are refurbished every 4 years. Refurbishing the 67's radome material has become problematic and labor-intensive due to an inability for radomes to pass radio frequency (RF) acceptance testing after refurbishment. The purchase of new radomes is prohibitively expensive due to their complex composite structure.

The current refurbishment procedure requires hand-sanding and painting of composite radomes. These radomes are large panels, and the current procedure produces variations in thickness of the radome and surface texture during each refurbishment, negatively impacting performance. This process also leads to inconsistencies in the paint thickness and ultimately damage to the radome, as hand-sanding, by-nature, is inconsistent.

The Applied Research Laboratory, funded through the iMAST ONR ManTech COE (iMAST/ARL), will develop an alternative refurbishment procedure and identify a coating system that will eliminate unnecessary iterations during refurbishment. This project will investigate alternative coating removal systems (laser ablation, soda blasting, sponge blasting, etc.) to replace inconsistent hand-sanding. It will also include alternative coating systems that will be more uniform to achieve an increase in service life and/or improved removal without sacrificing performance.

Additionally, iMAST/ARL will investigate the potential use of a radome boot to act as the paint substrate and end refurbishment of the radome structure for life of the part. The clear boot will protect the coated surface from abrasion, UV, and other wear without affecting radar performance. This will further reduce refurbishments costs and help to eliminate future inconsistencies and iterations of radome testing, as radomes will be untouched during system overhaul.

Payoff

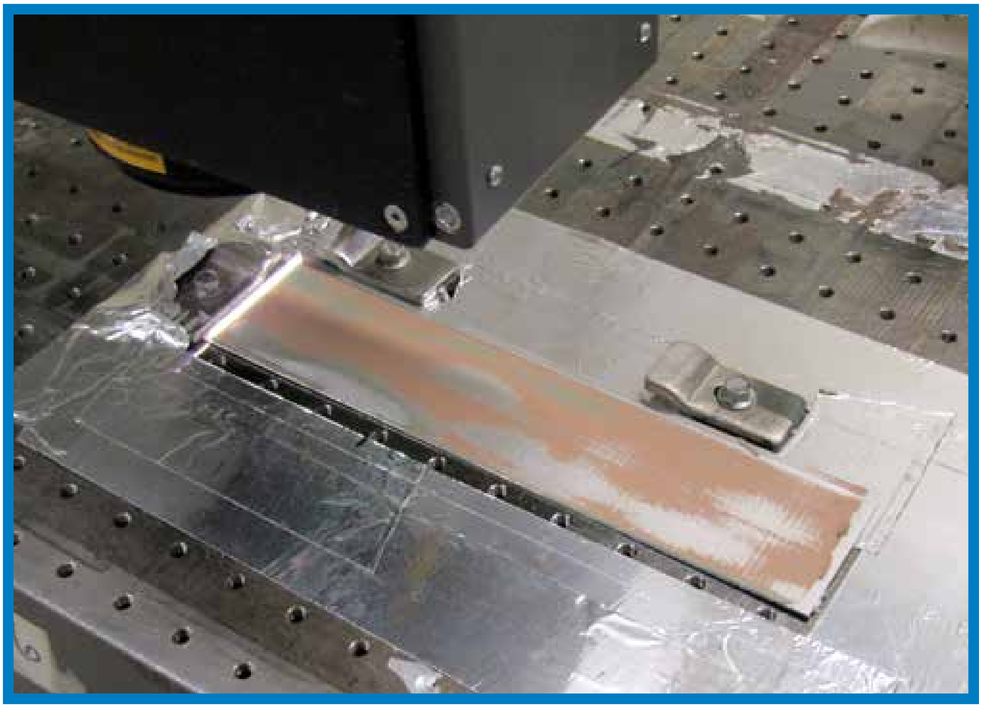
By executing this program, it will extend life expectancy of radomes, reduce the labor costs associated with the current refurbishment procedure, and, overall, decrease the number of radomes that are being scrapped each year. All changes will require an engineering change proposal (ECP) II that must be approved by the stakeholder before final implementation.

Implementation

Implementation will occur when a refined refurbishment process has been developed and successfully tested on a AN/SPS-67(V)3/5 radome. Concurrently, if the use of a radome boot is found to be transparent to radome signal without degradation of performance, a radome boot will be designed for use on the radar systems. Once either or both of these solutions are determined to be effective without degradation of performance, the procedures and materials will be moved to implementation. This must be approved by the Program Office, NSWC-Crane. It will likely require a variance but could escalate to a Class II ECP.

PI: David Rearick

RT2825 — Radar System Parts Laser Ablation and Passivation



Affordability Focus Area(s): Sustainment
Stakeholder(s): PEO-IWS 2.0
Platform(s): LHA, LPD, CVN, LHD

Investigating Laser Ablation of Aluminum Alloys for Restoration and Increased Corrosion Resistance

Naval Surface Warfare Center Crane (Crane) uses media blasting to remove paint and corrosion during SPS-48E radar antenna overhaul. This process is labor-intensive and uses consumable media. Additionally, the aluminum components of the SPS-48E radar system are treated with Mil-DTL-5541, Type 1 Class 1 A hexavalent chromium (Cr+6) conversion coating as a corrosion barrier and to enhance paint adhesion. Cr+6 is a health risk requiring special treatment. Consequently, consumable media must be replaced frequently and treated as hazardous waste. Media blasting can also cause warpage, damage, and pin-holing of critical components, thereby reducing life expectancy and inspection failures.

The Applied Research Laboratory, funded through the iMAST ONR ManTech COE (iMAST/ARL), will test and develop laser ablation and hyper-passivation processes for use on aluminum components utilizing commercial off the shelf systems. A key benefit of laser ablation is the capability to remove multiple layers of paint efficiently with minimal waste and limited exposure to Cr+6. In addition to increasing safety for the operator, laser ablation can be fully-automated, thus reducing labor hours and the risk of damage.

The iMAST/ARL team will also be exploring the potential that a laser ablation process may also passivate the surface by changing the pulse length and intensity to create a thick aluminum oxide layer on the surface. This process is known as hyper-passivation. This thick oxide layer creates an excellent barrier for corrosion and would allow for the removal of the hazardous Cr+6 dip on aluminum components. By adding this processing step to current procedures, it would innovatively reduce health risks while increasing corrosion resistance, enhancing paint adhesion, and removing a hazardous step from their refurbishment process.

This project will implement an innovative, state-of-the-art system at Crane that will reduce cost and increase performance and life expectancy of components. Crane is looking to be a leading innovator in the implementation of laser ablation for the Navy fleet, and with IWS's support, believes that laser ablation is part of the future of refurbishment at the depot.

Payoff

The benefits of this project will be reduced labor, exposure to hazardous chemicals, and waste. Potential additional savings may be realized by extending life expectancy of components and increasing refurbishment periodicity. Pending successful completion of testing, the passivation effect will proliferate to numerous additional aluminum structures and components.

Implementation

Crane and In-Service Engineering Agent will ensure that required metrics are achieved. This project will evaluate the cost of updated procedures compared to legacy procedures and the materials properties post laser processing to determine detrimental effects and cost savings. Both of these metrics are important for justifying a business case that has both near-term cost reduction and longer-term cost avoidance implications. Expected implementation will occur in November 2020.

PI: David Rearick

RTR2786 — Synchronized Cable Feeding System

Affordability Focus Area(s): Sustainment
Stakeholder(s): PSNS, NAVSEA 04X3 Tactical Innovation Implementation Lab (TIIL)
Platform(s): USS SEAWOLF Class and All Other Ship Classes

New Electrical Cable Installation Tool Expected to Save ~ $15M on 1st Use

Faced with a large, schedule-busting cable installation project, Portsmouth Naval Shipyard (PSNS) engineers conceived an alternative approach to the manual 'pull-loop-band-move-pull-loop-band-move' (etc.) technique. The new process reduces stress on the cable to levels below those induced during manual installation. Using multiple hand-cranked feeder-rollers and idler-rollers, PSNS demonstrated the ability to simultaneously push and pull on the cable while snaking it through a series of turns. Before PSNS could use the system, however, they needed to figure out how to satisfy Note 1.10 of USS SEAWOLF Class DWG 6404832 which states: *Cables shall be installed taut in cableways without mechanical means such as rope or chain-falls.* Rope and chain-falls can only pull on cable, risking damage to internal conductors. The key to success was to develop a system that simultaneously pulls and pushes the cable at each drive-point and synchronizing all drive points, so the system does not stretch or compress the cable between drive points. For help, PSNS turned to the Applied Research Laboratory (ARL) Lifecycle Engineering Department and iMAST.

Through the Institute for Manufacturing and Sustainment Technology (iMAST), the ONR MANTECH program funded a Rapid Response Project enabling the ARL Lifecycle Engineering Department to develop a Synchronized Cable Feeding System (SCFS) to interface with the PSNS drive-roller and idler-roller prototypes. ARL designed, fabricated, demonstrated, and delivered a 6-motor system in which all of the motors turned at the exact same rpm. The system has three forward speeds, reverse, and several emergency stop buttons for placement along the cable path. PSNS demonstrated the system on a full-scale mockup to the technical warrant holder (TWH) nearly a year before the scheduled project date. Based on the strength of this demonstration, the TWH provided written approval for the new process, concluding the SCFS does not violate the intent of Note 1.10.

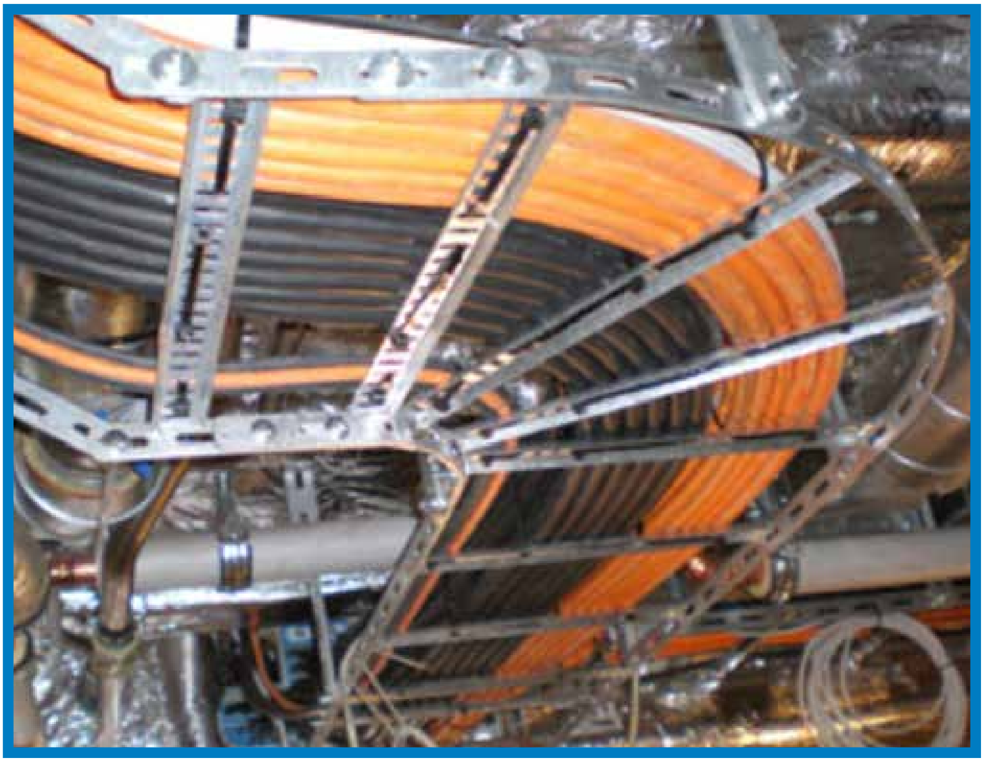
Payoff

PSNS estimated the SCFS would reduce the cable installation schedule for the July 2019 installation task by 89 working shifts, saving 790 man-days of labor and 70 days of schedule time. Including cost avoidance associated with late undocking, the total cost savings for the July 2019 cable installation task exceeded $15M, netting a one-year ROI of 128:1.

Implementation

In this rapid response project, ARL developed (designed, fabricated, tested, and delivered) a 6 motor, synchronized cable-feeding system addressing PSNS's immediate need for the July 2019 cable installation project. Providing a full Technical Data Package (TDP) was beyond the scope of this $120K rapid response project.

PI: Charles Tricou



RTR2811 — Repair of AAV Hydrostatic Steering Units

Affordability Focus Area(s): Sustainment
Stakeholder(s): Assault Amphibious Vehicle (AAV) Program Office
Platform(s): AAV

Additive Repair of Ductile Cast Iron

The successful completion of this project provided a repair for the AAV Hydrostatic Steering Units (HSU). The HSUs are ductile cast iron and have stringent flatness requirements to achieve the pressure for operation. During extended use, the HSUs warp and are not able to maintain the operating pressure. The HSUs are removed from the vehicle and shipped to the Marine Depot where the critical face is precision ground or honed to reach the required flatness. Eventually, enough material is removed from the critical surface that the HSUs no longer meet dimensional requirements and must be removed from service. The HSUs are no longer in production, and there is no approved repair process. The purchase of new units requires the vendor to set-up the manufacture process and produce new parts, and this process can take up to 18 months. An efficient and economical repair process would greatly reduce operating costs, increase system availability, and reduce repair times.

The objective of this Institute for Manufacturing and Sustainment Technologies (iMAST) project was to develop and transition cold spray repair processes to the Department of the Navy (DoN), Naval Surface Warfare Center, Crane, and its support contractors to repair the AAV hydrostatic Steering Units.

Payoff

Cold Spray technology has been implemented for many different DoD applications. The DoN successfully implemented this technology for innovative additive repair of components that could not previously be returned to service. Benefits that resulted from this project include: an approved process for ductile cast iron, a reduced repair time and cost, and improved readiness. The estimated cost avoidance for the first five years of implementation is $10.25M for a return on investment of 19.6:1.

Implementation

The repair process developed through this project will be implemented through the Marine Depot Maintenance Command or an approved vendor. Detailed repair processes and qualifications will be developed following Uniform Industrial Process Instruction (UIPI) 6320-901. Implementation is expected in FY20.

PI: Timothy Eden, Ph.D.

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

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

Alternative Coating and Surface Preparation Solutions Offer Significant Savings for Submarines

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, potentially causing an increase in seal wear and operating torque. Teflon® peeling of ball valves has increased inspection rejections, which increased re-work and acquisition costs. The project goal was to identify, test / evaluate, and implement potential alternative coating systems, coating deposition processes, and/or surface modification processes that improve the performance and extende the life cycle of ASBV. Finding the root cause failure mechanism helped identify the coating properties / surface modifications that meet the minimum performance requirements. The coated ASBV / seating material interaction was evaluated to serve as a baseline. Currently, four potential solutions were evaluated: improved Teflon® coating process, improved seat / ball materials, super-finished valve balls, and a diamond-like carbon coated valve ball.

Payoff

Approximately 400 Teflon®-coated valve balls are required to achieve full qualification acceptance for approximately 200 ball valve assemblies due to the rejection rate during acquisition. An improved coating system eliminated the need to rework the ASBV and saved approximately 50% of the total acquisition cost. General Dynamics Electric Boat (GDEB) estimated savings of over $155K per boat in materials for baseline VIRGINIA Class submarines (VCS) and $514K per boat due to planning / engineering, which resulted in a total acquisition savings of $669K per boat. Over five years, at two boats per year, this correlates to $6.9M in savings with a return on investment (ROI) of approximately 4.94:1. There is also a potential acquisition savings of $960K per VIRGINIA Payload Module (VPM) and $2.2M per COLUMBIA Class submarine (CLB) due to the increased number of ASBV per boat. The VPM savings are for the whole submarine; therefore, the savings include the $669K for the rest of the submarine. If additional benefits from CLB are considered, and only two CLB are assumed to be built in the same five-year period, an additional $4.4M in savings will be realized. In addition, if two VPMs are built within the 10 VCS, an additional $2.3M in savings will be realized, and the revised five-year ROI is 10.95:1.

Implementation

This project will be implemented in late FY19 on new construction VCS and existing hulls on an attrition basis. GDEB and NAVSEA are committed to this project as a means of reducing acquisition total ownership costs for VCS and CLB. 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.

S2727 — Advanced Steel Production Facility – Industrial Modeling and Simulation

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

Industrial Modeling and Simulation to Evaluate Current Factory Configurations and New Facility Designs

The Institute for Manufacturing and Sustainment Technologies (iMAST) developed stochastic discrete event simulation models of the entire fabrication process for the products created by Huntington Ingalls Industries (HII) - Newport News Shipbuilding's (NNS) current and future state Steel Production Facility. The models provide a means for NNS to assess alternatives for modifications to the current factory configuration, as well as new facility design to obtain the productivity increases needed to support accelerated production schedules and cost-reduction initiatives for CVN construction.

NNS proposed a radical shift in manufacturing within the Advanced Steel Production Facility (ASPF). The models enable productivity changes to be assessed globally and at the station level, allowing productivity variations to be determined and technology gaps to be identified. Alternative equipment, process flow configurations, and new stations will be "modeled." Modules representing these stations will be inserted into the model to iteratively evaluate alternative scenarios which will, in turn, facilitate capital investment decision making.

Payoff

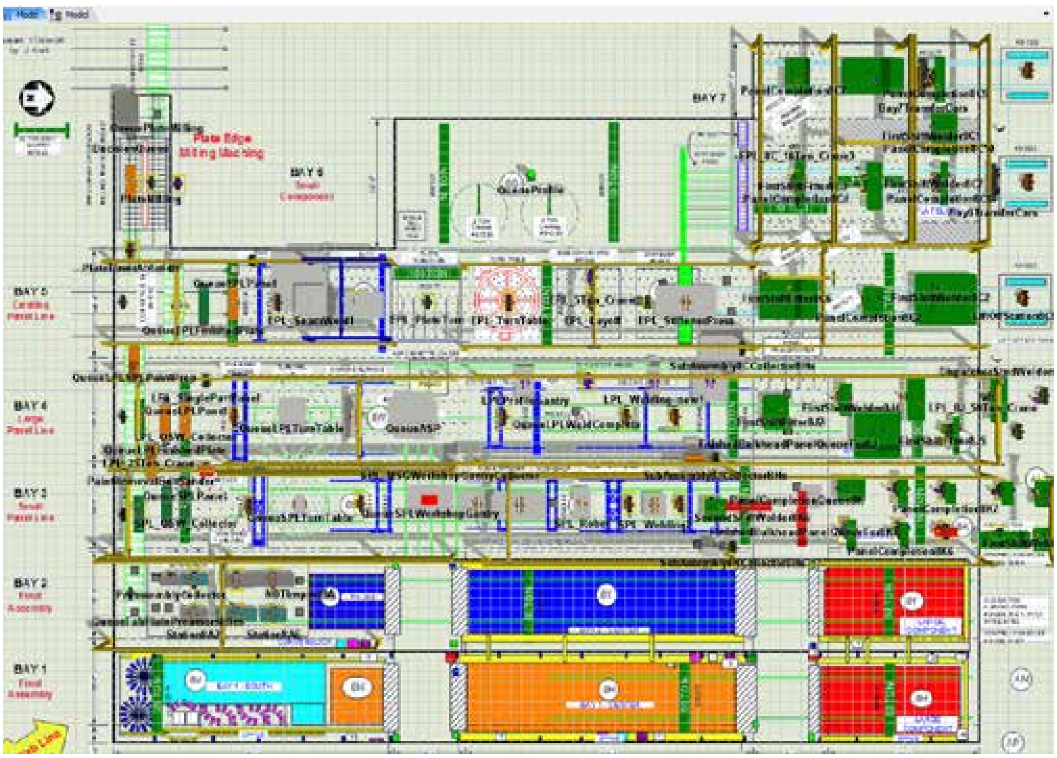
While no benefits may be estimated until the actual completion of the ASPF concept, the concept itself may be assessed on a global scale. If only the ASPF concept can be achieved, then significant savings may be obtained:

- CVN 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 that are currently statically built and have a high level of manual operations. If these products can be fabricated using an assembly line method, it is estimated that 40% reduction in structural fabrication and assembly man hours can be achieved.
- CVN products currently assembled on the panel line are to be assembled and joined, and will undergo early outfitting more effectively. This is to include a more completed final product with a goal of completing the majority of hot work (i.e., welding) either on the line or in the shop. It has been estimated that an increase in productivity can be achieved resulting in approximately 20% savings.

Implementation

Upon completion of this project and acceptance of the technology and associated business case by the acquisition Program Office (PMS 379), the models and all associated software applications and source code were transitioned to NNS. The technology was implemented at NNS to support follow-on research and development efforts expected to be funded to support the ASPF concept.

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



RT2744 — Hatchable Cold Spray Technology for Naval Shipyards and Marine Corps Depots

Affordability Focus Area(s): Metals Processing and Fabrication
Stakeholder(s): NAVSEA 04X3, NAVSEA 04, USMC LOGCOM, Public Shipyards
Platform(s): Other Sea Platforms

Innovative In-Situ Repair for Ships

This effort developed and delivered a high-pressure hatchable cold spray system, commensurate support equipment, and operating procedures to include on- board ship, and developed and validated shipboard repairs of specifically selected components.

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

Payoff
Benefits as a result from this project include: 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; approved repair processes for submarine and aircraft carrier components; repairs that return components to service that previously had to be scrapped; repair costs of less than 20% of the cost of a new component; reduced repair times (lead times taking as long as 24 months now take one day to four weeks depending on the component); and an improved process to identify additional candidate components for repair by shipyard or depot personnel. The estimated cost avoidance for the first five years of implementation is $8M for a return on investment of 13:1.

Implementation
The Hatchable Cold Spray system was demonstrated at the Intermediate Maintenance Facility Bangor and Puget Sound Naval Shipyard. Full implementation will occur in late 2019/ early 2020. Approved repairs are expected to be implemented in late 2019. 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 and the Marine Depot. The system will also be made available to NAVAIR facilities.

PI: Timothy Eden, Ph.D.

S2750 — Diagnostic and Predictive Monitoring for Facilities Equipment

Affordability Focus Area(s): Modeling and Simulation, Advanced Manufacturing Enterprise
Stakeholder(s): PMS 450, PMS 397
Platform(s): VCS / CLB Submarines

Predictive Facilities Maintenance and Capacity/Production Planning Systems to Reduce Costs and Meet Manufacturing Schedules

Unplanned equipment maintenance has a profound effect on the production capacity of manufacturing facilities and shipbuilding schedules for both the VIRGINIA Class and the COLUMBIA Class submarines. While many capacity and production planning tools can organize the production schedule around planned maintenance events, most cannot quickly re-plan for unexpected equipment failure. The objective of this project is to implement a predictive health monitoring system at General Dynamics Electric Boat (GDEB), and to integrate the resulting information into their production planning and scheduling systems to reduce the impact of downtime due to unplanned equipment failure.

Payoff

This Institute for Manufacturing and Sustainment Technologies (iMAST) project, executed by the Applied Research Laboratory at Penn State, will identify, evaluate, and implement equipment health monitoring systems to more accurately predict failure of critical equipment identified by GDEB. This predictive capability will support improved planning and scheduling. The project is expected to reduce schedule disruptions due to catastrophic breakdown of identified equipment and support improved shipyard and ship building schedule performance, reduce outsourcing, and lower inventory costs. GDEB estimates annual savings of $252K per year and five-year savings of $1.3M for Groton, and $787K per year and five-year savings of $4.0M for Quonset Point; the five-year return on investment (ROI) is 1.1 for Groton and 2.2 for Quonset Point.

Implementation

This project began with a machinery evaluation, called a degrader analysis, to determine the critical failure modes that the selected health management technology can optimally support. The appropriate capacity planning tools will be enhanced to accept machinery maintenance and condition trend information, and to display this information to the schedulers. Phase 2 will expand the implementation of the predictive maintenance system and integrate this information with the Critical Resources Planning Tool. iMAST will provide the tools and hands-on training to GDEB. Software interfaces will be developed and implemented to connect condition information to the enhanced capacity planning tools. This will result in increased effectiveness of the diagnostic and monitoring tool, and GDEB's scheduling process.

PI: Jeff Banks

S2758 — Automated Assembly Planning and Work Package Information Generation

Affordability Focus Area(s): Modeling and Simulation, Advanced Manufacturing Enterprise
Stakeholder(s): PMS 450, PMS 397
Platform(s): VCS / CLB Submarines

Development of Automated Assembly Planning Software Will Improve Shipbuilding Structural Assembly

The objective of this project is to develop a process and tools that automatically generate an assembly plan for structural fabrication of the VIRGINIA Class submarine (VCS) and the COLUMBIA Class (CLB) submarine. The plan will then be supplemented with additional information, converted to a digital work package, and delivered to General Dynamics Electric Boat (GDEB) tradesmen on the shop floor using the platform and processes established in the Navy ManTech S2653 Mobile Computing for Design Build project conducted by the Naval Shipbuilding and Advanced Manufacturing Center.

Phase 1 focused on the documentation of assembly rules and preferences for structural fabrication of submarine assemblies and the development of the software tool to augment the build authority model. In addition, the project team developed requirements and methods for the generation of electronic work packages. Finally, in Phase 1, the project team developed a prototype version (an extension of tools developed by the Defense Advanced Research Projects Agency) of the assembly planning algorithms and concluded with prototype system results for test assemblies.

In Phase 2, the project team will mature the structural fabrication assembly sequencing tool based on feedback obtained from the user group prototype testing. The electronic work package data / information generation process and software will be finalized, and the two developed technologies will be integrated. The project team will also test the efficacy of auto-generated assembly sequences for candidate assemblies and demonstrate the generation of electronic work package data to obtain feedback and refine the software.

Payoff

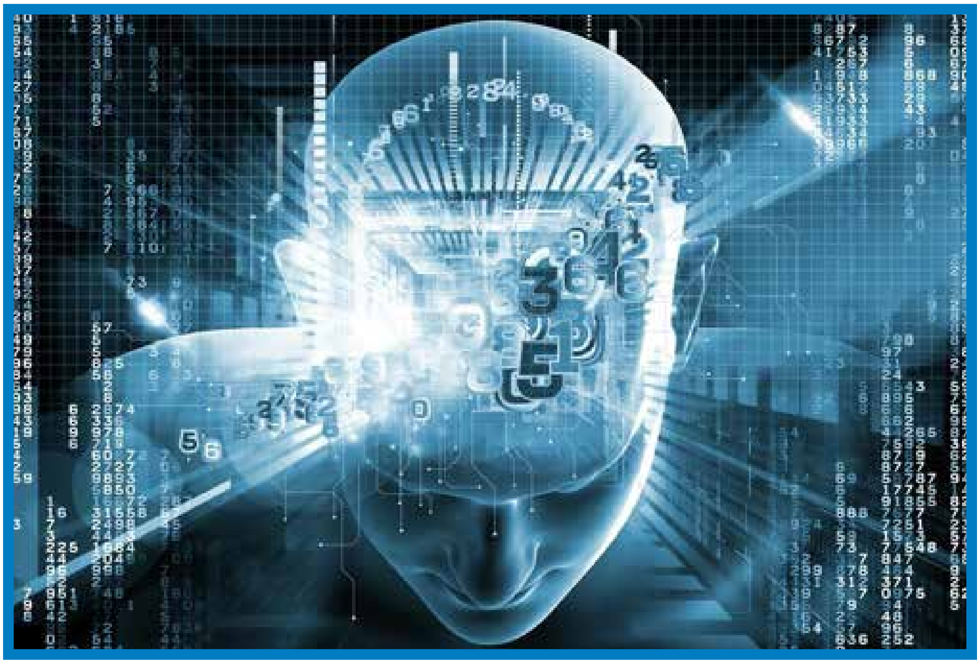
Savings will result from reductions in planning labor hours, production control inventory, and shop floor job planning hours. The estimated planning labor-hour reduction is 1,500 hours for VCS and 3,000 hours for CLB, which will result in $450K savings. In-process inventory is estimated to be reduced by 2.5% and result in $75K savings for both VCS and CLB. Shop floor planning hours are expected to be reduced by 1,600 labor hours and 3,200 labor hours for VCS and CLB, respectively, resulting in an estimated combined savings of $480K. This results in total five-year savings of $5.9M and a return on investment of 5.62:1.

Implementation

Upon successful completion of this project, the tools and methods will be transitioned to the VCS Program at GDEB in mid 2020. Post-project technology insertion will be limited to full-scale deployment of the piloted technologies / improvements developed during the project. GDEB management has expressed its commitment to implementing these tools and methods in an effort to reduce VCS production costs for two subs per year and one CLB per year.

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

S2797 — Production Bill of Material Quality Assurance using Artificial Intelligence



Affordability Focus Area(s): Modeling and Simulation, Advanced Manufacturing Enterprise
Stakeholder(s): PMS 400D
Platform(s): DDG 51

Artificial Intelligence to Improve the Shipyard Production Planning Process

The DDG-51 Production Bill of Material (PBOM) is a hierarchical data structure used to represent the shipyard's manufacturing processes in the context of the ship's design. The conversion of the ship's various material lists into this integrated PBOM is what enables the Manufacturing Resource Planning (MRP) system to effectively back-schedule all the fabrication and procurement activities that support efficient assembly of the ship. Due to the complexity and scale of this data, and the process for managing it, errors are easily introduced. The complexity and scale also make it difficult to identify these errors through basic data analysis.

In this project, the Institute for Manufacturing and Sustainment Technologies (iMAST) will develop an Artificial Intelligence (AI) to increase the effectiveness of PBOM quality checking while reducing the associated costs, which will result in very small, short-term savings within the planning area and more significant savings in the operations areas. Accordingly, the development and implementation of the PBOM Quality Assurance (PQA) software with embedded AI and Machine Learning at Bath Iron Works will improve business efficiency by reducing product disruption costs due to PBOM errors without introducing large costs associated with large-scale manual checking.

Payoff

Whenever a PBOM error is identified during construction, a process called BCR or “Bill Change Request” is used to correct it. BCR is designed to ensure that material is routed back to inventory, new demand is created, work budgets are redistributed, and tasking is rescheduled. There are an average of 2000 BCRs per DDG 51 hull.

- It is assumed that BCRs will reduce by 25% from hull-to-hull.
- It is assumed that the PBOM QA using AI tools will results in a 50% reduction in PBOM errors from hull-to-hull.
- There will be an average savings of $700K for 6 DDG hulls (Total Savings = $4.2M).

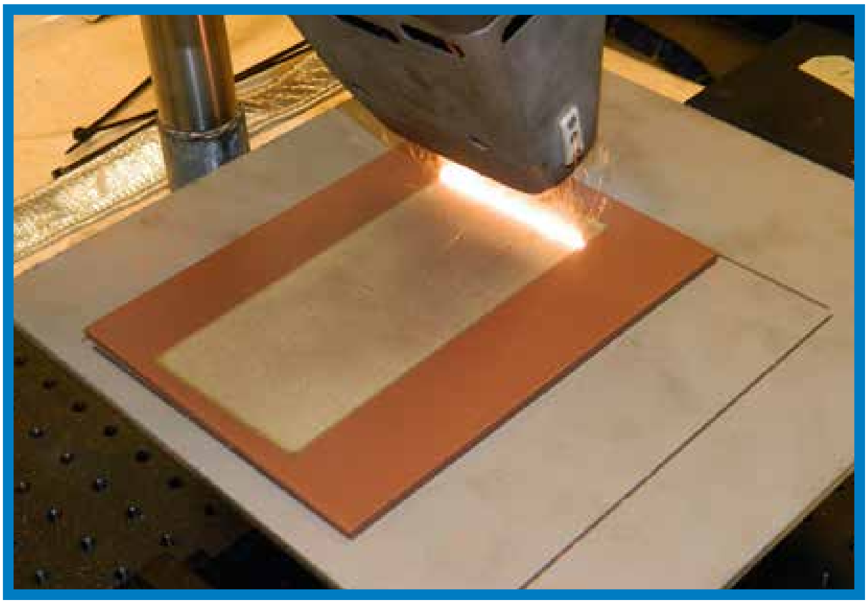
5-year Return on Investment = 3.5

Implementation

Upon successful and timely completion of the PBOM Quality Assurance Using AI project and acceptance of the technology and associated business case by the stakeholders (PMS 400D), the resulting software and tools will be transitioned to Bath Iron Works (estimated completion date [ECD] for transition–FY20/Q1). It is expected that the new technologies will be implemented at BIW. Post-project technology insertion should be limited to full-scale deployment of piloted technologies/improvements during the project.

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

S2823 — Laser Ablation of PCP from HSLA Steel



Affordability Focus Area(s): Metals Processing and Fabrication
Stakeholder(s): CVN / PEO Aircraft Carriers, PMS 379
Platform(s): CVN

Using Lasers to Improve Preconstruction Primer Removal Operations in Shipyards

Preconstruction primer (PCP) must be removed prior to welding in aircraft carrier (CVN) construction. Typically, needle guns, handheld or walk-behind grinders, and/or abrasive blast equipment are used, which are often laborious, dangerous, detrimental to the substrates, and/or produce excessive waste materials that may be costly to dispose. At the Newport News Shipbuilding (NNS) Steel Production Facility (SPF), a substantial percentage of CVN steel fabrication labor is consumed in PCP removal. This process inherently results in an unacceptable number of personnel injuries per year, some surface erosion of the steel substrate, and cleanup and disposal costs for blast media.

Laser ablation (LA) technology can reduce the detriments that are tied to current practices. Numerous civilian industries are implementing LA as supported by many studies showing its potential. Challenges for implementation (comprising technical, procedural, training, safety, environmental, and financial) may be overcome by appropriately identifying and carefully addressing them on an as-needed basis.

The objective of this project is to qualify and implement LA technology for the semi- or fully-automated removal of PCP from HSLA steels within the NNS steel fabrication facilities that are being prepared to support the more rapid construction schedules of CVN 80 and CVN 81.

Payoff

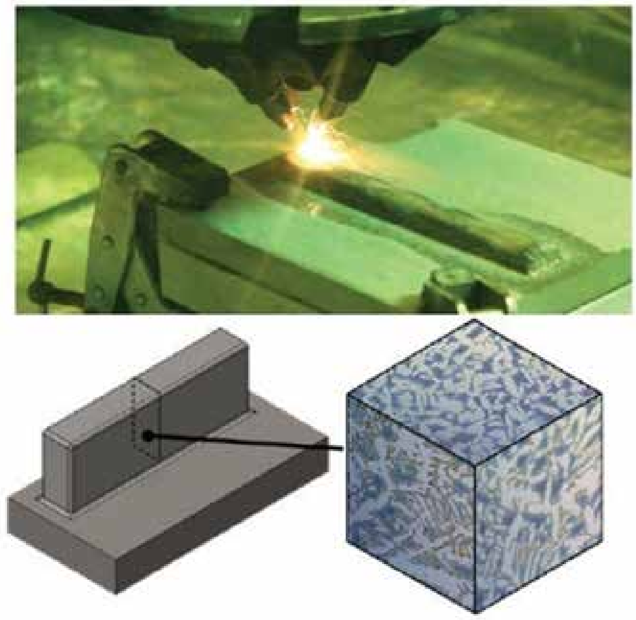
The preliminary business case, based on pre-project figures provided by NNS, shows a labor reduction in excess of 20,000 hours for the first year of full LA implementation for automated PCP removal. Following full implementation of LA at NNS, the 5-yr ROI is expected to be approximately 2.4. The figure does not include yet to be fully quantified savings in material costs (e.g., abrasive), or cost avoidances related to injuries experienced using current PCP removal methods. In the last phase of this project, NNS will provide an updated business case.

Implementation

For full implementation to occur at the SPF at NNS, technical, procedural, safety, environmental, financial, and workforce development aspects must be addressed. Early estimates for implementation costs are nearly $3M, which includes procurement of capital equipment; environmental permitting; development of standard operating procedures and safety protocols/training; and equipment installation, debugging, and training. NNS anticipates the need for 3-5 LA systems in the SPF and will begin transition with their final business case. The strategy for implementation has a timeline beginning in first quarter FY2022 and ending in last quarter FY2024.

PI: Stephen Brown/Melissa Klingenberg

T2716 — Development of Additive Manufacturing Processes for Corrosion Resistant Alloys



Affordability Focus Area(s): Metals Processing and Fabrication
Stakeholder(s): PEO (Ships), NSWCDD
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, provided limited geometries and frequently required significant levels of post-processing to produce the desired component geometries. These limited geometries and post-processing requirements resulted 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 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 had previously occurred. In this project, two categories of materials systems were investigated. These materials systems included the Ni-Cu-based Monel® alloys and CRES alloys. Each of these systems has unique characteristics that potentially made the AM processing of these alloys challenging.

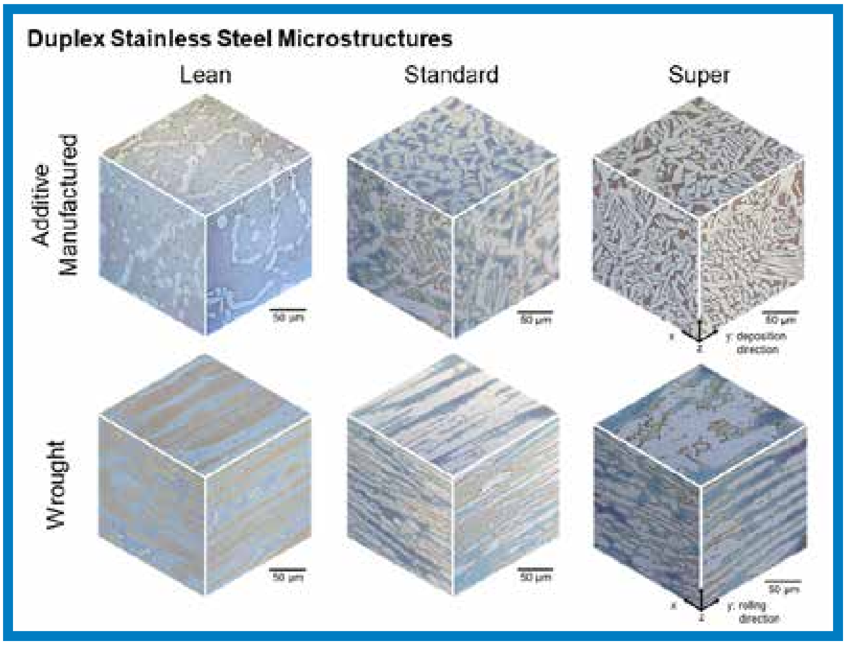
Payoff

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 of the ranges typical for powder bed fusion processes. But, 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 offered the opportunity to investigate the impact of AM on these classes of materials and provide a sound scientific foundation for developing a fundamental understanding of the governing process-structure-property relationships. This project also serves as a test bed for the application of data analytics and data capture for important processing and property conditions.

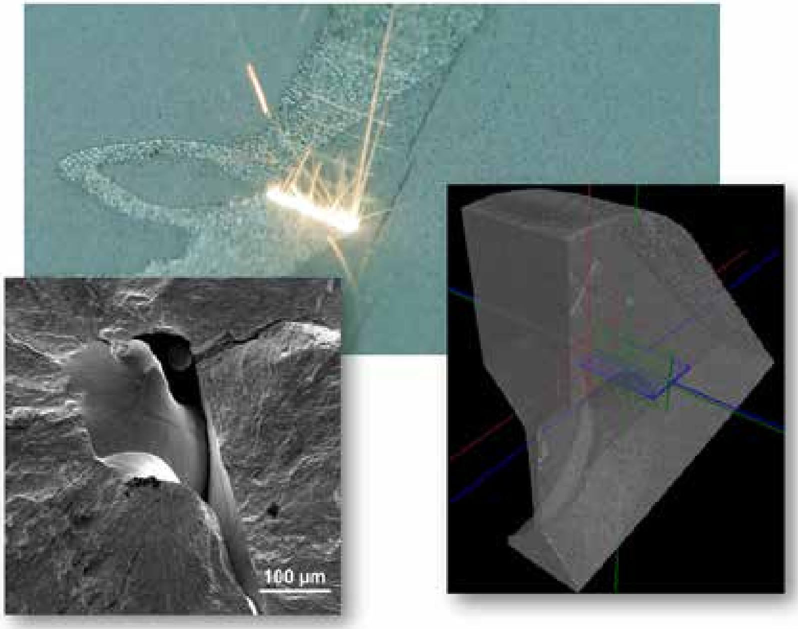
Implementation

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

PI: Jayme Keist, Ph.D.



T2783 — Optimizing X-ray Computed Tomography for Defect Detection



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

Assuring that Additively Manufactured Metallic Components are Free of Detrimental Defects

This Institute for Manufacturing and Sustainment Technologies (iMAST) project will investigate how the X-ray computed tomography (CT) analysis process and data reconstruction algorithms can be optimized for additive manufacturing (AM) metallic components. Different alloy systems that include titanium and stainless steel alloy systems will be investigated. The project will lay the initial foundation to better understand the critical defects that need to be identified within high-value, high-risk AM components. In AM, components are built in a layer-by-layer manner using either powder bed fusion or directed energy deposition processes. AM offers significant promise to the Navy for on-demand fabrication of parts of varying sizes and complexities. The ability to "print on demand" will have significant impact on lead times and procurement costs for new and replacement components. The Navy is currently investigating the production of high-value, high-risk components by AM. However, AM is still an emerging technology, and the process can introduce several types of defects into the build, such as lack-of-fusion porosity, gas porosity, and the entrapment of impurities. Non-destructive testing by X-ray CT has become the standard technique to qualify these high-value, high-risk components. CT can analyze and quantify internal structures (e.g., porosity) within components in three dimensions. The analysis of AM components by X-ray CT is complicated by many variables, and these complications could lead to the failure to identify defects that would be detrimental to the component during service.

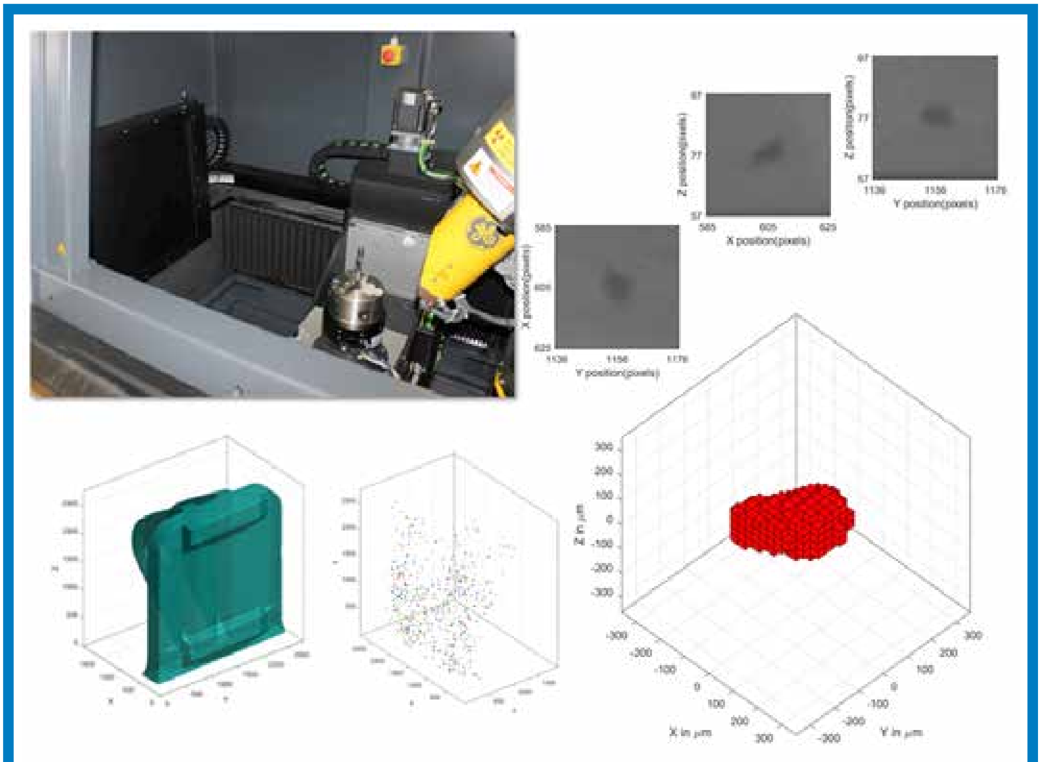
Payoff

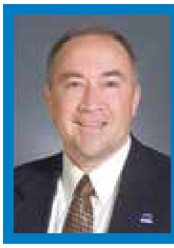
In the coming years, the Navy is expected to significantly increase its AM footprint and the use of AM to produce both new and replacement components. This project will help validate a method of qualifying AM components prior to service and assure they perform as expected, and this project will help meet the challenges of certifying AM components for structural applications. In addition, optimizing the X-ray CT process will help streamline the non-destructive testing of AM components allowing for rapid qualification of AM components for service.

Implementation

The alloy systems chosen for this investigation have significant applicability for naval systems. Efforts are directed toward better understanding the challenges of verifying that AM components are free of detrimental defects. In addition, efforts will be directed at better understanding critical defect size within a component. This effort includes establishing the groundwork to build a database of the impacts of defect size as a function of shape and the material systems investigated. At the completion of the project, the initial database of critical defect sizes along with the optimized X-ray CT techniques will be transferred to Navy to help qualify AM components. The iMAST team hopes to transition this knowledge and the testing techniques developed for the Navy within the FY20–FY21 timeframe for use on specific critical components through a follow-on project designed to mature the process for specific components.

PI: Jayme Keist, Ph.D.





Repair Technology

Timothy Bair
Technology Leader

Sustainment is a force multiplier in its own right. The vast majority of the Navy's investment in a weapon system or platform is its sustainment. The fiscal realities facing the naval services and the CNO's drive to expand the fleet have significantly increased the need to find or create cost-cutting measures that can reduce life cycle cost and enhance operational availability. The ONR ManTech, Repair Technology (RepTech) program, led 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.

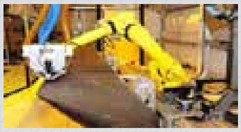
Management Structure

Oversight for the RepTech program is facilitated by the RepTech Working Group (RWG), which is chaired by ONR (Mr. John Carney) 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.

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

RepTech

iMAST is chartered by ONR ManTech to execute its vision to improve platform availability and life cycle cost using advanced and mature technologies, innovatively applied.


Robotic paint stripping for NAVAIR


Advanced metrology tools, like laser scanning, implemented in shipyards and depots

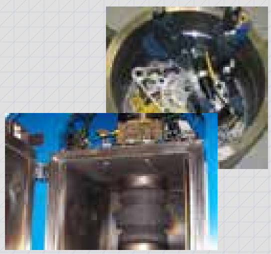

New repair technologies implemented in depots and yards


Repair technologies for returning condemned parts to service


Dual-track bug for SHT removal

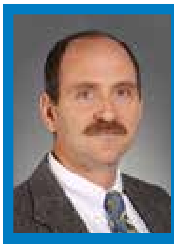
Advanced repair using additive manufacturing


Ultra High Pressure (UHP) waterjet tool development


Integrated grinding and cladding tool for tubes, in-situ

iMAST is an Office of Naval Research ManTech program Center of Excellence hosted by the Applied Research Laboratory at Penn State.

PennState
Institute for Manufacturing and Sustainment Technologies



Manufacturing Systems Technologies

Michael Yukish, 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
Unmanned Aerial Vehicle Build and Test

A combination of experience in both rotary and fixed wing UAS design, expertise in manufacturing methods appropriate to UAS, and a laboratory dedicated to UAS design and manufacturing, enable rapid design/build/test evolutions. The UAS team has exclusive access to Mid-State Airport (KPSB) with two 5000’ runways and 500 acres of surrounding property for dedicated UAV flight test activities. Members of the team are FAA-rated UAS pilots, with three designated as UAS Standardization Check pilots by Penn State. The team holds waivers for altitude and for operating at night.

Polymer Coatings Laboratory

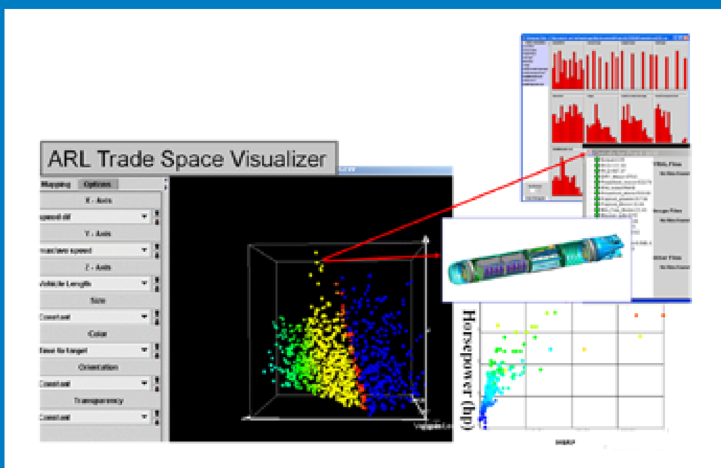
Addresses application, removal, inspection, formulation and testing of organic coatings. The lab also supports the development of surface preparation and cleaning processes and the development and testing of new tooling.

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

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.

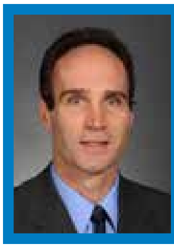
Distributed Engineering Center (DEC)

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.



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

Composites

Mission

Conducts basic and applied research in composite and multi-material and multi-functional hybrid materials and structures for DoD and commercial applications with emphasis on performance, reliability, affordability and technology transfer. Research and development efforts focus on emergent composite design, quality assurance and novel manufacturing technologies for future composite multi-material and multi-functional hybrid material implementation. After successful demonstration, these next generation technologies are implemented according to critical warfighter needs. The Composite Materials Division (CMD) 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.

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 hybrid material solutions to a unique extent. A typical critical element fatigue test setup is shown in the photo.

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. In addition, CMD can conduct Dynamic Mechanical Analysis, Differential Scanning Calorimetry, Thermal Mechanical Analysis, and Atomic Microscopy.

Design and Analysis

CMD possesses state of the art design and analysis capabilities to develop next generation multi-material and multi-functional components. 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. Tooling 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.




UNIQUE CAPABILITY
Prototype Fabrication

CMD developed and demonstrated a novel low-cost, low-maintenance net shape fabricated three-blade marine hydrokinetic (MHK) composite rotor using ARL's concurrent development approach. This process required that all critical technology participants (materials, design, analysis, fabrication, and test and evaluation subject matter experts) were engaged throughout the prototype evolution from concept to prototype demonstration. The composite rotor design was performed using computational fluid dynamics and structural finite element analysis that required multiple design iterations to limit the maximum composite strains to be less than a threshold fatigue strain established by coupon fatigue testing. As long as the composite strains were less than the threshold, the composite rotor won't experience fatigue wear-out over the 20-year operational life-time of the MHK rotor. Ease of fabrication was achieved by implementing an emergent net shape fabrication process (no additional finish machining), and finally, rotor robustness was demonstrated by half-scale prototype static and fatigue testing. As a result of this design, fabrication and test protocol, the net shape fabricated three blade composite rotor has the potential to significantly reduce capital and operational expenditures.

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.

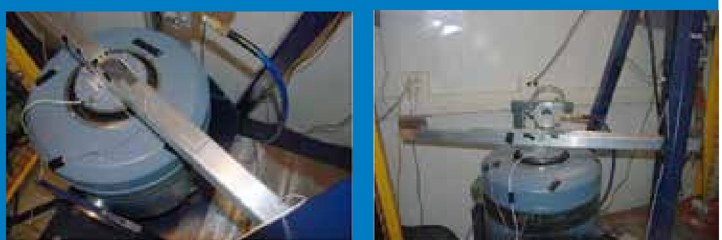
UNIQUE CAPABILITY
High-Rate Fatigue Test and Evaluation

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.

In-Water and In-Air Test Configurations

Long Duration Fatigue Test and Evaluation

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.



Shaker Testing Configurations

Materials Science Technology

Tim Eden, Ph.D.
Technology Leader

Mission

The Laser Processing and Materials Processing Divisions have been combined into the Material Science Division (MSD). The new division performs basic and applied research in a broad range of materials and material processing in support of the DoD and U.S. industrial base. MSD personnel develop and transition 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. Division personnel provide leadership in the fields of additive manufacturing, advanced laser processing, in-process monitoring, hybrid deposition processes, a wide-range of coating, material characterization , electronic materials, devices and sensors, drive train technology, and metal and ceramic processing. The six departments and one center are:

- Metals, Ceramics and Coatings Processing
- Process, Physics, Analytics and Engineering
- Materials Engineering and Evaluation
- Electronic Materials and Devices
- Mechanical Drivetrain Transmission Technologies
- The Center for Innovative Material Processing through Direct Digital Deposition (CIMP-3D)

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 Additive Manufacturing, Hybrid processes, 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 and ceramic development and processing for extreme environments, fragmenting steels, thermomechanical processing, failure analysis, and modeling, as well as development and production of bulk and thin film crystals. 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:

COMMERCIAL LASERS

Macro Processing

- 500 W single mode ytterbium fiber laser (1070 nm)
- 400 W (Average) pulsed Nd:YAG (1064 nm)
- 1 J/Pulse Q-switched Nd:YAG (1064)
- NdLVO4 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)

Work Cell

- Two 6-axis Robotic Systems (ABB and Kuka)
- Large 5-axis gantry system (3.4 m x 3.4 m)
- 5-axis motion system (3 linear and two rotational)
- A number of microprocessing systems

Technology Transfer Facility

- Support Equipment
- 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, WA
- 25 kW cw CO_2 laser at ATS Corporation, Samford, ME, with 7.3 m gantry

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

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 45 kW guns
- Capable of continuously feeding 3 ingots individually or simultaneously for the synthesis of complex compounds through co-evaporation processes
- Chamber is approximately 90 cm in length, 90 cm in width, and 90 cm in height for accommodating large components
- Evaporation rates range from 0.5 nm to 100 μm per minute depending on the material

Lab Scale Electron Beam Physical Vapor Deposition (EB-PVD)

- One EB gun (8 kW), four 25 cc hearths allows up to four different materials to be deposited
- Cold cathode ionization source with chamber size of 66 cm x 60 cm x 100 cm
- 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 8 cm 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

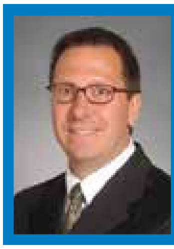
Deposition
- Chemical Vapor
- Cambridge Savannah ALD

Evaporation
- Kurt 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



Systems and Operations Automation

Jeffrey Banks
Technology Leader

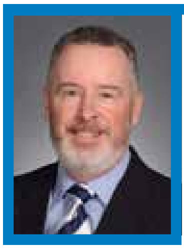
Mission

The Systems and Operations Automation (SOA) Division develops, demonstrates, and transfers new technologies to monitor and control the health and operation of mechanical, electrical, and electrochemical systems to DoD, other government, and industrial customers. Within SOA, the Complex Systems Monitoring (CSM) Department applies a systems engineering approach for designing, costing, and implementing Condition Based Maintenance Plus (CBM+) solutions. CSM then identifies applicable technologies and formulates an engineering implementation plan for deployment. 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 processing, and data fusion, the division is pioneering much of the technology, techniques and practices for engineers to apply CBM+ across the Navy and DoD. 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, Marine Corps, and Army sources the SOA Division conducted many demonstrations of system health monitoring aboard submarines, ships, aircraft, rotorcraft, ground tactical vehicles and fixed facility. Along with maturing technology, the SOA Division was instrumental in the development and advocacy of standards pertaining to condition based maintenance information. 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/management. More recently we have assisted in the cost benefits analysis and analyses of alternatives as the various program managers within DoD are building condition based maintenance plus into their weapon platforms to realize the benefits of lower life cycle costs and increased operational availability.

Facilities

Automation Technology Laboratories

The Robotic Technology Laboratory 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.



Logistics and Operational Effectiveness

Bob Walter IV
Technology Leader

Mission

The Logistics and Operational Effectiveness (LOE) Division's mission is to help the DoD to be more effective and efficient by developing new science and technology, building prototypes, demonstrating prototypes in relevant environments, and transitioning successful results to programs of record. We conduct basic and applied R&D efforts focused on acquiring data, turning data into information and knowledge, and delivering that data, information and knowledge to the right warfighter at the right time.

Our research spans the spectrum from the tip of the spear to the heart of the enterprise. Specific benefits are different for each domain but our common objectives are to increase the quality and speed of military decision-making in these areas:

- Planning supply chain inventory allocation and placement
- Forecasting spare parts requirements
- Developing tactical courses of action and analyzing options
- Implementing robotic process automation
- Defining enterprise resource planning processes

The LOE Division uses modeling and simulation to create a broad set of courses of action then applies artificial intelligence and machine learning identify the best solutions for a given scenario. The solutions are constrained by the time and computational power available to the decision makers.

Facilities

Systems Integration Laboratory

The LOE Division and the Systems and Operations Automation Division developed the Systems Integration Laboratory to conduct experiments and demonstrations at the scale of enterprise computing. The SIL is best described as a private cloud. The SIL contains virtual computing centers, each designed and developed to meet the needs of individual research projects. The applications in the SIL include global combat support, enterprise resource planning, blockchain, supply chain, predictive maintenance analytics, battlespace knowledge, and big data management. The SIL is connected to the AWS Government Cloud environment to create a "hybrid cloud".

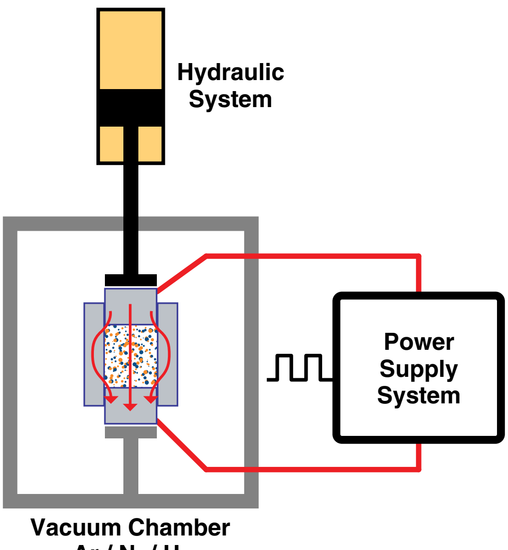
Field Assisted Sintering Technology (FAST) Center of Excellence

Jogender Singh, Ph.D.
Technology Leader

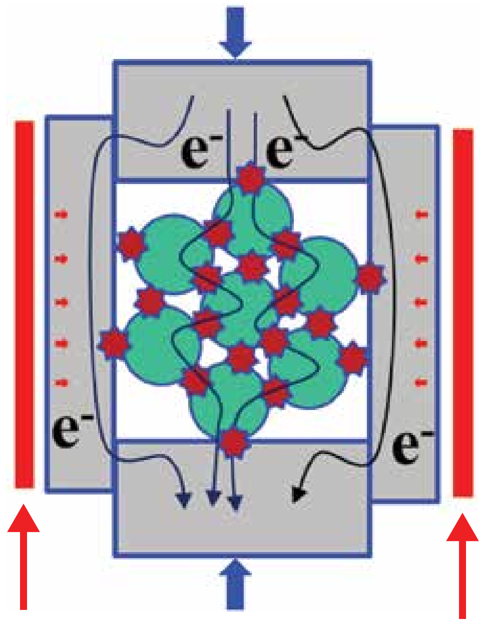
Field Assisted Sintering Technology (FAST) is an emerging manufacturing technology process having a significant impact on sintering and densification of various ceramic, metallic, and composite materials. Also known as Spark Plasma Sintering (SPS), this process offers higher heating rates and lower sintering 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

- Processing cycle time: 60–80 times faster than conventional method
- Lower sintering temperature than conventional methods
- Retain sub-grained structure
- Compositional graded structures
- High density achievable
- Significant energy savings: 30–40%
- Joining of dissimilar materials (metals and ceramics)



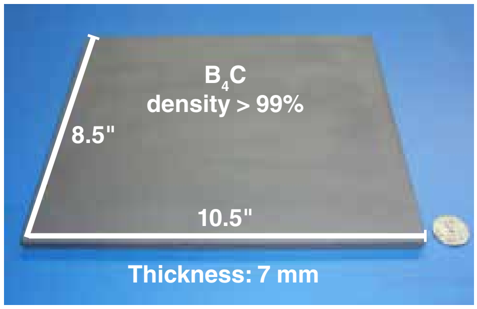
Conventional FAST System



Hybrid FAST System incorporates Induction Heater

Potential Materials

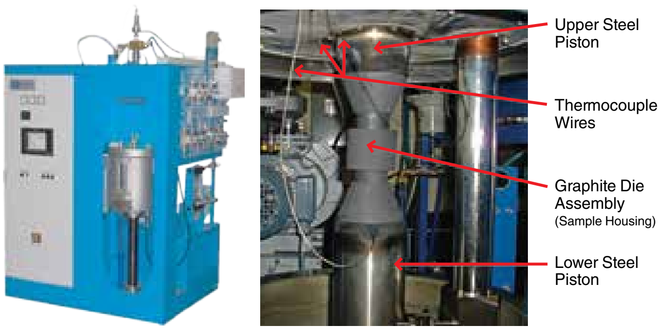
- Polymers: High molecular weight polymer based composites
- Metals: Al, Cu, Ti, Ni, Re, Ta, W, and their alloys
- Ceramics (carbides, nitrides, oxides): SiC, B_4C, Si_3N_4, TaC, HfC, Hf-TaC
- Composites: SiC-SiC, C-SiC, B_4C/Al, W/Cu



Ceramic plate

Machine Capability

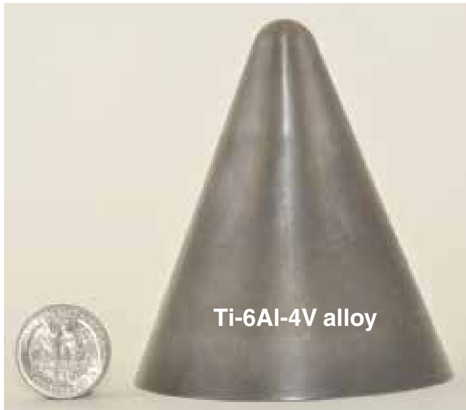
- Component size: Up to 14-inch diameter and 10-inch height
- Temperature: Up to 2400˚C

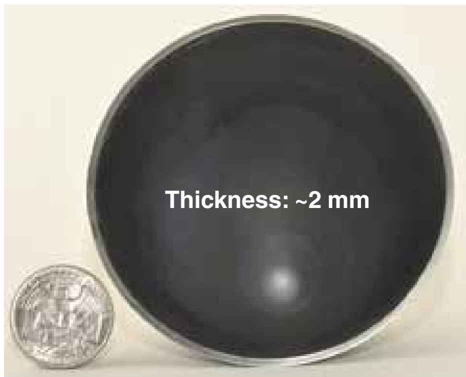


25 ton

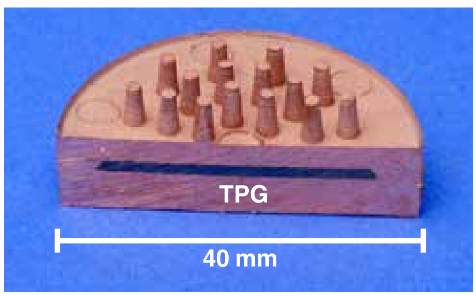
250 ton

Hybrid 325 ton





Net-shaped Fabrication of Hollow Cone



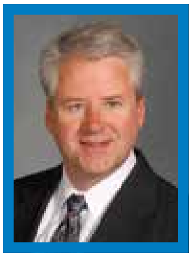
Encapsulated TPG heat sink with fins

Penn State is the only academic institution in the USA with such capabilities

Applied Research Laboratory

Staff Profiles

PennState
Applied Research Laboratory

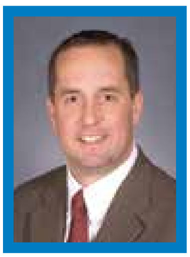


Allan G. Sonsteby, Ph.D.

Executive Director, Applied Research Laboratory
The Pennsylvania State University

B.S., Electrical Engineering, minor in Mathematics, The Pennsylvania State University
M.S., Electrical Engineering, The Pennsylvania State University
Ph.D., Electrical Engineering, The Pennsylvania State University

The 7th director of Penn State's Applied Research Laboratory, Dr. Allan Sonsteby oversees and coordinates ARL's strategy, research activities, and operations. 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. ARL is comprised of approximately 1,400 research faculty, staff, and students who are supported by more than $319 million of sponsored research awards annually. ARL has field activities located across the country including in: Warminster, Pennsylvania; Kittanning, Pennsylvania; Freeport, Pennsylvania; Reston, Virginia; Keyport, Washington; and Key West, Florida. As a designated University Affiliated Research Center, ARL is critical to developing and executing essential research in support of our nation's priorities free from conflict of interest or competition with industry. Prior to assuming directorship of ARL, he was the Deputy Executive Director at ARL, and previously served as a senior scientist and chief scientist for the U.S. Navy. He also served as chairman and U.S. representative for two NATO technical panels addressing electronic warfare and information operations. In addition, he recently completed a four-year appointment on the U.S. Air Force Scientific Advisory Board, reporting directly to the Secretary of the Air Force and was awarded the Commander's Public Service Award. He is a founding trustee of the Intelligence and National Security Foundation—a nonprofit, nonpartisan organization that works to promote and recognize the highest standards within the national security community.



Mark T. Traband, Ph.D.

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.

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

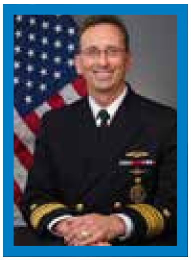
A.S., Business Administration, The Pennsylvania State University
B.S., Finance, The Pennsylvania State University

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.

Supporting the Navy — Marine Corps — Penn State Team

Office of Naval Research

Sponsor Profiles



Rear Admiral David J. Hahn USN

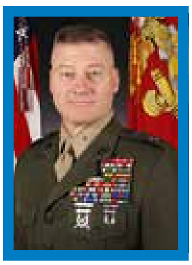
Chief of Naval Research

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

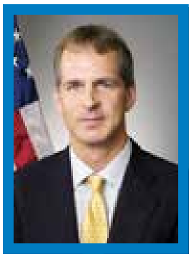
Vice Chief of Naval Research
Commanding General, Marine Corps Warfighting Laboratory

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

Points of Contact

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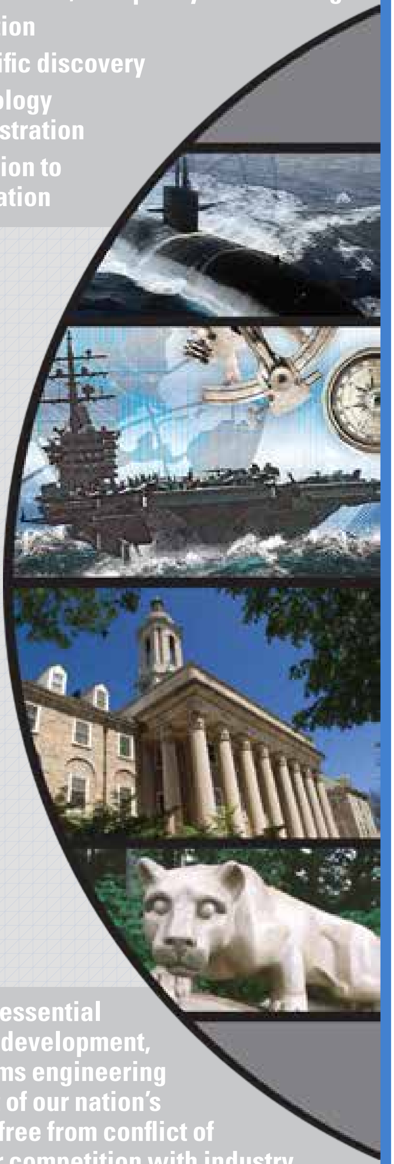

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U.Ed. ARL 20-1