Navy Metalworking Center

ADVANCED METALWORKING SOLUTIONS FOR NAVAL SYSTEMS THAT GO HARM'S WAY

2016 ANNUAL REPORT

The Navy Metalworking Center (NMC) was established in 1988 as one of the Centers of Excellence of the Office of Naval Research's Manufacturing Technology (ManTech) Program.

To support the Navy's mission to reduce total ownership cost, NMC works with government and industry to develop and optimize metalworking and manufacturing processes and to implement the solutions in the U.S. industrial base.

NMC is operated by Concurrent Technologies Corporation, an independent, nonprofit applied scientific research and development professional services organization located in Johnstown, Pennsylvania. For more information on NMC, visit www.nmc.ctc.com.

Navy Metalworking Center

ONR Technology Transition Achievement Award

2016 – Tow Cable Maintenance Winch (winner)

This award recognizes the exceptional effort required for rapid transition of new technology into a program of record for improving system performance or decreasing operations or support costs.

DoD ManTech Achievement Awards

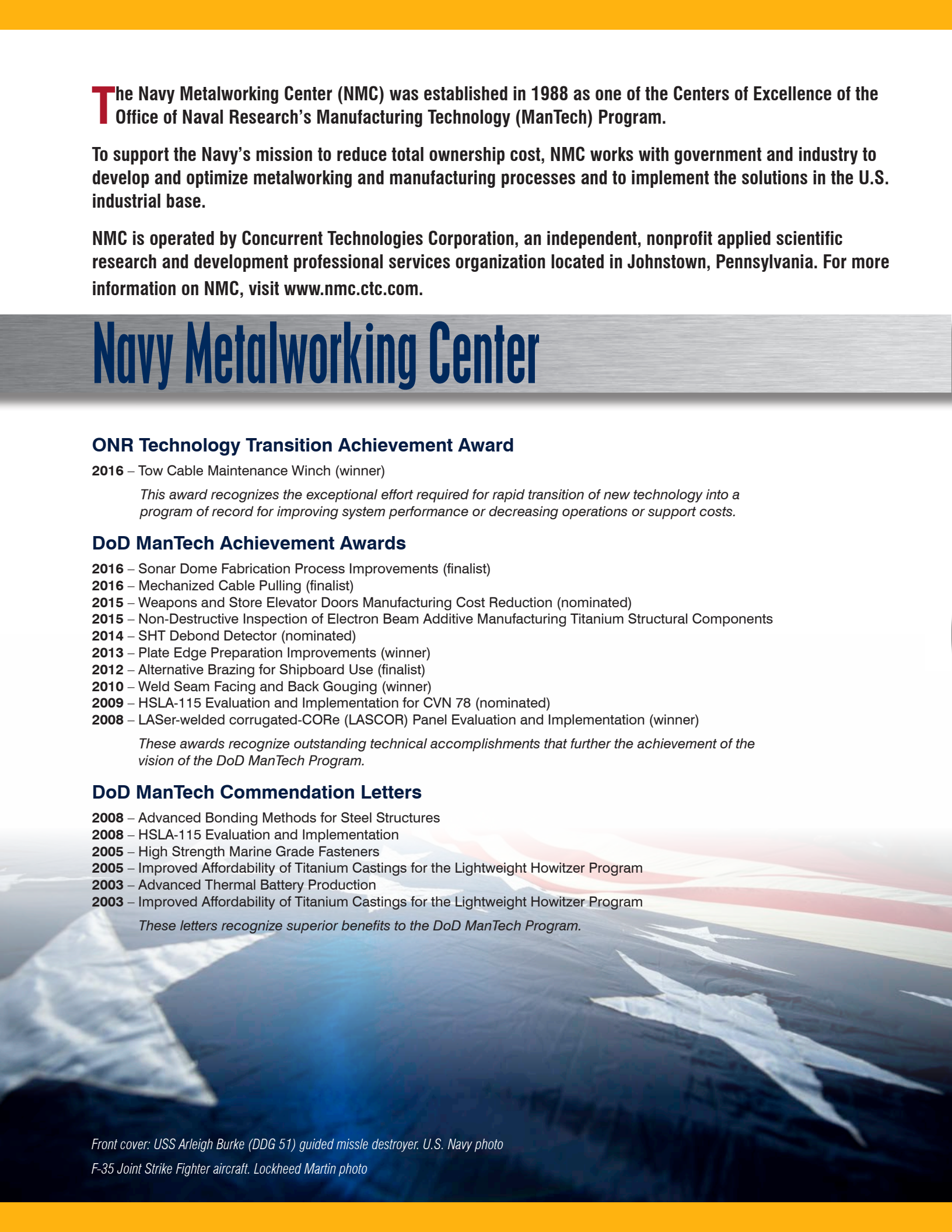
2016 – Sonar Dome Fabrication Process Improvements (finalist)
2016 – Mechanized Cable Pulling (finalist)
2015 – Weapons and Store Elevator Doors Manufacturing Cost Reduction (nominated)
2015 – Non-Destructive Inspection of Electron Beam Additive Manufacturing Titanium Structural Components
2014 – SHT Debond Detector (nominated)
2013 – Plate Edge Preparation Improvements (winner)
2012 – Alternative Brazing for Shipboard Use (finalist)
2010 – Weld Seam Facing and Back Gouging (winner)
2009 – HSLA-115 Evaluation and Implementation for CVN 78 (nominated)
2008 – LASer-welded corrugated-CORe (LASCOR) Panel Evaluation and Implementation (winner)

These awards recognize outstanding technical accomplishments that further the achievement of the vision of the DoD ManTech Program.

DoD ManTech Commendation Letters

2008 – Advanced Bonding Methods for Steel Structures
2008 – HSLA-115 Evaluation and Implementation
2005 – High Strength Marine Grade Fasteners
2005 – Improved Affordability of Titanium Castings for the Lightweight Howitzer Program
2003 – Advanced Thermal Battery Production
2003 – Improved Affordability of Titanium Castings for the Lightweight Howitzer Program

These letters recognize superior benefits to the DoD ManTech Program.



Front cover: USS Arleigh Burke (DDG 51) guided missle destroyer. U.S. Navy photo

F-35 Joint Strike Fighter aircraft. Lockheed Martin photo

Manufacturing Tooling Development

Some of NMC's most significant technical achievements, implementation successes, and cost reductions result from projects that developed innovative manufacturing tooling and fixturing to address naval manufacturing issues. Our capabilities span the entire process – from creating the initial concepts, to iteratively refining the tooling to ensure it meets the need, to transitioning the final product to a commercialization partner or manufacturing facility. NMC leverages internal and industry expertise throughout the process.

Arleigh Burke class guided missile destroyer USS Benfold (DDG 65). U.S. Navy photo

S2560 Mechanized Cable Pulling

The Joint Defense Manufacturing Technology Panel has nominated two NMC-led projects for the 2016 Defense ManTech Achievement Award, including one that developed two mechanized tools for pulling cable on board ships at both Ingalls Shipbuilding (Ingalls) and Bath Iron Works (BIW) that are saving significant labor. Ingalls initially used the prototype dual roller and capstan tools on DDG 113 and DDG 114 in 2015 and has purchased more tools for future use. BIW purchased one dual roller and one capstan tool for use on DDG 116 in 2016 and expects to purchase more. Ingalls anticipates a 20 percent labor savings for installing Class III and Class IV cables on the Amphibious Assault Ship (LHA), Amphibious Transport Dock (LPD), Guided Missile Destroyer (DDG) and the National Security Cutter (NSC), which will result in $1.5 million savings based on using the tools on a single hull of each of the programs that Ingalls constructs. Newport News Shipbuilding (NNS) plans to evaluate the tools for use on CVN 79. The project team included the LHA, LPD, DDG 51, and CVN Program Offices, Ingalls, NNS, Naval Sea Systems Command (NAVSEA) 05Z, and NMC.

Tools developed under the Mechanized Cable Pulling project will reduce labor as well as health and safety issues associated with shipboard cable pulling. Pictured are the capstan (left) and dual roller (right) tools. NMC photos

NMC and Ingalls developed and implemented an easy-to-use prototype mechanical arm to perform hull exterior abrasive blasting from a man lift during ship construction. Ingalls photo

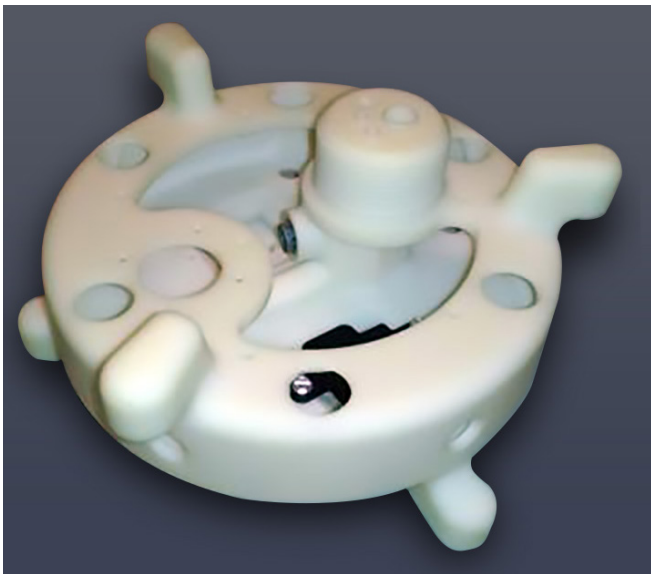
R2658 Abrasive Blasting Arm for Man Lift

Ingalls has also implemented the results of another NMC project that improves the process to perform abrasive blasting on hull exteriors during construction. A project team comprised of the DDG 51 Program Office, Ingalls, and NMC developed an easy-to-use, motion-assisted positioning system for use on a man lift that significantly reduces strains and fatigue for the worker performing these operations. Ingalls began using the blasting arm in March 2016; the technology can also be transferred to other Navy construction programs, shipyards, and industries that perform abrasive blasting from a man lift. Five-year estimated cost savings are $840,000 for all ship platforms constructed at Ingalls (DDG 51, LHA, LPD, and NSC).

S2564 Hull Production Automation Methods

Ingalls is also benefitting from the efforts of an NMC-led project team that optimized mechanized processes to reduce labor and improve quality during hull fabrication. Ingalls is expected to save $6.7 million over five years on LHA, LPD, and DDG platform construction through implementation of the project team's solutions to the current labor-intensive manual processes for certain fitting and welding activities. In the third quarter of FY15, Ingalls began implementing project results, including portable jack supports for structures, tee beam alignment tools, ratcheting push-pull tools, and transverse stiffener jacks, and completed full implementation in the fourth quarter of FY16. The project team included the DDG 51 and LHA Program Offices; Ingalls; Naval Surface Warfare Center, Carderock Division (NSWCCD); and NMC.

Mechanized and/or automated processes will reduce labor and improve quality during hull fabrication. Ingalls photo



The use of additive manufacturing in ship construction will save acquisition costs on several ship classes. NMC photo

S2691 Pipe Cutting Machine Technology

NMC is leading a project with NNS and Ingalls to optimize an onboard pipe cutting/beveling process that will reduce labor and improve worker safety. The project team is developing tooling and fixture concepts to address issues with the current equipment that is intended for use in open environments – not the confined working conditions on Navy ships. The project results will be used on large, thick-walled piping on Virginia class submarines (VCS) and CVN new construction and CVN Refueling and Complex Overhaul at NNS, and DDG 51, LHA, LPD, and NSC new construction at Ingalls, starting in October 2017. Reduced labor on all hulls is expected to save $3.5 million over five years. In addition to the shipyards and NMC, the project team includes the VCS Program Office and NSWCCD.

S2608 Additive Manufacturing for Shipbuilding Applications

Shipbuilding and other industries are increasingly interested in exploring the benefits of additive manufacturing (AM) to save costs. A project team led by NMC investigated AM for Ingalls by assessing and demonstrating the use of AM during ship construction activities, quantifying the expected benefits, and providing a recommended path forward. For General Dynamics Electric Boat (EB), the team validated a process map that reduced the lead time associated with printed parts. Ingalls estimated a minimum acquisition cost savings of $405,000 per year by utilizing AM technology to support the construction of DDG, LHA and LPD. However, Ingalls has determined this is not a sufficient business case to justify purchase of a three-dimensional (3-D) printer at this time; it will instead outsource this capability for immediate and near-future needs. EB has estimated a minimum acquisition cost savings of $213,000 per VCS hull by using AM technology to rapidly deploy new tooling/fixtures. The EB Quonset Point facility intends to expand its printer capability laterally (i.e., purchase multiple identical desktop printers for increased volume and availability) in FY16. The project team included the DDG 51 and VCS Program Offices, Ingalls, EB, and NMC.

Virginia class submarine USS Texas (SSN 775). U.S. Navy photo

Joining Technologies

NMC considers a multitude of factors when determining the best method to join materials on Navy platforms – material, joint type, design and manufacturing requirements, and others. NMC applies and/or optimizes various innovative welding technologies to address the challenges associated with joining weapon system components.

San Antonio class amphibious transport dock USS Green Bay (LPD 20). U.S. Navy photo

S2602 Weld Sequence Planning for Major Assemblies

An NMC project is developing a user-friendly weld sequence planning tool that allows shipbuilders to quickly determine the optimal weld sequence and best practices to improve acquisition affordability for VCS and Ohio Replacement (OR) class submarines. Currently, weld-induced distortion on major VCS assemblies is addressed by labor-intensive, trial-and-error methods during the fabrication process. This project will enhance commercially available software so that it can quickly and easily be used by manufacturing planners to provide best practice fixture and weld sequence recommendations to the shop floor to minimize distortion and obtain critical structure tolerances with reduced rework. EB estimates a $3.87 million cost savings over five years for VCS and $580,000 per OR hull through reduced trial-and-error weld sequencing, mitigation of weld-induced distortion in the final product, and improved throughput. This solution also has the potential to impact all platforms that experience weld distortion (CVN, LHA, DDG, LPD, etc.), which could result in significant long-term cost savings. The tool is expected to be implemented at EB on SSN 796 starting in the second quarter of FY17. The VCS and OR Program Offices, NSWCCD, EB, and NMC comprise the project team.

A weld sequence planning tool will save labor costs for VCS and OR class submarines. U.S. Navy photo

S2590 Modular Scalable Cold Plates for Naval Electronics

NMC led a project to optimize friction stir welding (FSW) processes to join modular heat exchangers to form a larger cold plate assembly. FSW provides lower distortion, improved weld strength and quality, and improved overall system affordability. Current manufacturing approaches for the fabrication of edge-cooled naval electronic assemblies are size limited, resulting in low product yield and high costs due to difficulties associated with brazing large, monolithic, highly complex assemblies. An estimated $300,000 per hull cost savings is possible for DDG 51 Flight III and $880,000 per hull for DDG 51 Flight IIIA. Raytheon is considering other implementation opportunities, such as Enterprise Air Surveillance Radar (EASR), Enterprise X-Band, and Army Navy / Transportable Radar Surveillance (AN/TPY-2) X-Band Radar. The project team includes PEO IWS 2.0; Naval Surface Warfare Center, Crane Division; Raytheon Integrated Defense Systems; Thermacore; and NMC.

S2604 Shape Cutting and Welding Automation

Fabricating stiffener assemblies on surface ships creates many quality challenges as manual processes are used throughout the manufacturing sequence. An NMC project characterized the causes of inaccuracies and inconsistent quality of the fabricated stiffener assemblies. The project team developed process improvements, and optimized tooling and prototype equipment to improve the stiffener manufacturing process, including improved forming processes to increase part accuracy and consistency. The project's solutions will reduce labor and rework, and increase accuracy and throughput, significantly lowering costs and improving the production schedule for this operation. The automated technologies are expected to save $5.4 million during a five-year period across several platforms in labor and material savings alone. Upon successful completion of the project, results will be implemented at Ingalls in support of LHA, LPD, DDG 51, and NSC, starting in the second quarter of FY17. The DDG 51 Program Office, Ingalls, NSWCCD, and NMC contributed to this effort.

Automating the cutting and welding of stiffeners will reduce shipbuilding costs and improve the schedule due to reduced labor and improved efficiency and quality. Ingalls photo

Robotic welding of innerbottoms and side shell assemblies will improve productivity and reduce costs of DDG 51 construction. BIW photo

S2636 Robotic Welding of Complex Structures

NMC is leading a project to develop and demonstrate a system to rapidly instruct existing welding robots on welding path locations in complex assemblies. The project team, including the DDG 51 Program Office, BIW, NSWCCD, and NMC, is investigating several robot-mounted sensing systems for use on large complex ship structures such as innerbottoms and side shell structures. Large-scale implementation of robotic welding is estimated to produce more than $5 million savings for the DDG 51 class at BIW over five years as a result of labor and material savings and schedule compression. Implementation is expected to take place at the DDG 1000 peripheral vertical launch system cell in the Aluminum Shop at BIW in the third quarter of FY17 in production of DDG 120.

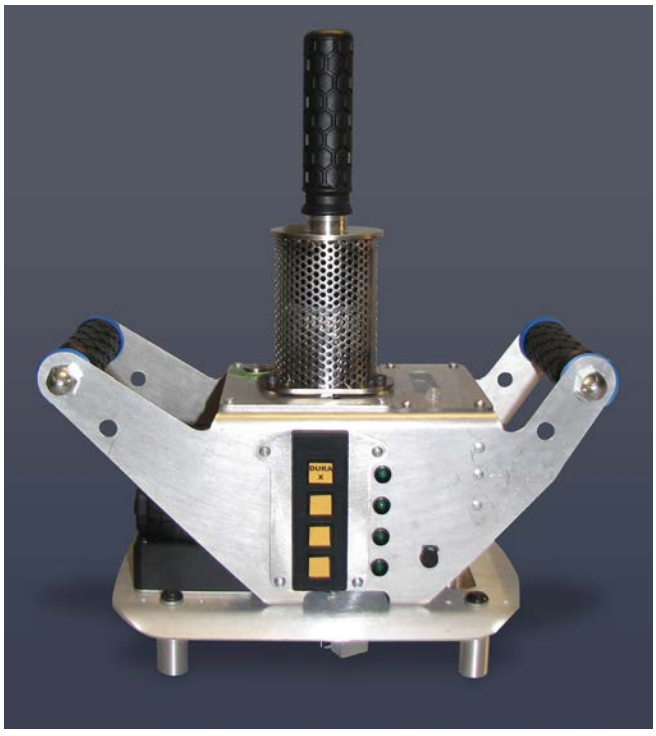
Advanced Metrology and Inspection Technologies

The processes and tools used to measure and inspect system components can significantly impact cost and performance. NMC leads projects that are developing and implementing advanced measurement (metrology) and inspection technologies at industrial facilities.

Gerald R. Ford (CVN 78). U.S. Navy photo

R2709 Debond Detector Units

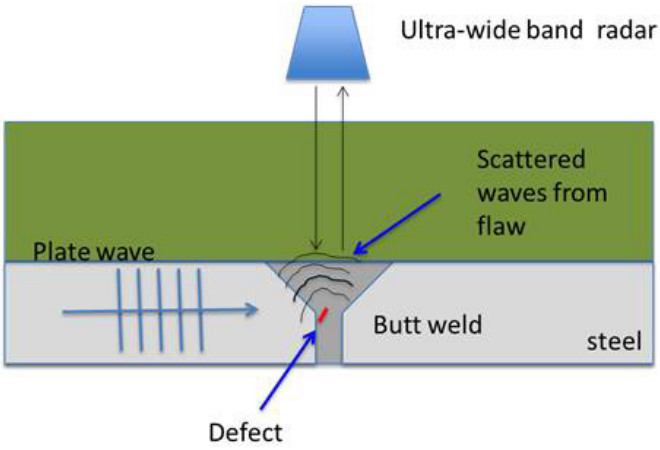
NMC and industry partner Rentz Technology Systems have once again expanded technology they initially devised to inspect SHT on VCS during new construction. The original debond detector unit (created under Navy ManTech project S2363) replaced a manual tap inspection on VCS at EB. A follow-on ManTech project (R2607) modified the design for use in-service and demonstrated the units at Pearl Harbor Naval Shipyard (PHNSY) and Intermediate Maintenance Facility (IMF). That facility subsequently requested further modifications to meet its unique requirements. Three of the latest debond detectors were delivered to PHNSY and IMF for use on VCS hulls during future availabilities. The technology eliminates operator subjectivity, reduces the level of inspection training needed, and saves an estimated 100 labor days per hull. Rentz Technology Systems, PHNSY and IMF, and NMC comprised the project team.



A modified debond detector will support special hull treatment (SHT) inspection operations at Pearl Harbor Naval Shipyard. NMC photo

Q2711 Inspection Under SHT Phase I

NMC is conducting a project that will reduce the cost of the periodic inspection of submarine pressure hulls. The current processes, which include visual and ultrasonic inspection, require the removal of significant amounts of SHT to access the hull structure underneath, followed by reinstallation of SHT after the inspection. Advanced technologies that allow for inspection directly through SHT could significantly reduce inspection costs. Of significant interest are the use of ultra-wide band radar, phased array ultrasonic with reduced contact area, and terahertz imaging. Reducing the amount of SHT that must be removed and reinstalled to accommodate hull integrity inspection during availability of VCS has the opportunity to reduce cost by as much as $1.2 million per hull per inspection cycle. The project team includes SEA 05U7; Naval Surface Warfare Center, Philadelphia Division; Lawrence Livermore National Laboratory; Penn State Applied Research Laboratory; Naval Undersea Warfare Center, Newport; and NMC.

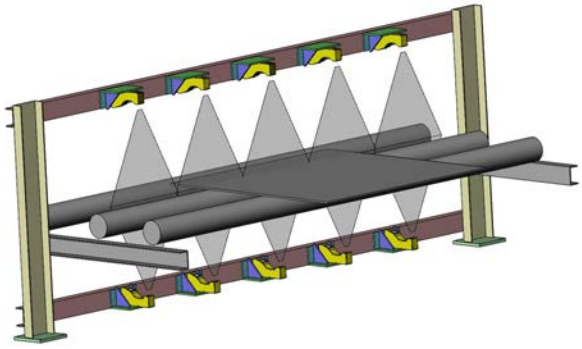


Advanced technologies that allow for inspection directly through special hull treatment could significantly reduce inspection costs. Lawrence Livermore Laboratory photo

Virginia class submarine USS North Carolina (SSN-777). U.S. Navy photo

S2606 Efficient Identification of Plate Defects

An NMC-led project team is developing a 3-D inspection tool that can reliably detect critical surface flaws as early as possible in the construction process to maximize cost savings. The tool must have the speed, accuracy, repeatability, and durability to work in a shipbuilding environment. By implementing an inspection system at the pre-construction primer line prior to painting, NNS is expected to reduce inspection and repair costs by $3.5 million over a five-year period for the construction of CVN 78 class aircraft carriers. Ingalls expects a $650,000 five-year savings on DDG 51 and LHA class ships. Implementation is planned in August 2017 at Structural Coatings, a subcontractor to NNS. Secondary implementation is planned in 2018 for the pre-construction primer line at Ingalls in support of DDG 51 and LHA. The technology can be successfully implemented in other Department of Defense (DoD) and commercial shipyards. The project team includes the CVN 79 Program Office, NAVSEA 05V, NNS, Ingalls, and NMC.



Identifying defects in steel plates earlier in the construction process will save shipbuilding costs. Custom Lab Software Systems, Inc. photo

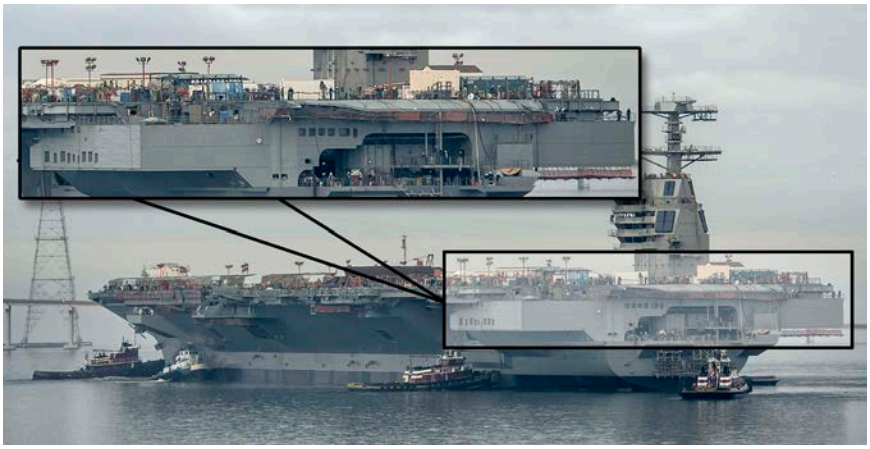
Manufacturing Process Optimization

NMC has a long history of working with external partners and implementing organizations to identify the best manufacturing processes for a given task and then optimizing those processes for the unique applications required in weapon system construction. Our internal technical staff optimizes and refines manufacturing processes for specific applications to improve quality and performance and to reduce cost, including recommending design changes to enhance manufacturability.

F-35C Lightning II Joint Strike Fighter aboard the USS Dwight D. Eisenhower (CVN 69). U.S. Navy photo

S2561 CVN Vertical Build

NNS is implementing NMC project recommendations to perform certain outfitting activities earlier in the shipbuilding process on future aircraft carriers, saving construction costs. Pre-outfitting items such as piping, wiring, ductwork, insulation, machinery, and other equipment prior to erection and concurrent with structural assembly will substantially improve efficiency on the panel line and platens on CVN 79 and on all future ships. The project team produced a specific plan for complete outfitting of four spaces prior to erection – a first in CVN construction. They also identified an approach that combines multiple items onto a common frame, creating one unit that can be constructed in the shop and then installed as a single, pre-tested item on the ship. Cost reductions are based on the 1-3-8 rule (shop/platen/post-erection construction costs). An NNS analysis indicates a nearly $4 million benefit. Project team members include the CVN 79 Program Office, Supervisor of Shipbuilding-Newport News, NNS, Hepinstall Consulting Group, and NMC.



Efficiencies can be realized for CVN by increasing the amount of construction work done prior to erection. The project target area is highlighted. U.S. Navy photo

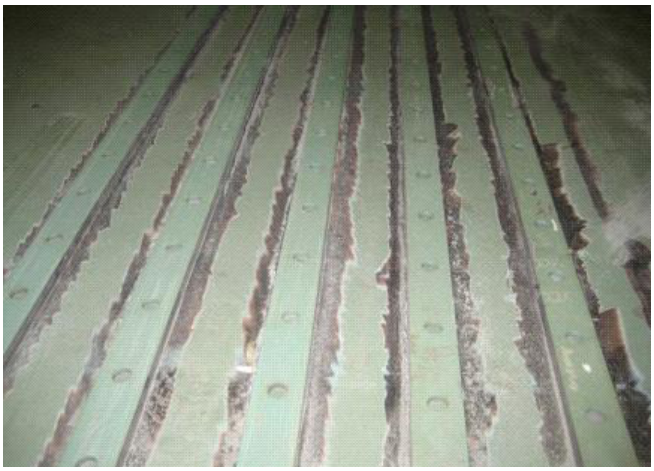
New tools and technologies will reduce time, labor, and rework associated with sonar dome fabrication. Ingalls photo

S2579 Sonar Dome Fabrication Process Improvements

Ingalls implemented several tools and technologies that streamline the processes to fabricate the DDG 51 class sonar dome, which is challenging to construct due to its complex geometry. Because of this project's success, the Joint Defense Manufacturing Technology Panel has selected it as one of the top six nominations for the 2016 Defense ManTech Achievement Award. NMC led a project team that developed, enhanced, and tested several material removal technologies that increased efficiency. Notably, the team developed and pilot tested a portable grinding station consisting of a mechanical arm and versatile mounts for various conditions. They also investigated and recommended implementation of a laser scanner system to perform plate check verification to reduce or eliminate rework prior to installation. To date, Ingalls has implemented a portable grinding station featuring zeroG® and 3arm® mechanical arms with optimized gimbal and mounting hardware provisions, a Hypertherm Powermax® 125 air plasma cutting/gouging system, a stem bar gauge, and a Surphaser® laser scanner with custom measurement plan. Ingalls is procuring additional tools and plans to use the project results in other process areas and platforms, namely LHA, LPD, and NSC. BIW, Portsmouth Naval Shipyard and BAE Systems-York also expressed interest in the project results. This project reduced labor to fit and assemble DDG sonar dome components and structures across Ingalls other platforms by an average of 16 percent. Reduced labor is expected to save $7.6 million over five years at Ingalls. The DDG 51 Program Office, NSWCCD, Ingalls, material removal and metrology industry partners, and NMC contributed to this project.

S2582 Improved Weapons Magazine C-Channel

An NMC-led project team reduced the overall installation hours and the associated costs to install the Universal Weapons Magazine Tie-down System (WMTDS) on Navy platforms through improved manufacturing and installation processes. Installing the deck channel (C-channel) involves considerable grinding, leveling, welding, and surface preparation. In addition, access is difficult when applying surface coating to the C-channels. The project optimized and evaluated several WMTDS concepts; early implementation of the spacing, tolerancing, and other process improvements began in July 2015 on LHA 7 at Ingalls. The implementation target date for C-channel improvements is the fourth quarter of FY17 on LHA 8 at Ingalls and the third quarter of FY19 on CVN 80 at NNS. An estimated $5.5 million will be saved over five years based on reduced installation costs (layout changes, welding, grinding, leveling, painting, and rework) on CVN 80, LHA 7 and LHA 8, and DDG 122, 124, 127, 129, and 130 hulls. The project team was comprised of the CVN 79 Program Office and PMS 377, NNS, Ingalls, NSWCCD, NAVSEA, and NMC.



Improving the manufacturability and installation of weapons magazine C-channels will reduce labor and costs. Ingalls photo

A manufacturing work cell that automates and / or mechanizes various processes will reduce costs, improve ergonomics and quality, and increase throughput on multiple naval platforms. Ingalls photo

A new joint detail that enables Self-Locating/Self-Fixtured (SLSF) deck construction for OR and VPM deck flats will reduce labor hours and costs. Electric Boat photo

S2612 Automated Manufacturing Cell for Small Repetitive Assemblies

NMC is conducting a project that will generate manufacturing efficiencies at the Ingalls Industrial Products Division (IPD) shop, which fabricates hundreds of relatively small, high-volume parts per ship, mostly through manual labor at individual stations throughout the facility. The project team is investigating mechanized or automated technologies along with a work cell approach to improve the manufacture of components such as ladders, manhole covers, and lifting lugs. The improvements will enable these products to be produced more efficiently with improved part quality, resulting in reduced costs. Implementation of the project results is estimated to result in an annual savings of $1.5M across all platforms constructed at Ingalls, i.e., DDG 51, LHA, LPD, and NSC. The results of this project are expected to be implemented beginning in the second quarter of FY17. The project team includes PMS 400D, NSWCCD, Ingalls, and NMC.

S2633 Self-Locating / Self-Fixtured Structures

NMC led a project that devised a more efficient way of fabricating submarine deck structures, which have been traditionally constructed of many short, fitted pieces (intercostals) between continuous beams. The project team developed the manufacturing process for a new concept – the self-locating, self-fixtured (SLSF) method – for fitting and joining the deck structures for OR class submarines and the Virginia Payload Module (VPM). SLSF will enable construction with notched beams that interlock and are continuous in both directions. The team investigated manufacturing processes and requirements to determine the most efficient means of building these structures and produced a final mock-up. The estimated savings are $3 million on the first two OR hulls and $760,000 on each of the eight VPM sections planned in the first five years following completion of the project, for a total five-year benefit of $12 million. Implementation is expected on the lead OR hull and on the first VPM in the third quarter of FY19 at EB's facility in Quonset Point.

S2634 Automated Hanger Manufacturing

An NMC project team is working to streamline the production of hangers used extensively on submarines at EB by developing potentially multiple automated work cells. The solution will efficiently produce several types and sizes of hangers that are used to route pipe, ventilation, and electrical cable onboard VCS and OR class submarines. EB currently manufactures these parts in several labor-intensive forming and machining operations that are dispersed throughout the facility. Mechanized or automated processes are anticipated to save $943,000 per VCS hull and $1.79 million per OR hull through reduced rework and material handling, as well as an increase in throughput. The potential five-year savings are $10.3 million. The results will be implemented at EB on VCS and OR platforms starting in the second quarter of FY18. The project team is comprised of the VCS and OR Program Offices, NSWCCD, Ingalls, and NMC.

S2642 Fuel Cell Producibility

NMC identified opportunities to improve the producibility and to reduce the manufacturing costs of the fuel cell system that will be used on current and future Unmanned Undersea Vehicles. The project team developed a list of alternative materials and manufacturing processes. Transition will occur when the prioritized recommendations are delivered to the Unmanned Maritime Systems Program Office. Implementation is planned for the initial run of the vehicle in FY18-FY19. The project team consisted of the Unmanned Maritime Systems Program Office, ONR Code 333, Strategic Analysis, UTC Aerospace Systems, and NMC.

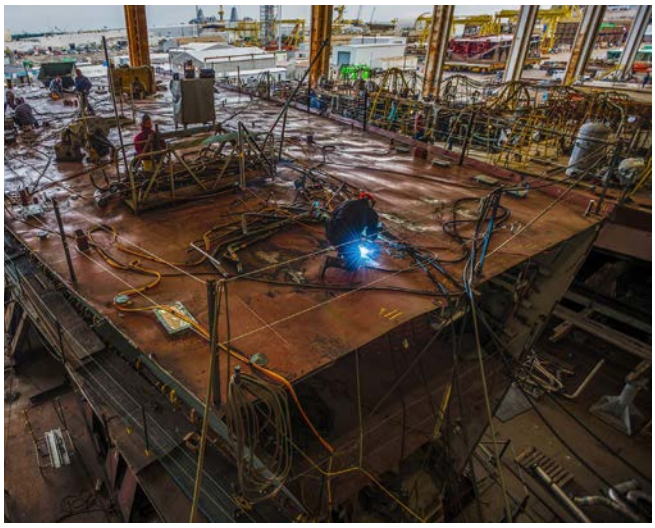
Separating nickel alloy from grinding swarf will significantly reduce material costs for the F135 engine components. P&W image

A2689 Grinding Swarf Reclamation and Reversiong

An NMC project team is developing a process to revert the scrap from grinding the Joint Strike Fighter (JSF) engine turbine disks into the finished shape. Currently, the swarf (material filings) left after grinding contains the metal as well as cutting oil and media from the grinding disk. This project is devising a process to separate and recover the high-cost nickel superalloy, which will reduce costs for the F135 engine program by reducing the amount of virgin nickel material to be procured. The project team, consisting of the JSF Program Office, Pratt & Whitney (P&W), and NMC, will expand upon initial lab-scale trials to optimize a grinding swarf separation process for use on a production scale. Once the production separation process has been successfully demonstrated, the team will produce a forged billet using the reclaimed nickel superalloy combined with new virgin material. The billet will be tested for concurrence with the applicable material specifications for the turbine disks. The project is expected to save at least $5,200 per engine, which equates to a five-year savings of $6.18M (1,188 engine sets). P&W further anticipates using the reversion process to recover material from other grinding swarf waste streams. The total projected savings are $7.6 million over five years. Implementation is planned during the fabrication of F135 nickel alloy components at P&W in FY20.

S2690 Unit Family Construction Optimization

NMC is leading a project that is identifying and optimizing fixturing and material handling solutions to improve unit assembly efficiencies within the Ingalls unit construction areas. The project team is developing technologies that will support a work cell approach to unit construction (i.e., co-locating processes). Specifically, the team is investigating technologies such as modular unit fixture development, deployable material handling and mechanized processes that support fabricating and pre-outfitting the unit within the cell. These technologies and the work cell approach are expected to improve the leveling of structures, handling/setting of bulkhead structures, and transporting components to and within the units. The down-selected concepts will be tested at NMC and demonstrated at Ingalls to support full-scale implementation, which will produce an annual $1.4 million savings across all platforms constructed at Ingalls (DDG, LHA, LPD, and NSC) as well as future platforms. The total projected five-year process savings are $7.2 million. Implementation is expected in early 2018. The project team includes the DDG 51 Program Office, NSWCCD, Ingalls, and NMC.



More efficient unit construction will increase shipbuilding throughput while reducing production costs and labor. Ingalls photo

Advanced Metalworking Technologies

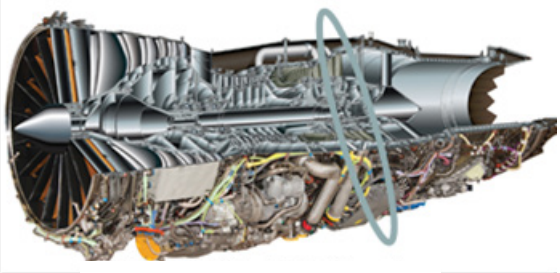
Improving the way metallic materials – whether they're traditional steel alloys, high-strength naval steels, lightweight alloys, or corrosion-resistant metals – are fabricated and integrated into ship and aircraft structures can have a major impact on reducing acquisition and total ownership costs. NMC projects develop and implement advanced metalworking processes and technologies to improve the performance of Navy weapons system components.

CH-53K King Stallion helicopter. Lockheed Martin photo

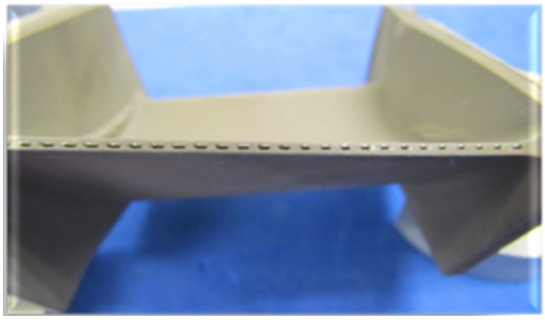
S2576 Mitigation of Cracking in Sensitized Aluminum

A low-cost alternative to reduce cracking in the superstructure of CG 47 class cruisers has been developed and validated by an NMC-led team. In this project, the project team addressed a major contributor to the cracking issue – the sensitized microstructure in the 5456 aluminum-magnesium alloy. The team optimized and demonstrated a portable heat treatment system that reverses sensitization and restores the affected material to a stabilized condition, which greatly reduces the propensity for subsequent cracking. The final reverse sensitization unit was transitioned in September 2016 to Ingalls, the planning yard for CG repairs. This new process can save as much as $2.4 million per CG 47 ship and could result in a cost avoidance of up to $43.2 million for 18 ships serviced within five years. The Littoral Combat Ship (LCS) program will also benefit from this improved technology at a conservative estimate of $500K avoidance per hull, resulting in an additional $4 million in cost avoidance for the LCS hulls in service over the next five years. The project team included the Surface Ship Modernization and LCS Program Offices, NAVSEA 05P2 and 05D, NSWCCD, ElectraWatch, DDL OMNI Engineering, Serco Inc., and NMC.

Application of a device to mitigate sensitization in aluminum structures will be less labor intensive than the current remove and replace process. NMC photo



F135-PW-100 Engine



Implementation of an automated, adaptive grinding solution will reduce production labor costs and improve quality and performance. P&W images

A2632 Automated Turbine Airfoil Trailing Edge Rounding

An NMC-led project team is developing an automated, adaptive profiling system to establish the required trailing edge profiles on F135 turbine engine airfoils that will save more than $15 million for the JSF program over five years. Candidate solutions will integrate metrology, adaptive grinding, and automation technologies to reduce production labor costs and improve quality and performance. The validated solution will be implemented at P&W and Howmet in FY20. The project will reduce acquisition costs by an estimated $13,000 per engine set based solely on reduced scrap; additional labor savings will be quantified on the project during evaluation/validation of the preferred adaptive profiling solution. This equates to a five-year savings of $15.4 million (1,188 engine sets). Other potential benefits may include supporting repair processes and strengthening the industrial base for commercial engines. The Joint Program Office, P&W, Howmet, and NMC make up the project team for this effort.

S2631 Distortion Mitigation for Additively Manufactured Electronic Chassis

NMC is conducting a project to quantify the effectiveness of various dimensional distortion mitigation approaches that would allow the use of AM to produce monolithic aluminum alloy chassis for electronics applications. The project team, comprised of Raytheon, North Carolina State University, and NMC, is evaluating factors such as reinforcement geometry and post-build heat treatment. Fabrication of metal electronics chassis using evolving AM technologies offers the Navy the ability to produce new chassis designs with lower procurement cost and more than 50 percent reduction in lead time relative to the current state-of-the-art, particularly for fluid-cooled chassis requiring internal hermetic fluid channels. In addition, AM reduces the total part count of chassis by 50 to 90 percent, decreasing initial procurement labor and overhead. Multiple weapon systems are candidates to benefit from the successful outcome of this project. A specific weapon system and implementation timeframe will be selected concurrently with development of initial AM builds.

Maturing additive manufacturing technologies to fabricate metal electronics chassis on Navy platforms will reduce cost and lead time. Raytheon image

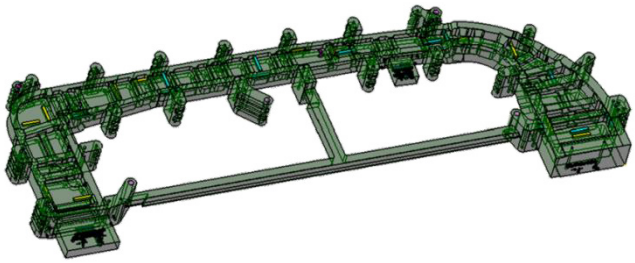
An improved process to repair cracks in the upper structure of MRAP Cougar CAT I/II hulls will reduce the cost and schedule associated with the current method. USMC photo

R2659 MRAP Improved Crack Repair

A Rapid Response project identified improvements for repairing high hard steel (HHS) armor hull structures at DoD depots. Specifically, the project team identified the root cause of in-service cracking in structures used for ballistic protection in the upper hull of the Mine-Resistant Ambush Protected (MRAP) Cougar Category I and II vehicles. The team's findings support the requirement for highly regulated inspection and repair operations. Implementation of general depot-level improvements (e.g., pre-heating the hull to ambient temperatures before doing any work) has been initiated, and the U.S. Marine Corps Medium and Heavy Tactical Vehicles (MHTV) Program Office (governing MRAP assets) has funded an effort to devise a better defined USMC MRAP hull repair technical manual. The project team consisted of the Project Manager MRAP (now MHTV), PEO Land Systems, and NMC, with support from the Naval Postgraduate School, NSWCCD, and both Army and Air Force Program Offices.

S2635 Printed Sand Casting Molds and Cores for HY Steels

NMC is conducting a project that is investigating the use of printed sand mold technology to produce complex high yield (HY) steel castings for VCS and OR class submarines. Potential applications include components currently produced as steel weldments, which are challenging and expensive to manufacture. Printed sand mold technology offers the ability to rapidly design, produce molds and cast complex geometries that would be difficult, if not impossible, to achieve as weldments or conventional castings. This project will reduce rework and material handling and increase throughput as a result of a more efficient work flow. The preliminary savings estimate of converting complex welded assemblies to castings is $1.1 million per OR hull and $271,000 per VCS hull. The potential five-year savings for both platforms are $4.1 million. This solution also is available to other weapon systems. Implementation is expected at EB in January 2019. The project team includes the OR and VCS Program Offices, NSWCCD, EB, ExOne, Naval Undersea Warfare Center Division, Keyport; Bradken; and NMC.



Transitioning a process that mitigates distortion in the production of the CH-53K cabin frame will improve manufacturing cost, schedule, and quality. Spirit AeroSystems image

A2687 CH-53K Frame Machining Distortion Mitigation

NMC is working to reduce distortion of the side cabin frames of the CH-53K Heavy Lift Helicopter. This project will develop and demonstrate mitigation technologies that will reduce a majority of the distortion during manufacturing stages, including machining and quenching. The project will provide direct cost savings by reducing manufacturing errors and improving assembly costs. Industry has reported that reducing or eliminating distortion in the side cabin machine frames is expected to save $87,000 in rework and cost of quality per airframe, with a five-year savings of $6 million over 70 units. The anticipated life-of-program savings are projected to be $16 million based on 197 CH-53K cabin frames. These mitigation technologies will potentially benefit other Navy and non-Navy platforms since distortion is a universal issue. After successful demonstration, the down-selected technology(ies) will be integrated into the standard manufacturing process at the cabin manufacturer, Spirit AeroSystems. In addition to Spirit AeroSystems, PMA 261, Sikorsky Aircraft, and NMC make up the project team.

Coatings Application and Removal

Protecting weapon system components with coatings for performance improvement and corrosion protection can be critically important. Improving the coating materials, as well as how the coatings are applied and removed, can have a major impact on Navy platform affordability.

The Virginia class submarine Mississippi (SSN 782). U.S. Navy photo

S2562 Improved Tiling Systems

EB has begun implementing manufacturing improvements identified by an NMC project to reduce cost and improve performance of SHT on VCS. Specifically, EB partially implemented near-net-thickness molding on VCS tiles in the fourth quarter of FY15, and fully implemented the results in early FY16 to realize a total savings of $440,000 per hull. The VCS Program Office also accepted the project-developed assembly process for multi-layer tile, which will be used to procure the tile for the large-scale mock-up and ship test patch. Beyond the savings mentioned above, the project's recommended improvements to materials and/or installation processes will further reduce costs and improve reliability for VCS and benefit the OR Program, which will save an estimated $848,000 per hull. The VCS and Strategic and Attack Submarine Program Offices, NSWCCD, EB, and NMC participated in this project.

S2541 GTC Durability Coating

Another project intended to improve a specific coating on submarines is pending implementation on VCS and OR class submarines. The gradual transition coating (GTC) SONAR baffle tiles installed on Seawolf and Virginia class submarines have experienced issues with cracking and delaminating while in service. An NMC-led project team, including the Strategic and Attack Submarine and VCS Program Offices, and NSWCCD, extensively tested materials and process parameters and recommended various improvements. Implementation is expected in two ways. For in-service hulls, shipyard personnel will apply the recommended coating on SSN 777 if the tiles are scheduled for removal during scheduled maintenance. For new construction, the durability coatings can be applied at the tile manufacturer or by a third-party applicator. The first new construction implementation is expected by the end of 2017.

ShipTech 2016: A Top 50 Defense Manufacturing Event

ShipTech 2016, a Navy ManTech-sponsored conference coordinated by NMC, is ranked 13 on the list of 50 Top Industry Events to Learn the Latest Best Practices in Defense Manufacturing. Camcode included in its list the year's best defense-related conferences based on themes, keynote speakers, educational opportunities, expositions of advanced defense technologies, and networking opportunities.

Three hundred people attended ShipTech on March 1-2, 2016, in Charleston, South Carolina. ShipTech is a two-day defense manufacturing event for the domestic shipbuilding industry, its supplier base, the U.S. Navy Program Offices and the U.S. Navy-sponsored shipbuilding research programs to exchange information on shipbuilding technical developments. Featured are advances generated respectively by the National Shipbuilding Research Program (NSRP) and the Navy ManTech Program through its Centers of Excellence and related shipbuilding initiatives. The objective of the information exchange is to reduce total ownership cost of naval ships while enhancing the competitiveness of the domestic shipbuilding industry.

Keynote addresses were given by Vice Admiral William H. Hilarides, Commander, Naval Sea Systems Command, and Rear Admiral Mathias W. Winter, Chief of Naval Research, ONR.

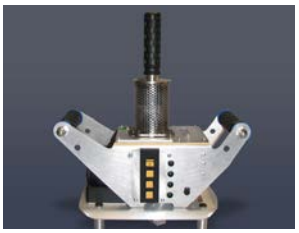
Speakers at ShipTech 2016 included, clockwise from top left: Dr. Thomas H. Killion, Director, Office of Technology, ONR; John U. Carney, Director, Affordability Initiatives Division and Navy ManTech Program, ONR; Vice Admiral William H. Hilarides, Commander, Naval Sea Systems Command; Rear Admiral Mathias W. Winter, Chief of Naval Research, ONR; Rear Admiral Thomas J. Kearney, Deputy Commander, Naval Sea Systems Command, Acquisition/Commonality/ Expeditionary Warfare; Captain David A. Goggins, Program Manager, Ohio Replacement Program, PEO Submarines; Rick Spaulding, Vice President, Central Planning and Process Excellence, Ingalls Shipbuilding; Rear Admiral Thomas J. Moore, Program Executive Officer, Aircraft Carriers; Rear Admiral Jon A. Hill, Program Executive Officer, Integrated Warfare Systems; and Richard T. McCreary, Chair, NSRP Executive Control Board/Vice President & General Manager, BAE Systems.

Manufacturing Tooling Development

S2560 Mechanized Cable Pulling
R2658 Abrasive Blasting Arm for Man Lift
S2564 Hull Production Automation Methods
S2691 Pipe Cutting Machine Technology
S2608 Additive Manufacturing for Shipbuilding Applications

Joining Technologies

S2602 Weld Sequence Planning for Major Assemblies
S2590 Modular Scalable Cold Plates for Naval Electronics
S2604 Shape Cutting and Welding Automation
S2636 Robotic Welding of Complex Structures



Advanced Metrology and Inspection Technologies

R2709 Debond Detector Units
Q2711 Inspection under SHT Phase I
S2606 Efficient Identification of Plate Defects

Manufacturing Process Optimization

S2579 Sonar Dome Fabrication Process Improvements
S2561 CVN Vertical Build
S2582 Improved Weapons Magazine C-Channel
S2612 Automated Manufacturing Cell for Small Repetitive Assemblies
S2633 Self-Locating/Self-Fixtured Structures
S2634 Automated Hanger Manufacturing
S2642 Fuel Cell Producibility
A2689 Grinding Swarf Reclamation and Reversion
S2690 Unit Family Construction Optimization

Advanced Metalworking Technologies

S2576 Mitigation of Cracking in Sensitized Aluminum
A2632 Automated Turbine Airfoil Trailing Edge Rounding
S2631 Distortion Mitigation for Additively Manufactured Electronic Chassis
R2659 MRAP Improved Crack Repair
S2635 Printed Sand Casting Molds and Cores for HY Steels
A2687 CH-53K Frame Machining Distortion Mitigation

Coatings Application and Removal

S2562 Improved Tiling Systems
S2541 GTC Durability Coating

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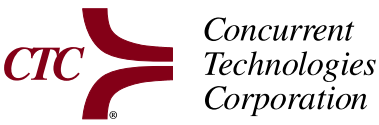

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