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REDUCING THE COST AND TIME TO BUILD & REPAIR **NAVY** PLATFORMS

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CENTER FOR NAVAL METALWORKING

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315 Sigma Drive
Summerville, SC 29486

PHOTO CREDITS:

Cover

Workers with protective mask welding large steel beam, view from above. Workers can not be recognized because of the masks and equipment.
Photo Courtesy of iStock: Floriana

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Northrop Grumman anticipates submarine cost reductions through replacement of multi-pass conventional arc welding process with their high efficiency electron beam welding and cladding system.
Photo Courtesy of NGC

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Gas metal arc welding process variant with a rotating contact tip that "spins" the filler wire while welding.
Photos Courtesy of Weld Revolution LLC
www.weldrevolution.com

Weld defect discovered with soap bubble leak detection method.
Photo Courtesy of Ingalls

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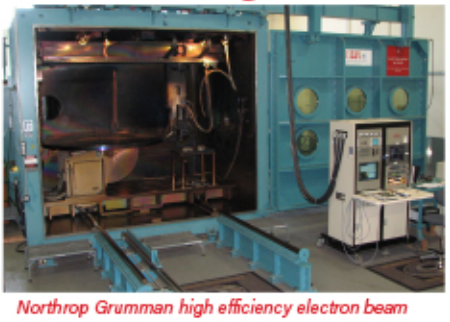
Incorporation of robotics similar to the one pictured above is anticipated to significantly reduce the time and cost of the legacy process used to install hull inserts through automation of locating, cutting, beveling, and welding sequences.
Photo Courtesy of ABB

CNM and Northrop Grumman "Joining" for COLUMBIA Class Submarine Savings



Northrop Grumman high efficiency electron beam welding and cladding system.

The mission of the U.S. Navy focuses on "maintaining security and deterrence through sustained forward presence." The submarine force is essential in the execution of this mission by providing the primary deterrent in the US Military's arsenal – ballistic missiles. Since the first nuclear-powered ballistic missile submarine (SSBN), USS George Washington, embarked on its maiden patrol in late 1959, the U.S. Navy has relied on the strategic placement of SSBNs throughout the world's oceans to achieve global security.

As the OHIO Class Submarine program approaches its twilight, construction and delivery of the COLUMBIA Class Submarine (CLB) is essential in ensuring that this staple of global security is maintained and a readily available resource when called upon. One key advancement in the design and construction of the CLB is referred to as the Common Missile Compartment (CMC), which will house submarine-launched ballistic missiles in quad-packs aboard both U.S. and United Kingdom submarines. The CMC will house UGM-133 Trident II nuclear missiles, one of the most advanced submarine-launched atomic missiles in the world.

Revolutionary design change combined with the Navy's need for expedited submarine delivery schedules has resulted in a need for improvements in CMC component-level construction process improvements. One such process improvement is with the methods utilized for welding of CMC eject system components. The existing qualified processes for welding and cladding submarine eject components use conventional arc welding, such as gas tungsten arc welding, gas metal arc welding, and hot-wire gas tungsten arc welding to manufacture several components that are critical to a submarine's missile eject system. Rework due to common weld anomalies is often experienced and contributes to increases in part cost and lead-time. Lack of fusion, tungsten inclusions, and slag inclusions are sometimes identified during final weld inspection by radiographic testing and commonly require excavation and re-welding activities, adding weeks of schedule delay and costs to the part. Additionally, the current process requires various welding consumables, filler metal, and is time-consuming because of multiple weld passes and layers, inter-pass cleaning, in-process inspections, and potential rework. Opportunities for improved weld quality and cost, and lead-time reductions are anticipated through using a more efficient joining process - Electron Beam Welding (EBW) and Electron Beam Cladding (EBC).

Through the Electron Beam Welding and Cladding project, Northrop Grumman Corporation (NGC) will develop, approve, and support qualification of EBW and EBC procedures for four key COLUMBIA Class Submarine components: Cooling Chambers, Stand Pipes, Gas Generators, and Cooling Chamber Shipping Safety Covers. EBW and EBC provide a higher quality of welding and cladding than conventional arc welding and cladding due to the work being performed in a vacuum chamber where atmospheric contamination is not an issue. The work performed is fully computer-numerically controlled and highly repeatable. This project has the potential to provide a significant savings to the CLB program resulting from key attributes of the electron beam process, including increased travel speeds, single pass welds, vacuum welding environment, automatic weld execution, and minimized distortion.

Through the application of the many benefits of EBW and EBC to submarine eject system component construction, NGC anticipates the potential of significant reductions in the rework required by the legacy welding processes, as well as, significant labor reductions. Following implementation in Q2 FY21, initial estimates forecast substantial savings per CLB hull and for the program's lifecycle.

Where will CNM be?

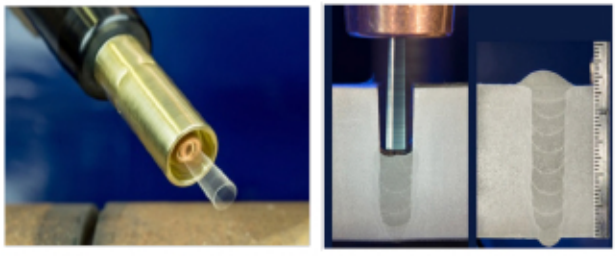
CNM will be attending **DMC2018** on December 3-6, 2018 at the Nashville Music City Center located in Nashville, TN. Visit us in booth #217.

NSRP ALL PANEL MEETING

The **NSRP All Panel Meeting** will be held on March 12-14, 2019 at the Francis Marion Hotel located in Charleston, SC. CNM and other Navy ManTech Centers will be in attendance.

Using High Speed Rotating Welding Arc Process Technology for Navy Surface Ship and Submarine Applications

The U.S. Navy, General Dynamics Bath Iron Works (GDBIW) and General Dynamics Electric Boat (GDEB) have joint initiatives to reduce the construction cost of surface ships and submarines. The Navy ManTech Centers of Excellence, GDBIW, and GDEB have identified areas that can benefit from new manufacturing processes and technologies to reduce costs. The *High Speed Rotating Welding Arc Process* project will determine the advantages of the High Speed Rotating Welding Arc Process for Navy surface ship and submarine applications.



Gas metal arc welding process variant with a rotating contact tip that "spins" the filler wire while welding.

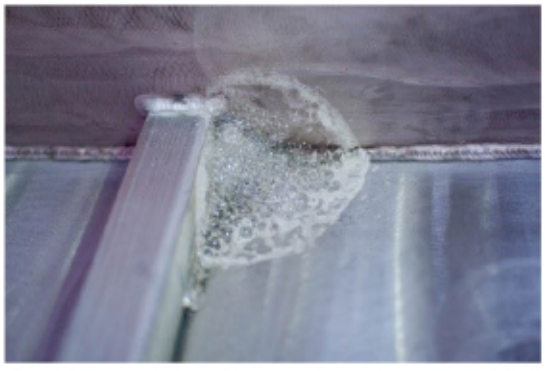
Current approved Gas Metal Arc Welding (GMAW) processes for welding groove joints require significant effort to prepare for welding, such as beveling the plate edges to create a single, or in some cases, double V-groove to ensure 100% weld penetration. High speed rotating arc welding processes have been proven in many non-Navy applications to be an effective means of dramatically reducing the time and effort required to weld thick-plates, which could be used in Navy ship construction. Current Navy approved weld processes for surface ships and submarines do not include high speed rotating arc welding as a qualified method for groove welding. Since the *High Speed Rotating Welding Arc Process* is not currently Navy approved, GDBIW and GDEB need to determine the feasibility of welding surface ship and submarine weld joints using this innovative technology, then conduct shipyard testing to determine the viability of the process in the shipyard environment.

High speed rotating arc welding processes (a.k.a., Weld Revolution's SpinArc®), is a GMAW process variant with a rotating contact tip that "spins" the filler wire while welding, allowing the arc to dig into the side walls of the weld joint. The centrifugal force propels molten metal spray creating consistent weld beads and eliminating the need for feathering. The adjustable spin diameter, speed and direction allow for optimization of welds for specific use cases and can easily be combined with existing approved methods of spray/pulse welding. Once the project team completes project work to generate the test data needed to validate the feasibility of GDBIW and GDEB parameters thus meeting NAVSEA weld procedure qualification requirements, the *High Speed Rotating Welding Arc Process* technology will have been verified to meet the expectations of the stakeholders and ready for implementation at GDBIW and GDEB.

Once proven, GDBIW and GDEB will have a new process that will improve Navy shipbuilders' performance. The *High Speed Rotating Welding Arc Process* project's technical improvements are estimated to provide a 5-year savings of $1.68M for the GDBIW DDG-51 acquisition program, an estimated $473K for the VIRGINIA Class Submarine acquisition program (VCS), another $994K for the COLUMBIA Class submarine acquisition program, and as much as $2.5M for the VCS variant known as the Virginia Payload Module.

New Inspection Technology Evaluated to Detect Weld Joint Leaks

The Navy ManTech Program participated in this initiative, with specific focus on manufacturing processes for ship construction. The ManTech Center for Naval Metalworking (CNM), Huntington Ingalls Industries - Ingalls Shipbuilding (Ingalls) and Edison Welding Institute (EWI) identified an area that can benefit from improved manufacturing processes and technologies to continue cost reduction efforts.



Weld defect discovered with soap bubble leak detection method.

The goal of the project was to evaluate candidate nondestructive testing (NDT) methods as alternatives for soap and bubble leak detection. This project evaluated candidate nondestructive testing methods to replace the legacy soap and bubble leak detection inspection of weld joints. The Ingalls team defined the baseline soap and bubble leak detection inspection procedure and identified any inspection trends. The most common welds to be inspected were identified, physical attributes defined, and the most commonly encountered weld defects were identified. Ingalls provided mitigation guidelines for any recurring weld defects.

Open and closed trials using acoustic ultrasound, eddy current, and soap bubble inspection processes were conducted to compare inspection process performance in laboratory and shipyard environments, respectively. An acoustic ultrasound system technology was determined to be the most promising replacement, as the testing results support the reduction in the current amount of time it takes to perform acoustic ultrasound inspection vs. legacy soap bubble leak detection testing. This recommended alternative has several intangible benefits including improved quality leak testing, increased schedule flexibility with alternate test locations, and decongesting of on-ship construction locations. This technology and process, once fully implemented, could potentially save an estimated 5-year combined savings of $640K.

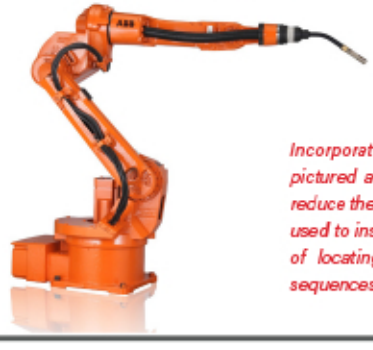
Two candidate technologies were evaluated: acoustic ultrasound leak detection and eddy current (EC) testing. A limited industry survey was conducted to identify the best equipment candidate for the acoustic ultrasound leak detector and to obtain any additional information about this candidate inspection technology. EWI selected EC technology based on EWI experience with the technology and best practices for EC testing of weld joints to test alongside acoustic ultrasound inspection. Ingalls procured three of the most promising acoustic ultrasound leak detectors. Welded specimens with implanted, machined flaws were fabricated, and EWI demonstrated the alternate inspection procedures in the laboratory environment. Ingalls identified acoustic ultrasound inspection technology to test in the shipyard environment. At Ingalls, side-by-side soap and bubble leak testing and the acoustic ultrasound inspection process was conducted to establish a performance comparison. Ingalls identified their preferred inspection solution, finalized the business case analysis, and created an implementation plan. The acoustic ultrasound inspection will be implemented to augment the manual application of soap and bubble to the weld joints.

CNM and GDEB "Inserting" Savings through Submarine Hull Construction Initiative

Submarine construction is a complex sequence of events requiring highly skilled labor and innovative technologies to complete each step of the complicated process. Since hull construction is the initial phase in this sequence of events and establishes the baseline for the rest of the construction program, maximizing hull throughput is essential in ensuring each hull is delivered on time and within the constraints of constantly compressed delivery schedules. General Dynamics-Electric Boat (GDEB), EWI and the Navy ManTech Center for Naval Metalworking (CNM) are executing the Robotic Process for Installing Hull Inserts project to develop a robotic system to install hull inserts on VIRGINIA and COLUMBIA Class Submarines (VCS and CLB, respectively). The solution technology will leverage previous robotic and automation efforts conducted at Electric Boat (GDEB) to develop a hull insert installation robot capable of automating each individual step while maintaining the tight tolerances required of submarine fabrication processes. The installation of hull inserts is a key hull construction activity that currently requires a significant amount of manual labor. However, by integrating robotics and automation into the hull inserts installation process, significant reductions of the cost and time required for hull construction are anticipated.

The legacy process for installing inserts into submarine hulls is an intricate sequence of events that consists of multiple manual operations, including cutting, beveling, grinding, and welding processes. Requiring extensive labor in excess of 45,000 man-hours per hull, hull insert installation significantly expands manufacturing span time for the initial outfitting phase, and since weld quality is dependent on "artisan knowledge" and individual skill level, the inserts are only welded by a small group of x-ray quality welders. Cutting and beveling holes in the hull requires constantly varying the bevel angle on the hull and the insert to keep the weld joint's included angle consistent as the hull curvature varies around the circumference of the weld. Because this process is entirely manual, a robotic installation solution would improve weld quality and has the potential to reduce the labor required within submarine build schedules. These welds are much more complex than linear welds in fixed welding position, as welding parameters must change multiple times as the weld torch moves along the curvature of the hull through various welding positions. Because of the complexities of each individual process, there are no readily available commercial off the shelf (COTS) capable of performing all the integral steps of this complex process.

Through automation and weld quality improvements, early estimates forecast a 20% reduction in cutting, fitting and welding labor. Through the increased efficiencies and quality improvements enabled by the solution technology, GDEB anticipates a per-hull savings of $1.2M per VCS hull and $1.9M per CLB hull for a combined 5-year savings of $15.9M across both programs.



Incorporation of robotics similar to the one pictured above is anticipated to significantly reduce the time and cost of the legacy process used to install hull inserts through automation of locating, cutting, beveling, and welding sequences.

CENTER FOR NAVAL METALWORKING

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Reducing the Cost and Time to Build and Repair Navy Platforms

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