Advanced Metalworking Solutions For Naval Systems That Go In Harm's Way

NMC Navy Metalworking Center

Report Documentation Page

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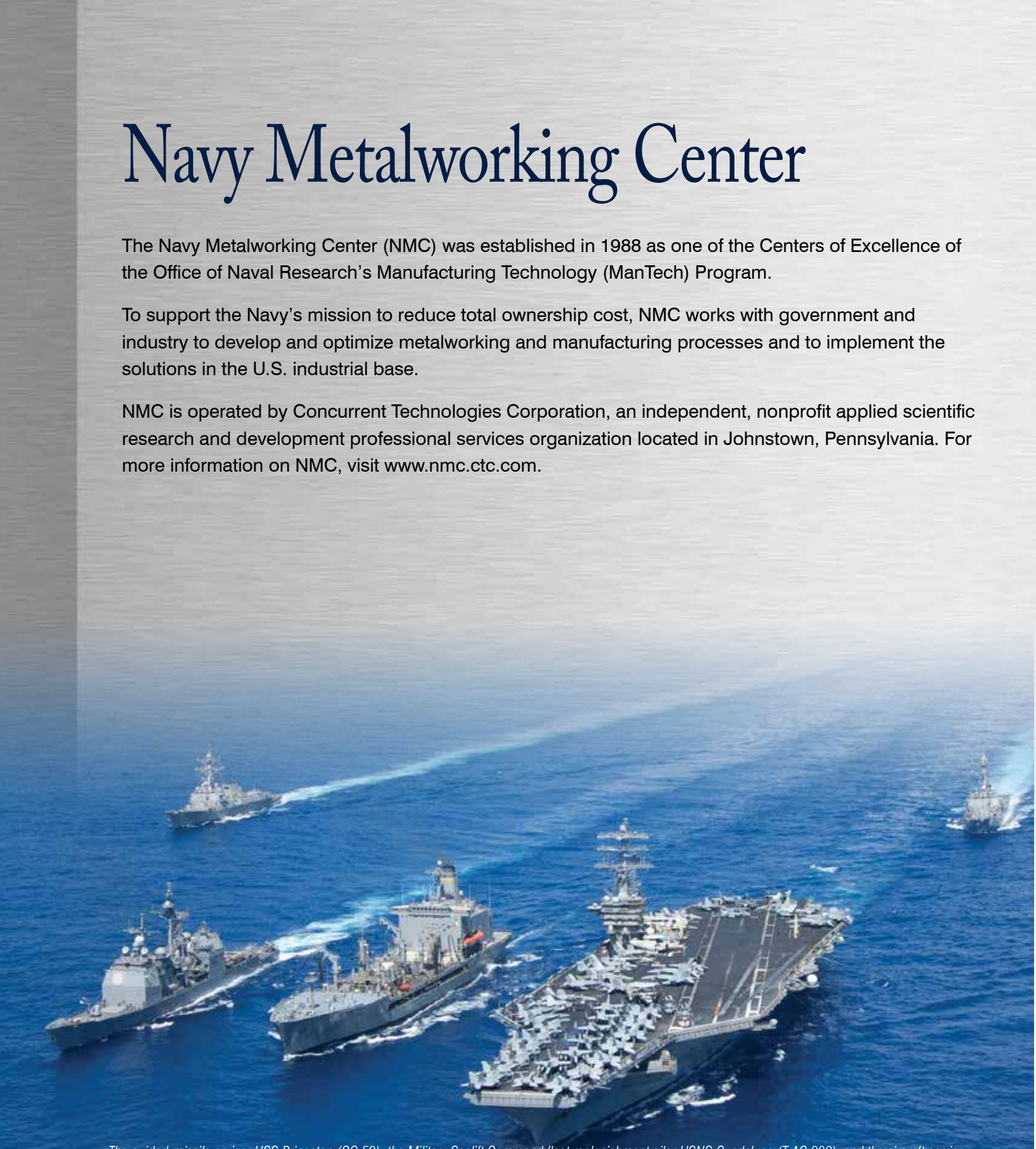
Navy Metalworking Center

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.



The guided-missile cruiser USS Princeton (CG 59), the Military Sealift Command fleet replenishment oiler USNS Guadalupe (T-AO 200), and the aircraft carrier USS Nimitz (CVN 68) participate in a replenishment at sea while the guided-missile destroyers USS Momsen (DDG 92) and USS Preble (DDG 88) are underway in formation. U.S. Navy photo

Front cover: Ingalls Shipbuilding welding photo
Smaller photos (left to right): Machining Alloy 625 Propulsor Components (NMC photo), Abrasive Blasting Arm for Man Lift (Ingalls Shipbuilding photo, page 16), Sonar Dome Fabrication Process Improvements (Ingalls Shipbuilding photo, page 8)

John U. Carney
Director, Affordability Initiatives Division and Navy ManTech Program

Through the years, the Navy has seen an increasingly heightened emphasis on reducing costs and getting more for less. The Navy Manufacturing Technology Program (ManTech) helps achieve the Navy affordability goals by transitioning advanced and innovative manufacturing technology.

Navy ManTech improves the affordability of the fleet by developing, demonstrating and transitioning manufacturing innovations that reduce weapon system acquisition and total ownership cost. As you'll read in this report, the Navy Metalworking Center (NMC) is leading project teams that are developing and optimizing manufacturing and metalworking in a variety of technology areas.

While enhanced technology development and demonstration are essential parts of the equation, transitioning the technology so that it is put to use is critically important. Implementation success for Navy ManTech as a whole has been high in recent years, and NMC's strong track record of implementation has greatly contributed to that success. Recently, implementation started early for a project that addressed the sonar dome manufacturing challenges for the DDG 51 class (page 8). The tools developed are reducing labor hours, which in turn cuts costs – ManTech's ultimate goal.

In addition to the DDG 51 class destroyer, ManTech's investment strategy includes the Virginia and Ohio Replacement class submarine, CVN 78 class aircraft carrier, F-35 Joint Strike Fighter, and CH-53K heavy lift helicopter. ManTech's focus on these strategic platforms maximizes the impact that every available dollar makes. I look forward to working with NMC as it develops and transitions projects that improve Navy weapon system affordability, endeavors that are critical to the future force.

John U. Carney

Director, Affordability Initiatives Division and Navy ManTech Program

Daniel L. Winterscheidt, Ph.D.
Senior Program Director, Navy Metalworking Center

In spite of the budget uncertainty in recent years, NMC has continued to successfully develop, demonstrate, and transition metalworking and manufacturing solutions for Navy weapon systems. In fact, the increased creativity and innovation required to stretch limited funds could be viewed as a bright spot. Working closely with our industry partners, we have implemented many advancements that provide benefits across the fleet, resulting in improved quality and affordability.

For example, NMC addressed a long-standing Navy issue for several ship platforms by developing mechanized tools that reduce the manual effort and time for cable pulling operations (page 14). Another project that developed a process to inhibit cracking in the aluminum on CG 47 class ships (page 3) can also benefit the Littoral Combat Ship, reducing nearly $30M in repair costs for both programs over five years.

In addition to these shipyard manufacturing solutions, we've successfully taken on more advanced technology challenges, such as developing an acceptable non-destructive inspection method for components manufactured using additive manufacturing (page 5). The project-developed inspection approaches will help facilitate the use of additively manufactured components for the F-35, and enable this technology in other applications going forward.

NMC understands that a smooth sea never made a skilled mariner. Whether the manufacturing challenge is fundamental or complex, impacts one platform or many, NMC will continue to meet the challenge, overcome the obstacle, and develop and transition advanced metalworking solutions for Naval systems that go in harm's way.

Daniel L. Winterscheidt, Ph.D.

Senior Program Director, Navy Metalworking Center

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 cost. NMC projects develop and implement a wide range of metalworking processes and technologies to improve the performance of Navy weapons system components.

S2548 Machining Alloy 625 Propulsor Components

BAE Systems began early implementation on an NMC project that addressed manufacturing challenges associated with the propulsors on Virginia class submarines (VCS). The Navy has changed the propulsor material on Block IV hulls to Alloy 625, a nickel-based alloy that is highly corrosion resistant but very difficult to machine. An Integrated Project Team (IPT) investigated innovative machine tooling, alternative cooling technologies, and other machining processes to improve the machinability of these critical components. Implementation of project-developed processes were targeted for VCS Block IV, but BAE Systems began early implementation on Block III propoulsor components in April 2015. Significant improvements in machining productivity is expected to save at least $6M over a five-year period. The IPT also investigated improved methods for threading hundreds of internal holes in these components, and demonstrated power tapping as a viable method. These improvements will yield an estimated additional $129K savings per hull. The project also reduces the risk of late components, which would have delayed ship delivery and incurred program costs estimated at $85,000 per day. The IPT included the VCS Program Office; Naval Surface Warfare Center, Carderock Division (NSWCCD); National Center for Defense Manufacturing and Machining; BAE Systems; and NMC.

USS Monterey (CG 61) guided-missile cruiser.
U.S. Navy photo

A portable heat treatment system that mitigates sensitization in aluminum structures is expected to significantly reduce repair costs compared to the current process. NMC photo

S2576 Mitigation of Cracking in Sensitized Aluminum

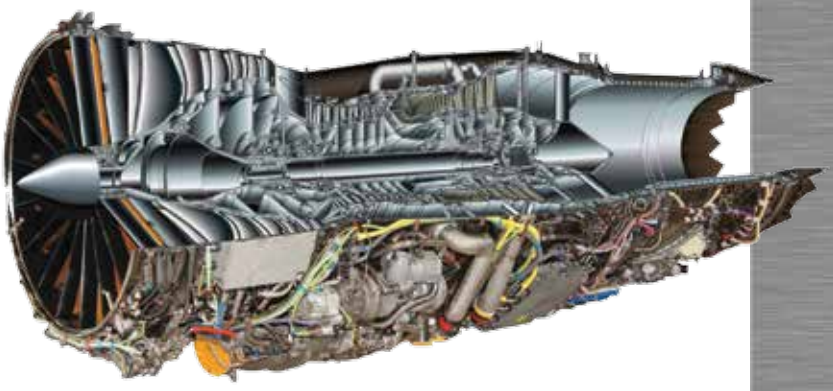
An NMC-led IPT developed a process to inhibit cracking of aluminum in the superstructure of CG 47 class ships. The solution is a low-cost alternative to the current method, which is an extensive and costly process that removes and replaces the affected plate (as well as all of the outfitting obstructing the area). The IPT developed and is demonstrating a portable heat treatment system that reverses the major contributor to the cracking – the sensitization of the microstructure in the 5000-series aluminum alloy. The reverse sensitization repair process is applied directly to the sensitized material. The process can reduce repair costs by as much as $1.7M per CG 47 ship, resulting in a cost avoidance of up to $25.5M for 15 ships serviced within five years. The Littoral Combat Ship (LCS) Program could also leverage this technology and avoid an estimated $500,000 in repair costs per hull, totaling $4M in cost avoidance for the LCS hulls in service over the next five years. The new process is expected to be implemented at Norfolk Naval Shipyard starting in early 2016. The IPT includes the in-service Surface Combatants and LCS Program Offices; NSWCCD; NAVSEA 05P2; NAVSEA 05D; ElectraWatch; DDL Omni; and NMC.

S2635 Printed Sand Casting Molds and Cores for HY Steels

NMC and an IPT are investigating printed mold sand casting versus conventional processes to manufacture geometrically complex VCS and Ohio Replacement (OR) components. The IPT is focusing on complex high yield (HY) steel castings that are currently produced as weldments. 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. Estimated savings are $1.1M per OR hull and $271,000 per VCS hull – a potential five-year savings of $4.1M for both platforms. The solution, which is also available to other weapons systems, is expected to be implemented on OR and the Virginia Payload Module (VPM) at Electric Boat Corporation in January 2019. In addition to the OR and VCS Program Offices, the IPT includes NSWCCD; Electric Boat; ExOne; Naval Undersea Warfare Center Division, Keyport; Bradken Inc.; and NMC.

A2632 Automated Turbine Airfoil Trailing Edge Rounding

NMC has initiated a project that will generate conceptual designs integrating several technologies – metrology, adaptive grinding, and robotics – to improve manufacturing of a Joint Strike Fighter (JSF) engine component. The F135 engine turbine airfoils trailing edges are typically manually ground to obtain their desired contour, but the process produces high labor costs and profile deviations that affect yield and quality. The IPT, comprised of the F-35 Joint Program Office, Pratt & Whitney (P&W), Alcoa Howmet (Howmet), and NMC, will develop and demonstrate an automated, adaptive grinding system to establish the required turbine airfoil trailing edge profiles. P&W will implement the grinding solution at Howmet in FY19. Acquisition cost savings from reduced scrap alone are estimated to be $12,000 per engine set, which equates to a $14.3M five-year cost savings for nearly 1,200 engine sets. Additional potential savings resulting from improved engine performance and reduced fuel burn and repair are not included. Other possible benefits may include supporting repair processes and strengthening the industrial base for commercial engines.



An automated, adaptive grinding solution will reduce production labor costs and improve quality and performance of a JSF engine component. P&W image

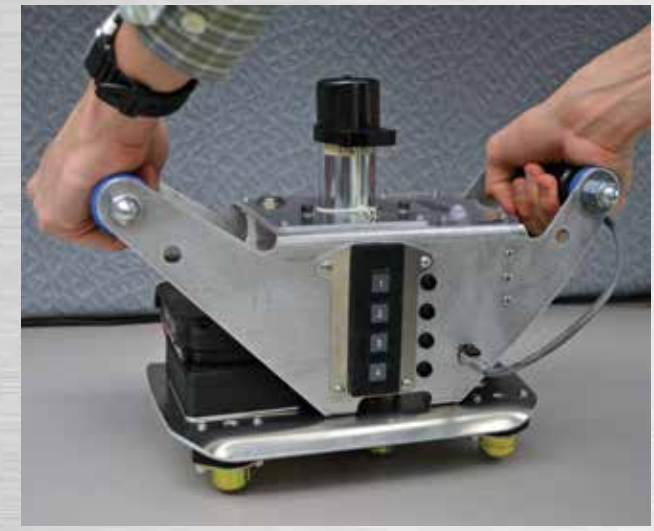
A Joint Strike Fighter lands on the flight deck of the USS Nimitz (CVN 68). U.S. Navy photo

Advanced Metrology & Inspection Technologies

The processes and tools used to measure and inspect system components can significantly impact cost and performance of Navy weapon systems. NMC has developed and led several projects that are focused on improving measurement (metrology) and inspection technologies and methods used to produce these complex Navy systems.

R2607 Debond Detector Improvements

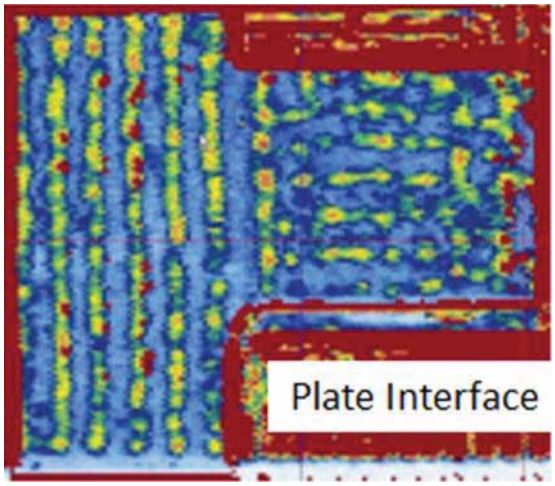
Based on the success of the ManTech-developed special hull treatment (SHT) debond detector used primarily in the construction of VCS hulls, the Strategic and Attack Submarines Program Office requested that NMC modify the system for in-service use. The SHT Debond Detector uses impulse hammer technology to replace manual inspection of SHT on VCS hulls, eliminating operator subjectivity, reducing the level of inspector training required, saving an estimated 100 labor-days per hull, and reducing false positive inspection results. The modified unit enables movement in multiple directions, allows for simpler operation, and adds the ability to connect directly to a 110V power source. The SHT debond detector has been approved as the primary tool for detecting debonds of SHT material on SSN 776, and seven units were delivered to the Navy in June 2015 for use on future VCS availabilities. The IPT included the Strategic and Attack Submarines Program Office, NSWCCD, Portsmouth Naval Shipyard, Rentz Technology Systems, Enterprise Ventures Corporation, and NMC.



An SHT Debond Detector developed for new VCS construction has been modified for use on in-service VCS hulls. NMC photo

A2506 Non-destructive Inspection for Electron-Beam Additive Manufacturing of Titanium

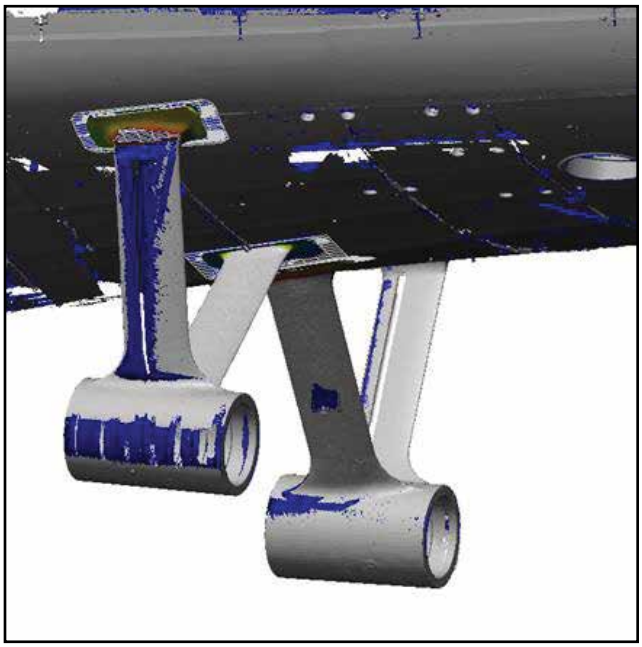
NMC led a project to address one of the major obstacles associated with introducing additively manufactured components into the F-35 supply stream – the development and acceptance of adequate non-destructive inspection (NDI) methods and standards to ensure the product meets quality and design requirements. In a project funded by Industrial Base Innovation Fund as well as Navy ManTech, an IPT evaluated the effectiveness of traditional and advanced NDI techniques to detect critical flaws in Electron-Beam Direct Manufactured (EBDM) components; developed a hybrid NDI approach incorporating several of those techniques into an overall NDI approach; and estimated the cost effectiveness of applying that approach to several parts. Lockheed Martin Aeronautics Company-Advanced Development Programs (LM Aero-ADP) is developing specific procedures for applying the project-developed inspection approach to EBDM components. When the procedures are approved, they will govern the NDI of targeted airframe components. The IPT included the JSF Program Office, Air Force Research Laboratory, Naval Air Systems Command, LM Aero-ADP, NMC, and Sciaky.



A combination of NDI techniques, including ultrasonic testing (pictured), will allow the use of components fabricated by EDBM on F-35. LM ADP photo

S2563 Integrated Metrology for Ship Construction

Ingalls is implementing NMC project recommendations on an integrated metrology solution developed to address construction alignment issues. In shipbuilding, components are manufactured independently and then integrated into larger builds, which necessitates considerable labor to address alignment issues. The IPT identified and optimized advanced metrology solutions for use in the ship construction process. Ingalls has begun partial implementation with total station evaluation for all ship classes; full implementation is expected with the procurement and use of laser tracking hardware. The potential five-year cost savings for the Navy platforms constructed at Ingalls are $4.3M, based on reduced rework and schedule impacts. The IPT included the DDG 51 Program Office, NSWCCD, Ingalls, and NMC.



An integrated metrology approach will improve evaluation of individual ship components and reduce rework during final construction on Ingalls-constructed ships. NMC image

S2606 Efficient Identification of Plate Defects

NMC is leading a project to develop three-dimensional inspection technologies that will help identify critical surface flaws on large steel plate surfaces earlier in the construction process, which will save costs. The IPT is creating an inspection tool with the requisite speed, accuracy, repeatability, and durability for 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 $3.5M over a five-year period for the construction of CVN 79 class aircraft carriers, starting in August 2016. In addition, implementation in 2016 of an inspection system at Ingalls is expected to result in a $650K savings over a five-year period on DDG 51 and LHA class ships. The IPT includes the CVN 79 Program Office, NAVSEA 05V, Newport News Shipbuilding (NNS), Ingalls, and NMC.

Joining Technologies

NMC considers many factors when optimizating joining methods on Navy platforms – material, joint type, design and manufacturing requirements, and others. NMC applies a variety of innovative welding technologies to address the challenges associated with joining weapon system components.

S2590 Modular Scalable Cold Plates for Naval Electronics

To improve component performance and reduce manufacturing issues, an NMC project developed a friction stir welding process to manufacture edge-cooled naval electronic cold plate assemblies. The modular, high-performance, and scalable manufacturing approach is based on a prototype system designed and developed by Raytheon. Friction stir welding offers considerable benefits over conventional joining technologies, such as lower distortion and improved weld strength and quality. Project results are expected to contribute to significantly lower cold plate acquisition costs. In addition, the size and relative simplicity of the modular heat exchangers will increase the number of vendors with equipment and personnel capable of manufacturing naval cold plates. Implementation is expected in FY18. The IPT is comprised of PEO IWS 2.0; Naval Surface Warfare Center, Crane and Carderock Divisions; Raytheon Integrated Defense Systems; Thermacore; and NMC.

DDG 1000. BIW photo

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

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

S2604 Shape Cutting and Welding Automation

An NMC-led IPT is working to improve the manufacturing of the I-beam stiffeners that make up the frames of surface ships. Currently, the stiffeners are manually cut and welded to various shapes, lengths, and geometries needed for the ship designs. The IPT is characterizing the causes of inaccuracies and inconsistent quality of these fabricated stiffeners, and developing process enhancements as well as tooling and prototype equipment to improve the process. The processing technologies developed to improve the fabrication of stiffeners will be implemented at Ingalls starting in the fourth quarter of FY16. The solutions are expected to save $6.1M in labor alone over a five-year period across the LHA, LPD, DDG 51 and National Security Cutter (NSC) platforms. The IPT is comprised of the DDG 51 Program Office, NSWCCD, and NMC.

S2602 Weld Sequence Planning for Major Assemblie

A weld sequence planning tool being developed by an NMC-led IPT could have a significant impact on a major manufacturing challenge for ship assemblies – determining optimal weld sequencing to minimize weld-induced distortion. While software packages are available to analyze welded structures, even an experienced analyst can take days or weeks to arrange, run, and obtain results from detailed weld analysis. The IPT will work with an industry partner to enhance commercially available software to rapidly determine optimum weld sequences in a manner that is easily integrated into existing manufacturing and shop floor systems. Electric Boat estimates a $5M cost savings over five years for VCS and OR programs through reduced trial-and-error weld sequencing, mitigation of weld-induced distortion, and improved throughput. The tool is expected to be implemented at Electric Boat on SSN 796 starting in the third quarter of FY16. The IPT includes the VCS and OR Program Offices, NSWCCD, Electric Boat, and NMC.

S2636 Robotic Welding of Complex Structures

An NMC project is investigating the application of robotic welding technology to improve the welding of large, complex ship structures such as innerbottoms. NMC and an IPT will develop and demonstrate a system to rapidly instruct existing welding robots on welding path locations for as-built structures and to execute welds in complex assemblies. The IPT, including the DDG 51 Program Office, Bath Iron Works (BIW), NSWCCD, and NMC, will investigate several robot-mounted measuring systems for suitability for use on these structures. The IPT also will develop and demonstrate a prototype system that integrates the necessary hardware and software to be able to semi-autonomously locate the weld seam, position and orient the welding head, and execute a suitable multi-pass weld. Large-scale implementation of robotic welding is estimated to produce $5.6M 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 at BIW in the second quarter of FY17.

NMC Project Manager John Forté demonstrates the zero gravity arm, which is one of the solutions developed by an NMC project for use on DDG 51 class ships. Ingalls 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 optimizing the processes to fit the unique applications. Our internal technical staff optimizes manufacturing processes to improve quality and reduce cost, including recommending design changes to enhance manufacturability.

S2579 Sonar Dome Fabrication Process Improvements

Implementation began early for a project that is improving the fabrication of the DDG 51 class sonar dome, which has a complex geometry and is challenging to construct. At the beginning of 2015, Ingalls implemented two material removal tools (the Equipois zeroG4® mechanical arm with NMC magnetic mounts and the Hypertherm® Powermax® 105 plasma cutting and gouging system) for DDG 117 and 119. In addition to the tools, the IPT investigated advanced metrology techniques that will improve dimensional accuracy, reducing the need for additional labor to address fit-up issues. The project is reducing labor to fit and assemble DDG sonar dome components by 30 percent and other DDG structures by 20 percent. The IPT includes the DDG 51 class Program Office, NSWCCD, Ingalls, and NMC.

This project is addressing fabrication and assembly challenges of the uniquely shaped DDG 51 sonar dome. Ingalls photo

Improved flexible infrastructure track system components and manufacturing processes will save costs for CVN 79 and other programs. NNS photo

S2517 Flexible Infrastructure Track System

Implementation is pending at NNS for an improved Flexible Infrastructure (FI) track system that was developed by an NMC-led IPT. The existing FI track system includes a large amount of track that is difficult and costly to manufacture. To reduce complexity, acquisition cost and lead time, the IPT employed a dual approach – developing "I-beam pedestal" and "hex bar standoff" concepts – and improving the overhead track installation. The new FI track system reduces the system complexity and the size of the extrusions. Cost savings are expected to be $4.8M over five years for CVN 79, LHA 7 and 8, LPD 28, LXR, and CVN 73 overhaul based on reduced track extrusion and machining efforts and labor savings on overheard track installation. Implementation of the new FI track system is expected during the second quarter of FY16 on CVN 79 and CVN 73 overhaul at NNS. The CVN 79 Program Office, NSWCCD, NNS, Gryphon Technologies, and NMC made up the IPT.

S2642 Fuel Cell Producibility

An NMC project is identifying improvements to the fuel cell system on current and future Unmanned Undersea Vehicles (UUV). UTC Aerospace Systems (UTAS) is developing a fuel cell system for demonstration, but it is manufactured in low volumes and requires significant manual labor and support resources to process and assemble the hardware. The IPT, including the Unmanned Maritime Systems Program Office, ONR Code 333, Strategic Analysis, UTAS, and NMC, will provide recommendations to improve the producibility of an advanced fuel cell system through alternative materials and/or manufacturing processes. Implementation is planned for the initial production run of the UUV after the fuel cell technology is transitioned to the naval acquisition program in the FY18-19 timeframe. This project is being conducted in support of the Navy's Long Endurance Undersea Vehicle Propulsion Future Naval Capability.

NMC is working to improve the producibility of the fuel cell to be used in UUVs through alternative materials and/or manufacturing processes. PMS 406 photo

Manufacturing and installation solutions are expected to reduce labor and cost for the weapons magazine C-channels on multiple platforms. NNS photo

Improving the manufacturability of the HTS degaussing system for future combatants will reduce costs and improve system performance. Pictured is the induction heating soldering system developed and validated in this project. NMC photo

S2582 Improved Weapons Magazine C-Channel

To address another labor-intensive process – the manufacture and installation of the universal Weapons Magazine Tie-down System – NMC is leading a project that will reduce the overall installation hours and the associated costs. The IPT has examined both NNS and Ingalls installation processes and is pursuing multiple manufacturing and installation process solutions, including optimization of C-channel layout and improved component procurement, preparation, installation, and preservation. Estimated cost savings are $5.5M over a five-year period on CVN 80, LHA 7 and LHA 8, and Ingalls-built DDG 51 class ships. Implementation is planned for mid-2017 on LHA 8 at Ingalls and mid-2019 on CVN 80 at NNS. Partial early implementation of some improvements is also being pursued for CVN 79 and LHA 7. In addition to the shipyards, the LHA and CVN 79 Program Offices, NSWCCD-Ship Systems Engineering Station, and NMC make up the IPT for this effort.

S2634 Automated Hanger Manufacturing

Another NMC project is developing an automated work cell to produce several types and sizes of hangers that are used to install and route pipe, ventilation, and electrical cable on VCS and OR submarines. Electric Boat manufactures the hangers in several labor-intensive forming and machining operations dispersed throughout the facility. The IPT, including the VCS and OR Program Offices, NSWCCD, Electric Boat, and NMC, will develop an optimized process using work cell principles. The five-year anticipated cost savings for both VCS and OR are $10.3M and will be realized through a reduction in rework and material handling as well as an increase in throughput. Project results will be implemented in the second quarter of FY18 at Electric Boat.

S2523 Degaussing System Manufacturing Improvements

An NMC project improved two key manufacturing aspects of the High Temperature Superconducting (HTS) degaussing system planned for installation on surface combatants. The IPT developed a mechanized soldering process to produce an effective and robust solder joint connection on the complex cable connectors and defined a manufacturing process to bundle the uniquely shaped HTS wire. The customized induction heating system to solder critical joints meets all physical and functional requirements, and the process to bundle the uniquely shaped HTS wire effectively twists and bundles the wires without damaging the delicate wire profile or wire insulation. An estimated cost avoidance of $651,000 will be achieved on a full HTS degaussing system shipset. Additional benefits include increased HTS degaussing system reliability, reduced lead time, and increased HTS degaussing cable capacity. Implementation is planned on future surface combatants as HTS degaussing system implementation is approved by the Navy. The LCS Program Office, Naval Ship Systems Engineering Station, AMSC, and NMC contributed to this project.

Increasing the amount of construction work done on CVN 79 prior to erection will lead to efficiencies and cost savings. NNS photo

S2561 CVN Vertical Build

By identifying outfitting activities that can be done earlier in the shipbuilding process, an NMC-led IPT plans to save construction costs for CVN 79. The build strategy for CVN 78 required much of the ship outfitting activities to be completed in the dry dock, in areas that were difficult to access. The IPT identified targeted systems and specific construction areas of CVN 79 that could benefit from pre-outfitting concepts, which improve construction efficiencies. Implementation will occur when pre-outfitted superlifts are erected in the dry dock on CVN at NNS beginning in the first quarter of FY17. The CVN 79 Program Office, Supervisor of Shipbuilding-Newport News, NNS, Hepinstall Consulting Group, and NMC make up the IPT

S2633 Self-Locating/ Self-Fixtured Structure

An IPT is developing and optimizing a manufacturing process for a new concept of fitting and joining submarine deck structures – the self-locating, self-fixtured (SLSF) method. SLSF, which utilizes notched beams that interlock and are continuous in both directions, is intended for construction of OR and the VPM. To determine the most efficient way to build these structures, the IPT is investigating cutting, weld joint methods, fixturing, and temporary bracing requirements, with both finite element analysis and trial fabrications. Total five-year savings are estimated at $12.1M for OR and VPM. Implementation is expected on the lead OR hull and on the first VPM in the third quarter of FY19 at Electric Boat. The IPT is comprised of the OR and VCS Program Offices, NSWCCD, DDL OMNI, Electric Boat, and NMC.

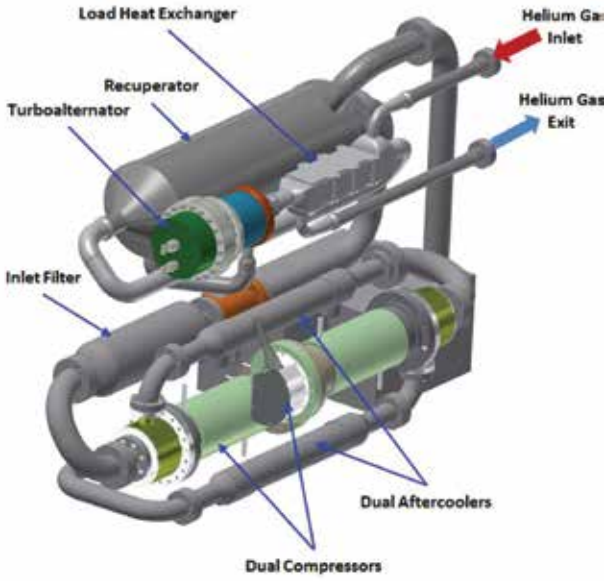
A manufacturing work cell that automates and / or mechanizes various processes will reduce costs, improve ergonomics and quality, and increase throughput on multiple naval platforms. Ingalls photo

S2612 Automated Manufacturing Cell for Small Repetitive Assemblies

NMC is conducting a project that will improve efficiency at the Ingalls Industrial Products Division (IPD) shop, which fabricates hundreds of relatively small weldments per ship, mostly manually constructed at individual stations throughout the facility. Applying work cell principles as well as planning, mechanization, and automation to the manufacture of parts, such as ladders, railings, aircraft tie-downs, manhole covers, and lifting lugs, will allow products to be produced more efficiently and improve part quality resulting in reduced costs. Project results are expected to be implemented in the second quarter of FY17 and will save $1.7M annually for the platforms Ingalls constructs, including DDG 51, LHA, LPD, and NSC. The IPT includes the DDG 51 Program Office, NSWCCD, Ingalls, and NMC.

S2603 Reverse-Brayton Cryocooler Manufacturing Improvements

To make HTS degaussing systems more attractive for use on naval platforms, an IPT is working to improve the manufacturability and reduce the manufacturing costs of the cryogenic refrigeration system required to maintain the low operating temperature of HTS cables. This project will identify and demonstrate production cost savings for the primary components that make up the reverse-Brayton cryocooler through various design-for-manufacturing alternatives. The goal is to reduce the cryocooler purchase price to no more than $200,000 per unit based on a 16-unit lot; success will result in $7M savings over five years if implemented on future ship classes. The IPT includes the LCS Program Office, NSWCCD, Creare LLC, and NMC.



Manufacturing improvements will reduce the purchase price for the reverse-Brayton cryocooler on future ship classes. Creare image

Coatings Application & Removal

Optimizing the coatings on Navy weapon systems, as well as how they are applied and removed, can be a major factor in improving affordability. Recent NMC projects were initiated to improve surface material durability and coating installation methods on Navy platforms.

S2541 GTC Durability Coating

An NMC-led IPT developed a solution that will reduce cracking and delaminating of the SONAR Baffle Tiles on Seawolf and VCS submarines. The IPT is finalizing recommendations for a durability coating that will be applied to the Gradual Transition Coating (GTC) tile. This recommendation is based on extensive material and process parameter testing, which ensured sufficient durability and compatibility with the tile material. The project is expected to result in an overall cost benefit of $13.4M for in-service Seawolf and VCS as well as new construction VCS. Once the Program Offices accept the project recommendations, implementation will occur on in-service hulls during shipyard maintenance activities and at the GTC tile manufacturer for new construction ships. NSWCCD, VCS and Strategic and Attack Submarine Program Offices, Globe Composite Solutions, Pearl Harbor Naval Shipyard & Intermediate Maintenance Facility, and NMC comprised the IPT.

S2562 Improved Tiling Systems

Another NMC project was focused on improving another tile on VCS – the special hull treatment. The IPT, comprised of the Strategic and Attack Submarine and VCS Program Offices, NSWCCD, Electric Boat, and NMC, optimized tile features, the manufacturing process, and installation materials and processes. The result will assist with lowered manufacturing costs, decreased installation labor and rework, shorter overall installation time, and improved reliability. Once completed, the project will save an estimated $600,000 per hull for new construction and $500,000 per year for fleet maintenance.

Virginia class submarine. U.S. Navy photo

Manufacturing Tooling Development

Some of NMC's most significant technical achievements, implementation success, and cost reduction have come from projects that develop innovative manufacturing tooling and fixturing that address naval manufacturing issues. Our development capabilities span the entire process – from developing the initial concepts, to iteratively developing and refining the tooling to ensure it meets the intended need, to transitioning the final product to a commercialization partner or manufacturing facility. NMC leverages internal, industry, and shipyard expertise throughout the process.

S2560 Mechanized Cable Pulling

To reduce the significant amount of manual effort and time required to pull cable on surface ships, an NMC-led IPT developed small, lightweight, portable, easy-to-use, power-assisted tools. A capstan tool and a dual roller tool can save significant labor hours over manual cable pulling. The tools can be used together or alone to apply a controlled pulling force while routing or maniupulating cable along straight, twisting, and/or turning paths. Ingalls expects to purchase six of each tool for use on DDG and LHA in the first quarter of FY16. The IPT includes the LHA, DDG 51, and CVN Program Offices; NNS, NAVSEA 05Z, and NMC.

NMC developed power-assisted tools that will reduce labor and health and safety issues associated with shipboard cable pulling. NMC photo

USS George Washington (CVN 73). U.S. Navy photo

The tow cable maintenance winch will provide a means for shipboard maintenance of the cable between the Remote Multi-Mission Vehicle (in black) and the towed mine hunting sonar system (in white). U.S. Navy photo

Z2581 Tow Cable Maintenance Winch

NMC is leading an IPT to develop a cost-effective Auxiliary Remote Minehunting System (RMS) Reelwinding Module that enables periodic shipboard maintenance of the RMS Mine Countermeasure Mission Packages used on the LCS. Currently no winch meets Navy requirements to conduct shipboard periodic maintenance on the cable. Leveraging commercial-off-the-shelf technology, the IPT is devising a winch and stowage system that meets all functional, dimensional, and environmental requirements for use with the LCS Mine Countermeasure Mission Package. The project-developed Tow Cable Maintenance Winch (TCMW) will not only meet requirements, but will cost $674,000 less per unit compared to the current maintenance winch. Over 26 systems planned for purchase by the Navy, the total five-year cost savings will be $5.5M. The TCMW will be implemented in July 2016. This project is funded by the Technology Insertion Program for Savings and includes efforts from the Remote Minehunting System and LCS Mission Modules Program Offices; Naval Surface Warfare Center, Panama City Division; Lockheed Martin Mission Systems and Training; and NMC.

S2608 Additive Manufacturing for Shipbuilding Applications

An NMC project is demonstrating the cost and time benefits of utilizing additive manufacturing technologies to aid in the construction of Navy ships and submarines at both Ingalls and Electric Boat. For Ingalls, the IPT is assessing and demonstrating the use of additive manufacturing for the fabrication of support tooling and fixtures during ship construction, quantifying the expected benefits, and providing a recommended path toward implementation. For Electric Boat, the IPT is developing and demonstrating a process map that will allow the rapid production of tools and fixtures using additive manufacturing. Ingalls estimates the cost savings from this project to be $800,000 per year for DDG, LHA, and LPD combined. Electric Boat estimates a minimum acquisition cost savings of $200,000 per VCS. Implementation is planned for FY17 at Ingalls and Electric Boat. In addition to Ingalls and Electric Boat, the IPT includes the Program Offices for DDG 51, LHA, VCS, and OR, and NMC.

S2564 Hull Production Automation Methods

Many of the fitting and welding operations performed at Ingalls during hull production are manually performed and are prone to rework. This NMC project investigated several improvements to the fitting and welding processes to improve quality and reduce costs. Ingalls has begun implementing project-developed tools to improve fitting and welding processes for ship hull fabrication. Ingalls is using portable jack supports for structures, tee beam alignment tools, ratcheting push-pull tools, and transverse stiffener jacks. The shipyard also plans to implement advanced leveling solutions pending successful test trials. Project results will be applied to DDG, LHA, LPD and the NSC ships. The cost savings across those platforms are expected to total $6.7M over a five-year period. The DDG 51 and LHA Program Offices, Ingalls, NSWCCD, and NMC participated in this effort.

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

A motion-assisted positioning device used for the blasting process will reduce costs and worker fatigue, and increase throughput on multiple naval platforms. Ingalls photo

R2658 Abrasive Blasting Arm for Man Lift

NMC is leveraging previous work in developing a mechanically assisted arm to make it usable for shipyard tasks, such as abrasive blasting of large ship structures during construction. The IPT is developing and evaluating a prototype man-lift-mounted, motion-assisted positioning system to perform blasting from a man lift. The new system will allow workers to remove rust, mill scale, and other surface contaminants from the ship's hull exterior with less effort than is required for the current method. Ingalls plans to use the system on all the platforms it constructs starting in the third quarter of FY16. Total five-year savings from this Rapid Response project are expected to be $840,000. The IPT includes the DDG 51 Program Office, Ingalls, and NMC.

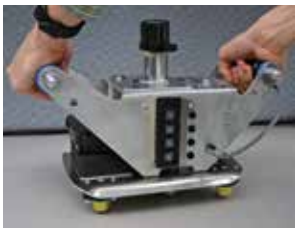
S2565 Pipe Production Automation Methods

Ingalls also began using the results of an NMC project that developed portable mechanized tools to reduce the cost to perform several thousand pipe welds on Navy ships. NMC worked with shipyard personnel to identify, develop, and enhance several technologies and tools. Ingalls has implemented three pipe fitting and alignment tools (the custom split-ring clamps, the custom enhanced plug rounding tool, and the Intercon Enterprises pipe alignment clamp) and plans to purchase more for use throughout the shipyard. The improved pipe production tools and technologies are expected to save approximately $7M on LHA, DDG, LPD, and NSC. Further development is required before an automated welding system and brazing technologies advanced in this project can be implemented. In addition to Ingalls and NMC, NSWCCD, and the LHA Program Office made up the IPT.

The automation / mechanization of pipe fabrication processes for shipboard applications will improve quality and reduce costs on multiple naval platforms. Ingalls photo

Advanced Metalworking Technologies

S2548 Machining Alloy 625 Propulsor Components
S2576 Mitigation of Cracking in Sensitized Aluminum
S2635 Printed Sand Casting Molds and Cores for HY Steels
A2632 Automated Turbine Airfoil Trailing Edge Rounding



Advanced Metrology & Inspection Technologies

R2607 Debond Detector Improvements
A2506 Non-destructive Inspection for Electron-Beam Additive Manufacturing of Titanium
S2563 Integrated Metrology for Ship Construction
S2606 Efficient Identification of Plate Defects

Joining Technologies

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

Manufacturing Process Optimization

S2579 Sonar Dome Fabrication Process Improvements
S2517 Flexible Infrastructure Track System
S2642 Fuel Cell Producibility
S2582 Improved Weapons Magazine C-Channel
S2634 Automated Hanger Manufacturing
S2523 Degaussing System Manufacturing Improvements
S2561 CVN Vertical Build
S2633 Self-Locating/Self-Fixtured Structure
S2612 Automated Manufacturing Cell for Small Repetitive Assemblies
S2603 Reverse-Brayton Cryocooler Manufacturing Improvements

Coatings Application & Removal

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