

UNDERSEAWARFARE

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UNDERSEAWARFARE

THE OFFICIAL MAGAZINE OF THE U.S. SUBMARINE FORCE

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FORCE COMMANDER'S CORNER

Vice Adm. Michael J. Connor, USN
Commander, Submarine Forces



Hello again from Norfolk!

This edition of *UNDERSEA WARFARE* Magazine focuses on Submarine Technology.

We are entering an exciting transitional period for our Force with the emergence of future technologies. As our undersea forces will continue to provide national security decision makers with options that no other community can offer, it is imperative that future operations and maritime security include the newest innovations. We need to hone our science and technology, research and development, and acquisition processes to ensure that we have the right capabilities for the future.

The advances in technology, both inside and outside the hull of our submarines, is truly astounding. What I am most excited about is the rapid advancement in capability being generated in the field of Unmanned Undersea Vehicles (UUVs) and submarine-launched Unmanned Air Vehicles (UAVs). UUVs and UAVs will greatly expand the capability of our submarines, allowing us to do more. They bring a set of capabilities that, in the hands of our talented Sailors, will surely translate into a limitless set of practical applications.

We will continue to advance the technology in-hull just as much as we work to bring expanded capability from UUVs. Between the hardware and software innovations that continue to be made each and every day, submarines are not at all what they used to be. I am constantly impressed by these innovations, but more so by our Sailors' ability to train on the fly and use these new technologies to their maximum potential. I can't wait to see what new technology may come out tomorrow and how well our Sailors will implement it into our Force.

I am proud of you all.

"We need to hone our science and technology, research and development, and acquisition processes to ensure that we have the right capabilities for the future."

A handwritten signature in black ink, appearing to read 'M. J. Connor'.

M. J. Connor



DIVISION DIRECTOR'S CORNER

Rear Adm. Rick Breckenridge, USN
Director, Undersea Warfare Division

We have a lot to be proud of as undersea warriors. This month we commissioned our newest submarine, USS *Minnesota* (SSN 783), the final ship in *Virginia* Block II. Like her sister ships, she delivered months early, on budget, and brings incredible capability to the fight—not least because the Navy and our submarine shipbuilders continue to leverage the most advanced technology in each new ship that we build. This issue of *UNDERSEA WARFARE* Magazine focuses on that technology, including the science and R&D processes that create it, the innovative thinking that figures out how to use it, and the training that turns it into greater operational capability. All this combines to provide the U.S. with a distinctive comparative advantage in the undersea domain, yielding

highly leveraged, strategic, global influence.

“The intelligent and efficient use of advanced technology has always been central to the success of our undersea forces and will be every bit as important in the future.”

The intelligent and efficient use of advanced technology has always been central to the success of our undersea forces and will be every bit as important in the future. From the outstanding diesel engines and surface search radars that multiplied the combat capabilities of our World War II fleet boats, to the nuclear know-how that's keeping our *Ohio*-class SSBNs in service for 40% longer than originally designed, to the versatile *Virginia*-class components that will be grafted into our *Ohio* Replacement SSBNs to provide the most potent capability at the lowest possible cost, our engineers and operators know how to squeeze the most advantage out of each and every piece of gear. This technological savvy has allowed

us to defer building a new class of SSBNs by almost two decades, providing the taxpayers a tremendous return on their investment. This mind-staggering endurance will carry over into the next-generation SSBN. The *Ohio* Replacement is currently under design with a planned 42-year service life and will incorporate a life-of-the-ship reactor core, shortening the mid-life overhaul period and generating the same operational availability as our current class of 14 *Ohio*-class boats with just 12 next-generation SSBNs. Other technological advancements will make the ship quieter and more capable while continuing to drive down cost, giving the taxpayer the most bang for the buck and ensuring a survivable strategic deterrent well into the 2080s. The future looks very bright indeed as we continue to maintain our undersea dominance for decades to come.

R. P. Breckenridge

UNDERSEAWARFARE

The Official Magazine of the U.S. Submarine Force

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UNDERSEA WARFARE is the professional magazine of the undersea warfare community. Its purpose is to educate its readers on undersea warfare missions and programs, with a particular focus on U.S. submarines. This journal will also draw upon the Submarine Force's rich historical legacy to instill a sense of pride and professionalism among community members and to enhance reader awareness of the increasing relevance of undersea warfare for our nation's defense.

The opinions and assertions herein are the personal views of the authors and do not necessarily reflect the official views of the U.S. Government, the Department of Defense, or the Department of the Navy.

Contributions and Feedback Welcome

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CHINFO Merit Award Winner



Silver Inkwell Award Winner

LETTERS TO THE EDITOR

In keeping with *UNDERSEA WARFARE* Magazine's charter as the official magazine of the U.S. Submarine Force, we welcome letters to the editor, questions relating to articles that have appeared in previous issues, and insights and "lessons learned" from the fleet.

UNDERSEA WARFARE Magazine reserves the right to edit submissions for length, clarity, and accuracy. All submissions become the property of *UNDERSEA WARFARE* Magazine and may be published in all media.

Please include pertinent contact information with submissions.

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INCOMING MESSAGE TRAFFIC

"Thanks for the great new issue we recently received at the St. Marys Submarine Museum. I had the opportunity to share a copy with one of our WWII Submarine Veterans ETCS(SS) David Mogil (USN-Ret) and his wife Marion from Sun City Center, Florida, who visited our Museum last week." (At right) Keep up the good work!

Keith Post
Executive Director
St. Marys Submarine Museum



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SAILORS FIRST



Electrician's Mate 1st Class Jason Burke embraces his children with the traditional first hug upon the *Virginia*-class fast attack submarine *USS New Mexico* (SSN 779) returning to Naval Submarine Base New London. *New Mexico* recently returned from a scheduled six-month deployment.

Photo by Mass Communication
Specialist 2nd Class Kristina Young

Question and Answer

Rear Adm. Klunder

Chief of Naval Research
on Undersea Applications
of Naval Science and
Technology Programs

Rear Admiral Matthew Klunder, a naval aviator, became the 24th Chief of Naval Research in November 2011. As the leader of the Office of Naval Research (ONR), he is responsible to the Secretary of the Navy for sponsoring scientific research efforts that will enable the future operational concepts of the Navy and Marine Corps. He discussed with us his organization's role and its undersea warfare applications.



Photo by John F. Williams, USN

The Virginia-class Program has received accolades for achieving the cost reduction target needed to increase the procurement rate to two submarines per year. Did Naval science and technology (S&T) contribute to that success story?

The Office of Naval Research (ONR) was pleased to participate in the Virginia Block III Cost Reduction effort. The primary ONR contribution was through the Manufacturing Technology (ManTech) program. ManTech Director John Carney played a key role in coordinating with the Virginia Program Office (PMS 450) and Electric Boat to identify ways to reduce Virginia cost by improving fabrication technology and processes. ManTech's Centers of Excellence took on the challenges one by one to produce a successful outcome. To date, ManTech has saved \$25 million for each Virginia-class submarine constructed and it is a great example of collaboration between ONR, NAVSEA, Electric Boat, and industry.

With the Virginia-class beginning to replace retiring Los Angeles-class attack boats, the submarine community now faces the challenge of developing a replacement for Ohio-class SSBNs. What role is ONR's S&T playing in support of that effort?

We're making vital contributions to the Ohio Replacement on several fronts. The most prominent is the Time-Critical S&T program, which is a body of basic research efforts focused on reducing risk and improving platform capability. The objective is the timely delivery of S&T products aligned with R&D efforts and timed to meet ship design timelines. To ensure success, ONR entered into an agreement with PEO SUB to coordinate all aspects of the research with the Ohio Replacement program office (PMS 397). I have followed this area closely and am very

The most important S&T issues we are taking on to help the undersea warfare community generally focus on improving the capabilities of the platforms themselves as well as the various payloads they employ globally in our nation's defense.

pleased by the results and with the ongoing teamwork between ONR and PMS 397.

Reliability and maintainability are more important than ever for ensuring that the fleet can meet growing operational demands despite budget constraints. Is Naval S&T involved in reliability and/or maintainability efforts that support the undersea warfare community?

We not only aim to provide new technologies and capabilities to our warfighters but also to improve existing technologies in the fleet and force. ONR investment in technologies supporting undersea warfare remains strong. For example, ONR has a substantial investment in technologies attacking the problem of corrosion. Future Naval Capability (FNC) projects begun in Fiscal Year (FY) 2010 and FY12 will make major improvements to the effectiveness and reliability of the Virginia-class corrosion protection system and develop a spray-on

alternative to the standard glued and bolted damping tiles that pose constant corrosion problems. Also, a portion of the investment in ManTech goes toward repair and sustainment technologies under the Repair Technologies (REPTECH) program. At present, there are several submarine-related REPTECH efforts in progress.

I understand Naval S&T has helped the fleet address reliability problems with thin-line towed arrays. Could you tell us a bit about that?

ONR began an FNC project in FY13 targeting the challenge of thin-line towed array reliability, an issue that has direct impact on the operational effectiveness of the Submarine Force. ONR is involved because, despite relentless efforts within Team Submarine, reliability has not yet reached the level needed by the fleet. Sometimes there is a facet of the problem that is just beyond our understanding. Our researchers are exploring the physics of the highly complex hydrodynamic forces that operate on the towed array while it is being deployed, towed, and recovered. The FNC is developing a high-fidelity tool for predicting the stress on the array so that designers will be able to build the right amount of ruggedness into it while preserving its acoustic performance characteristics.



The Virginia-class attack submarine USS Missouri (SSN 780) exits the Thames River as it departs Naval Submarine Base New London for a scheduled deployment.

Photo by Lt. j.g. Jeff Prunera

The Design for Undersea Warfare envisions broader use of unmanned undersea vehicles (UUVs) in the future to extend the reach and effectiveness of submarines in their many operational missions. How is Naval S&T helping to develop UUV capabilities, particularly submarine operations with UUVs?

We reserve a portion of our funding for leap-ahead technologies that could revolutionize naval warfighting. The Innovative Naval Prototype Program includes an effort developing a large-diameter unmanned undersea vehicle. In this project we are pursuing advances in the critical technologies that have to be in place for an effective UUV. Examples include energy, autonomy, and communications. The advancements we are achieving with this project will form the foundation for future UUVs that meet the Navy's varied needs.

An FNC project titled "Long Endurance Undersea Vehicle Propulsion – Air Independent Propulsion System" is also funded to provide current 21" diameter UUVs with 3X-5X increase in power/energy endurance over current silver-zinc (Ag/Zn) technology (100 watt-hours/kilogram). This scalable long-endurance, air-independent, energy-dense propulsion will be safe and will have gas-and-go rapid turn-around capabil-

ity to enable future intelligence, surveillance, and reconnaissance (ISR) and mine countermeasures missions. An FY17 transition to the Surface Mine Countermeasure Knifefish Program of Record is planned.

Is it possible that autonomous systems will eventually meet the bulk of surface and subsurface ISR requirements in much the same way that airborne ISR is now conducted autonomously?

It is possible, but that is not the goal. The promise of UUVs in the near term is to enhance the capability of manned platforms. Similar to Unmanned Aerial Vehicles, underwater autonomy expands reach and endurance for routine ISR missions while enabling other missions that might be considered too high risk.

How is the tightening Defense budget affecting Naval S&T's investment in undersea warfare?

Although we are making adjustments in response to the challenging budget environment, we understand the importance of undersea warfare to national security. CNO has made his priorities clear that he wants to maintain the U.S. Navy's dominance in the undersea domain by using a network of



Photo by John F. Williams, USN

ONR conducts Autonomous Underwater Vehicle (AUV) operations aboard the R/V *Moana Wave* off of San Clemente Island in the Pacific Ocean.

sensors, platforms, and unmanned autonomous systems. ONR investments will support this goal.

Do you see the new fiscal pressures impacting the way the Navy approaches S&T, and are there any big changes planned or pending for ONR's processes because of this?

Overall, the Navy's S&T investment strategy is sound, so that will not change, but we are looking at processes that can help accelerate mature technology through acquisition to the warfighter. Processes like Speed-to-Fleet, Rapid Innovation Fund, TechSolutions, and Rapid Technology Transfer are examples of tools we are using. An example of a recent rapid transition is solid state lighting (SSL), which was delivered in just 18 months. This added improvement was actually requested by a sonar technician at Commander, Submarine Force, Atlantic Fleet to replace noisy fluorescent bunk lights. The advantages of SSL are many, including improved efficiency, decreased energy usage, decreased maintenance requirements and associated storage, handling, and disposal costs. USS *New Hampshire*, USS *Missouri*, and other ships will benefit from this improved lighting.

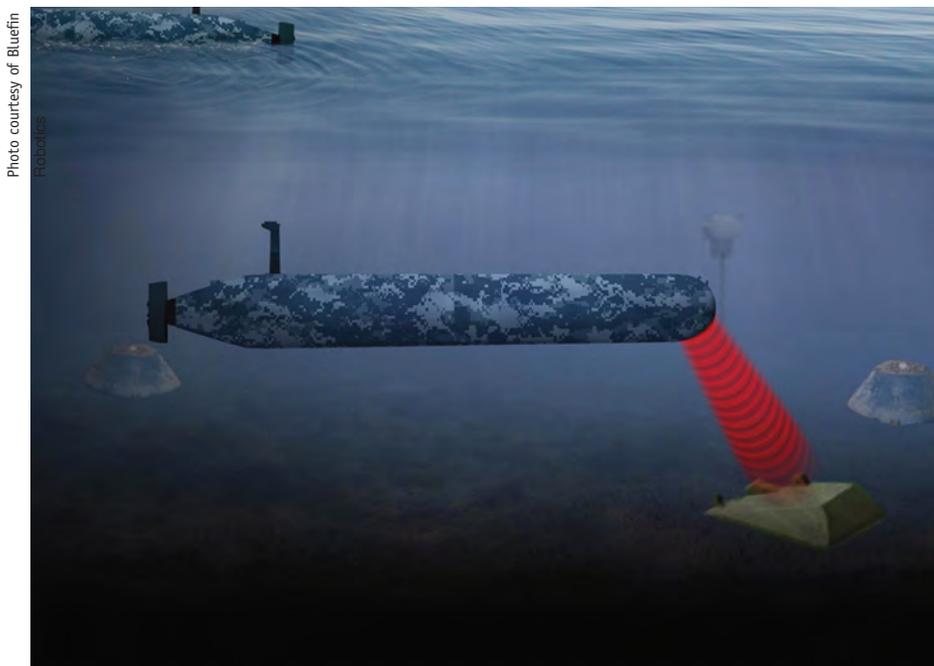


Photo courtesy of Bluefin Robotics

Unmanned undersea vehicles will extend the reach and effectiveness of submarines.

From your perspective, what are the most important S&T issues ONR is currently working on that relate to undersea warfare?

The most important S&T issues we are taking on to help the undersea warfare community generally focus on improving the capabilities of the platforms themselves as well as the various payloads they employ globally in our nation's defense. We are working across the full spectrum of undersea platforms and weapons to make them more effective and efficient in achieving their designed purposes. On the undersea platforms, we have dozens of S&T efforts underway from the sonar system at the bow of the boat to the propellers at the aft end. All these efforts are focused on improving the performance, efficiency, and durability of the many systems and components that all must work together to achieve mission success. In the area of payloads, we have several efforts in progress to advance the state of the art in undersea warfare by making weapons and other payloads smaller, more effective, and cheaper to design and build.

On another front, ONR is delivering adaptive training and mission planning products that enhance operator performance and combat readiness. ONR is addressing warfighting requirements defined by the Submarine Tactical Requirements Group and is working with PEO-IWS to field systems throughout the Submarine Force. For example, the ONR Capable Manpower Future Naval Capability program has developed a mission planning application that supports rapid development and execution of navigational plans integrated into the Voyage Management System digital navigation system. The mission planning application is preparing for Step 3 testing in the PEO-IWS Advanced Processor Build (APB) acquisition process. ONR's Narrowband Adaptive Training (NbAT) and Periscope Operator Adaptive Training (POAT) systems are also going through the APB testing process. These adaptive training systems are game-based and tailor training content to the needs of the individual operators. We're now investigating how both NbAT and POAT scores can automatically link to the Submarine Force Continuing Training and Qualification Software (CTQS) for credit.

As we look to the distant future, what

S&T areas do you feel warrant the greatest investment?

While autonomy is getting a lot of attention and for good reason, we can't forget about what enables these advances in unmanned systems. IT, power and energy, and capable manpower are three areas where we see high payoffs. IT is the critical infrastructure that makes future networks of autonomous systems possible. Advances in power and energy for unmanned systems are critical to realizing the promise of extended reach and presence. Finally, people have to be trained on how to operate a hybrid force, make decisions, and understand how this changes our CONOPS to leverage the true potential of this technology.

[I]f we assume that dominating the undersea domain is in part a function of presence, then the sooner we can economically produce autonomous systems that can match the capabilities of their manned counterparts, the better.

If there were one undersea warfare-related S&T effort you could magically make ready for service today, what would it be, and how would it impact the way the Navy approaches undersea warfare?

I think this comes back to how S&T enables the priorities of the undersea warfare community and their vision for the future of undersea warfare. So, if we assume that dominating the undersea domain is in part a function of presence, then the sooner we can economically produce autonomous systems that can match the capabilities of their manned counterparts, the better.

What do you consider the most difficult hurdle to overcome in transitioning new technologies to the warfighter?

From my perspective as the Chief of Naval Research, I see so many promising efforts. The challenge in getting these to the warfighter faster is that no single silver bullet solves the transition challenge. It might be better to look at this from what enables success. I will say that the most important success factor I have seen from recent transi-

tions is good communication. When ONR, SYSCOM, OPNAV, and the warfighting enterprises are in sync on requirements, capabilities, and technology needs, the process is very responsive.

What do you think is the biggest challenge to keeping our Navy's technological edge against our potential foes?

Given the rapid pace of technology advances worldwide, we are always pressed to keep pace. To do this, we need to continually draw upon the brightest minds in Naval S&T and across the country. At the same time, we need to maintain the health and vitality of the Naval S&T community for the future, and that means that the Navy needs

to pay attention to Science, Technology, Engineering and Math (STEM) education.

What advice would you give to OPNAV with respect to its planning for developing the Navy's undersea warfare capability?

I would say keep insisting that ONR has a seat at the table. While ONR is responsive to the needs of the warfighter with technology solutions, sometimes discoveries can lead to new capabilities and new ways of doing things. So sometimes an ONR program officer who is an expert in his or her research field might say, "Have you thought of this yet?"

How can deck plate sailors in the undersea warfare community communicate with ONR about their S&T needs and/or ideas?

We have a group called TechSolutions (www.onr.navy.mil/techsolutions) that does exactly that—takes ideas and needs submitted online by Sailors and, if selected, will work with the chain of command to develop a prototype solution, sometimes in less than a year.



Tactical Advancements Next Generation

On the midwatch, a boring transit—have you ever wished that the systems onboard the submarines were a little more like your iPad, Xbox, or Android phone? Imagine replacing the wardroom table with a large multi-touch collaboration surface like in the latest James Bond movie or in Corning’s “*Day Made of Glass*” video (<https://www.youtube.com/watch?v=jZkHpNnXLB0>). Visualize all of your publications and maintenance material on your own tablet. Think about using an Xbox360 controller to operate the periscope. Imagine a redesigned Sonar, Imaging, and Combat System that looks and feels like *one system* with all of the information at your fingertips just like at home. That’s what a bunch of hand-picked junior officers and sailors imagined at the first-of-its-kind Tactical Advancements for the Next Generation (TANG) Forum in November 2011. These creative and energetic Submariners looked beyond their current technology and challenged the notion of “this is how we have always done it.” Instead, the TANG participants asked, “How might we...?” The ideas and prototypes they created were so compelling that they were incorporated into development for the next Advanced Processing Build (APB). APB-13 will feature some of their ideas...all within two years!





for the

So how did this happen? Simple. By giving these “digital natives”—those who have grown up with the Internet, Microsoft, Google, Adobe, and Apple—a forum to be inspired, collaborate with each other, and create a vision of future submarine systems. The TANG Forum was a three-day workshop in sunny San Diego co-sponsored by Commander Submarine Development Squadron TWELVE and PEO IWS 5 (the submarine advanced development program office that develops Advanced Processor Builds).

Then-Vice Adm. John Richardson, COMSUBFOR, challenged PEO IWS 5 and Johns Hopkins Applied Physics Laboratory to make APBs more intuitive. TANG was the result. Vice Adm. Richardson’s strong belief in the creative power of the junior officers and Sailors was such that he keynoted the event and challenged the attendees to “arrive at better ways to synthesize the data from around the ship and come up with some displays that will allow us to be better decision makers.”

He was looking to these innovators to help visualize the future of the submarine combat systems.

A Creative Space

A submarine upkeep in port can be an extremely busy time with plenty of distractions for a Submariner, so in November 2011 we brought all 27 attendees away from their homeport to San Diego and asked them to leave their uniforms at home. We wanted to enable them to completely focus on this new innovation event. The attendees were hand-selected by Commodore Bill Merz, CSDS12, following nominations by their home squadrons. Vice Adm. Richardson and Rear Adm. Caldwell asked squadron commodores to “nominate two switched-on JO/ST/FT (three-man) teams from each squadron to participate. Ideally, your nominees should be motivated, energetic, creative Sailors with recent deployment or patrol experience.” The nominees had to be either junior officers or E-6 and below. We were targeting the junior operators to take advantage of their experience in the latest commercial technology along with their new and fresh ideas. We asked for an exceptional group, and we got it!

To make it even more exciting, we invited Microsoft and other commercial technology companies to showcase the realm of the possible in a technology expo. The tech expo allowed the attendees to see and touch some of the newest commercial technology. From the Kinect and Microsoft Surface to a new multi-touch table and tablets running the next generation navigation system, the tech expo succeeded in our goal to inspire the attendees!

The cool technology and the San Diego fish tacos set the stage for the event, but we wanted to bring in the innovation experts to guide the attendees on their journey. We consulted with Eric Haseltine, former head of science and technology for the entire U.S. intelligence community and former Executive Vice President and head of R&D for Walt Disney Imagineering; he recommended an industrial design firm called IDEO.

IDEO (pronounced “eye-dee-oh”) is an award-winning international innovation consultancy that takes a human-centered, design-based approach to helping organizations in the public and private sectors innovate and grow. Even though IDEO has worked with companies such as Apple, Microsoft, Google, P&G, Qualcomm, and NASA, they were really impressed with the initiative and creative energy from the 27

hand-selected Submariners at the TANG Forum. IDEO has been involved with some interesting projects such as EA Sports Madden Football ’09 and Ford Vehicles, but helping create a better experience for the submarine warfighter was an opportunity they didn’t want to pass up.

We paired IDEO with members of the submarine advanced development process, who provided subject matter expertise, in the workshop sessions. Together, the IDEO and subject matter expert (SME) team crafted a workshop using the Design Thinking innovation process (see sidebar).

Armed with the design thinking principles, the three-day event took the attendees through a series of brainstorming and rapid prototyping as they visualized new interac-



Junior Officers and operators brainstorming and rapid prototyping their future submarine concepts at TANG 2011

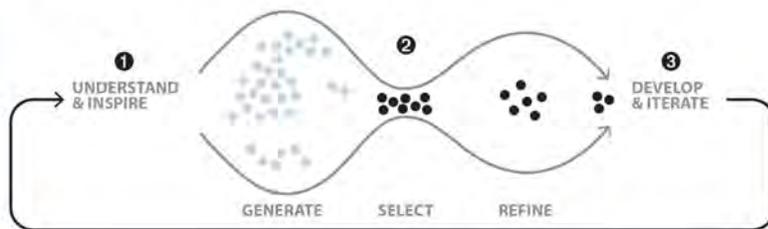
Design Thinking

The design thinking process is best thought of as a system of overlapping spaces rather than a sequence of orderly steps. There are three spaces to keep in mind: inspiration, ideation, and implementation. Inspiration is the problem or opportunity that motivates the search for solutions. Ideation is the process of generating, developing, and testing ideas. Implementation is the path that leads from the project stage into people's lives.

"Design thinking is a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for the business success." – Tim Brown, President and CEO of IDEO

Design Thinking Process

- 1 Understand the users and the context of the system being designed
- 2 Use this knowledge to generate a diversity of potential solutions at a low resolution
- 3 Explore the solution directions that show greatest promise and feasibility



IDEO's Design Thinking Process, the "Double Bubble"

tions, displays, and concepts using nothing more than arts and crafts materials like sticky notes, foam core, clay, glue, and construction paper. The simple supplies allowed the innovators to quickly turn hundreds of their ideas into concepts in physical form that invited collaboration and creative discussion with the group.

Here are some of the concepts that came out of TANG:

Data Mobility: Go-Anywhere Tablet (GAT)

The TANG attendees conceptualized different uses of their own version of tablets for data mobility: Go-Anywhere Tablet (GAT). The GAT concepts applied the power of allowing the user to move throughout the boat while maintaining continued access to the information and displays. Pre-watch tours and briefs while using the GAT allow the users to access various levels of information to improve situational awareness, watch team collaboration, and overall ease of use. Accessing screen shots of troubleshooting techniques outside of the control room can enable better collaboration among the maintenance team without affecting the on-watch section. The GAT concept is a prime example of fast-following the commercial sector in user interface design, therefore

making the interface familiar to the user warfighters.

Targeted Adaptive Training

The attendees asked themselves, "Why do I have to complete mandatory training during my off-watch period when I just did the real thing while on watch? Why can't it be more like video games where you receive experience points for completing tasks?" Their idea was that the operators and officers are "users" who could receive credit for tasks

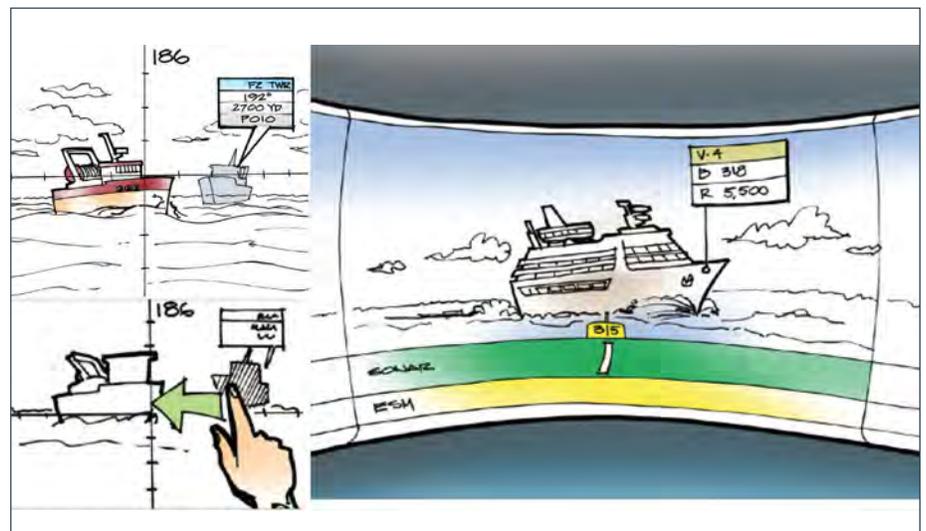
they complete during their normal watch routine. Whether it's achieving points for completing training modules and guided work flows or successfully carrying out certain real-world missions, the user could achieve similar experience points that will follow him/her throughout his/her Combat System journey. Taking credit for completing different tasks immerses users in a different environment that helps them "train like they fight." Motivating the users on watch to maximize the capability of the system will benefit the section, the crew, and ultimately the Submarine Force.

Immersive Imaging

Combining the power of augmented reality and multi-touch interface, the attendees wanted to be able to compare the combat system solution to the periscope information. Simply touching the "ghost image" generated from the fire control solution, the operator could drag the ghost image onto the actual contact. The TANG innovators envisioned the system being able to auto-fit the ghost image to the real contact, therefore updating the solution using the raw data.

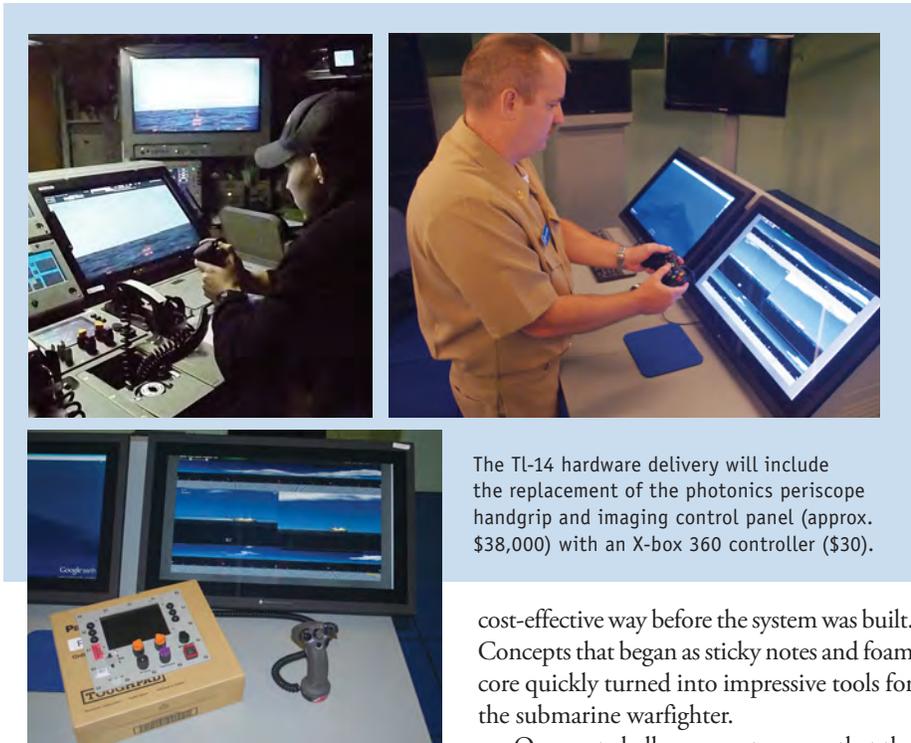
Control Room Vision

Ever wonder why the control room is arranged such that the supervisors are talking to the backs of the operators' heads? What if that was how we communicated outside of the submarine? The TANG team conceptualized a more natural layout of the control room, one that leveraged the multi-touch tables as well as the ability to



An artist's sketch of the Immersive Imaging concept for periscope observations

All photos courtesy of TANG Team



The TL-14 hardware delivery will include the replacement of the photonics periscope handgrip and imaging control panel (approx. \$38,000) with an X-box 360 controller (\$30).

move most of the electronic servers and processing out of the control room to provide more space for the watch team. Replacing workstations with flat panels can create more flexibility in the control room. Watch teams could communicate face to face around a digital table, similar to planning around the navigation plot. Taking the concept further, the attendees envisioned a 360-degree visual display inside the control room to immerse the watch team in the visual picture.

Impacting the APB Process

After the TANG attendees created the vision, we needed to turn their ideas into software ready for the submarine. Applying the design thinking principles to the APB process, the APB design team turned the foam core concepts into submarine tactical software. Over four months, we brought in more fleet operators to participate in a series of smaller “deep dive” workshops focused on building and iterating the concepts that started from the TANG Forum. These workshops were called Concept User Experience Events (CUE²) and included fleet users, integrators, developers, system testers, and Human System Integration (HSI) experts. The CUE² workshops allowed the developers to actually turn the user-generated concepts into display prototypes using cheap, commercial programming software. The group could then try lots of different views, interfaces, and controls in a

cost-effective way before the system was built. Concepts that began as sticky notes and foam core quickly turned into impressive tools for the submarine warfighter.

Our next challenge was to prove that the software prototypes were “more intuitive.” We tested using commercial industry practices (such as a User Experience Measurement, System Usability Scale (SUS), Task Load Index, and Tobii eye-trackers). We were striving for concepts that were intuitive and required minimal training. APB Step 2 testing leveraging the eye-tracker and other tools allowed us to identify issues and make additional low-cost changes before the concept was integrated into the rest of the system in preparation for APB Step 3 lab tests and Step 4 sea tests. So some of the ideas that started in the TANG Forum will be tested and delivered to the Submarine Force in APB13!

A Vision of the Future: Area 51

One of the best ways to experience what the future systems could look and feel like is to immerse yourself into a facility that showcases the art of the possible. Lockheed Martin, motivated by the TANG experience, built a unique facility they call Area 51. Area 51 provides a test bay that allows developers and fleet customers to try out a variety of commercial software and hardware technology in the physical constraints of a *Los Angeles*-class and *Virginia*-class submarine control room and wardroom. The facility couples the latest APB software with multi-touch tables, tablets, Xbox controllers, Kinect, Google Earth, and a variety of other technologies. Many submarine crews and instructors have already

experienced the magic of Area 51, including some of the TANG 2011 alumni. The Area 51 mission is simple: “Why wait for the future to do what can be done today?” The APB development community can try out their software in an environment featuring the latest user interface technology to better understand the end user’s experience. Some of the concepts from the TANG Forum are integrated with the rest of the system and are up and running in Area 51. Even the ideas for revolutionizing the submarine wardroom have been implemented!

The TANG Forum Series Continues

AUS-US TANG Forum: This past July we conducted the first international TANG Forum event at HMAS *Stirling* in Rockingham, Western Australia featuring 18 Royal Australian Navy and five U.S. Navy officers and sailors. Three of the U.S. participants were alumni from the first



Lt. Josh Hausbach and Andy Leal describing the Xbox 360 controller periscope controls



Members of the ACINT community prototyping new concepts



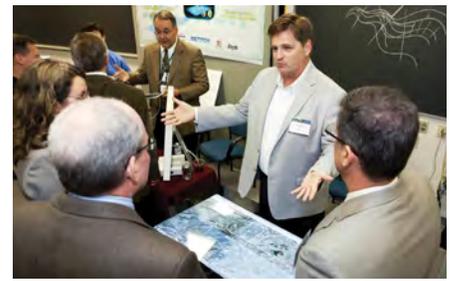
CUE² participants voting on their favorite ideas



Google showcasing "Liquid Galaxy" at Tech Expo



Adobe at AUS-US TANG Tech Expo



Microsoft demonstrating their technology

TANG. This time the AUS-US TANG Forum harnessed the creative power of the two submarine forces as they conceptualized ideas that will shape the future submarine systems on both sides of the world. Their concepts could show up as early as APB15.

Executive TANG Forum: On September 9-12, 2013, the Executive TANG Forum event will bring hand-selected PCOs, COs, and Post-Commanding Officers to Pearl Harbor for the next design thinking workshop event. The goal of Executive TANG is to leverage the command perspective on how to access and interact with command-level information and develop ways to free the CO from the cognitive load associated with operator tasks and instead facilitate risk vs. gain determination, pattern recognition, managing uncertainty, and keeping the CO "above the fray." Concepts generated from this workshop will drive the future development of submarine systems and processes.

The IDEO team will get underway onboard USS *Hampton* (SSN 767) in order to fully experience submarining first-hand.

Commercial Technology Collaboration is Growing

Submarines are cool and other commercial technology companies are excited to be

part of the submarine culture. Microsoft was the first large company to participate in a TANG Forum event but, since that time, Adobe and Google have joined the team. All three companies showcased their amazing technologies at the AUS-US TANG Forum and are going to show even more cool stuff at the Executive TANG Forum! The commercial industry is always creating new things that will continue to drive the realm of the possible.

Staying Connected

One of our biggest goals with the TANG Forum initiative is to stay connected with the past and future TANG attendees as great ideas can happen anytime and anywhere. There are plenty of opportunities to tell the TANG story, and it's always great to have the stories come from the warfighter. Look for the TANG Forum on the Internet as we share the excitement and creativity generated by our submarine innovators.

TANG Forum Facebook page: <https://www.facebook.com/tangforum?ref=hl>

TANG Forum Video: <https://www.youtube.com/watch?v=i9kxfgWU8M>

TANG Forum and Beyond Video: <https://www.youtube.com/watch?v=i-GOzOWQ-HI>

Conclusion

The powerful engine that drives the TANG Forum initiative is the creative energy of Submariners. By starting with the submarine warfighter and applying design thinking principles, commercial technology, and the rapid APB delivery process, the Submarine Force is creating an exciting and awesome future. We will be looking for more energetic and creative Submariners to participate in the next TANG Forum event.

"I thought that it would be a bunch of U.S and Australian Submariners sitting in a room complaining about problems and frustrations that we have with our combat system. Solving all the world's problems with grand solutions ... and then that would be that. And I was really wrong ... When you took structured thinking and you took the art of the possible and the technology that is out there, we could then be the third element and put that together and look at 'Here's a proposal of ways we could move ahead and make systems help us do our job better and make our job easier.'"

– LCDR Dan Sutherland, Executive Officer, HMAS *Dechaineux* (SSG 76)



TANG Forum attendees, November 2011 in San Diego, Calif.

All photos courtesy of TANG Team



AUS-US TANG: Team GROWLER



AUS-US TANG: Team BOWFIN

TANG Forum '11

- FT1 Don Moreno—USS *Bremerton*
- Lt. j.g. John Dubiel —USS *Bremerton*
- FT1 Rich Gunter —USS *Charlotte*
- STS2 Charles Augustine —USS *City of Corpus Christi*
- Lt. j.g. Jason Frederick —USS *City of Corpus Christi*
- FT3 Jordan Larry —USS *City of Corpus Christi*
- Lt. Dan Kohnen —USS *Columbus*
- Lt. j.g. Dan Justice —USS *Florida*
- FT1 John Keagle —USS *Florida*
- STS1 Randy Kelly —USS *Florida*
- STS2 Don Grubbe —USS *Houston*
- Lt j.g. Stephen Emerson —USS *Houston*
- FT2 Thaddeus Sciongco —USS *Houston*
- Lt. David Camp —USS *Key West*
- FT3 Glen Elam —USS *Key West*
- STS1 Robert Sarvis —USS *Key West*
- Lt. Tim Manke —USS *New Hampshire*
- STS1 J.P. Whitney —USS *Norfolk*
- FT1 Brent Caraway —USS *San Francisco*
- Lt. Eric Dridge —USS *San Francisco*
- STS1 Rich Hering —USS *San Francisco*
- STS2 Chris Remiesiewicz —USS *Virginia*
- FT1 Brandolf Schlieper —USS *Virginia*
- Lt. Arlo Swallow —USS *West Virginia*
- FT1 Ben Lang —USS *West Virginia*
- STS1 Gabe Brazell —USS *West Virginia*
- STS2 Jake Malone —SLC Det. San Diego

AUS-US TANG '13

- Lt. Dan Kohnen Yale ROTC
- FT1 John Keagle—USS *Florida*
- Lt. Tim Manke—CSDS12
- FTCS David Fennell —CSDS12
- Lt. Tony Le —PEO-IWS 5A
- 18 RAN Officers and Sailors from:
 - AUSSUBFOR
 - HMAS *Dechaineux*
 - HMAS *Farncomb*
 - HMAS *Sheean*
 - Submarine Training and Systems Centre

TANG Team

- Mr. Josh Smith, JHU/APL
- Mr. Don Noyes, JHU/APL
- Mr. Dave Blakely, IDEO
- Mr. David Haygood, IDEO
- Mr. Dan Soltzberg, IDEO
- Mr. Peter Macdonald, IDEO
- Mr. Deuce Cruse, IDEO
- Mr. Ray Rowland, NUWC Newport
- Mr. Andy Leal, Lockheed Martin
- Lt. Josh Hausbach, Submarine School

Contributors:

- Mr. Pete Scala, PEO IWS 5A
- Mr. Don Noyes, JHU/APL
- Mr. David Latham, Lockheed Martin

MODERNIZATION TRAINING:

HELPING BRING

TOMORROW

TO THE

SUBMARINE FORCE

TODAY

In the evolution of sonar, combat, and other non-propulsion electronic systems, each upgraded system only brings new capability. The teaming arrangement of the Systems Commands (SYSCOMs), the Submarine Learning Center (SLC), the Type Commander (TYCOM), and Submarine Development Squadron 12 (DEVRON 12) develops and delivers high-quality operational and employment training to transform that capability into what the fleet commanders need: readiness.

The History

In the typical training model of the past, the SYSCOM developed and delivered factory training for each new install in accordance with the Navy Training Systems Plan (NTSP). Since new systems didn't come along very often, this training model worked well for an individual ship. By the time the system had proliferated into the fleet, there were enough experts returning from those ships to the schoolhouses as instructors to conduct high-quality responsive training in the local schoolhouses. The process was self-sustaining.

During the initial fielding of Acoustic Rapid Commercial Off-the-Shelf (COTS) Insertion (A-RCI) sonar systems in the late 1990s, Naval Sea Systems Command (NAVSEA) and the Advanced Systems Technology Office (ASTO) established the Concept of Operations (CONOPS) and OMI Support Group-Acoustics (COSG-A), a cadre of senior enlisted operators, to perform a critical task: provide fleet input into the system development process.

At the same time, senior sonar operators in the fleet, including members of the COSG-A, became concerned that there was no training plan of record to accompany the introduction of A-RCI into the fleet. To meet this shortfall, these senior sonarmen formed a grass-roots A-RCI operations training program, approved by NAVSEA and



The crew of the PCU *North Dakota* (SSN 784), working with Naval Submarine School Modernization Training Team members in the Multi-Interactive Trainer, (MIT), at Fluckey Hall

the TYCOMs. These training teams evolved into the Tactical Systems Development and Installation Teams (TSDITs), which provided high-quality training during the initial A-RCI installation. As the number of new systems proliferated, however, the TSDIT process alone was no longer sufficient to create a broad and sustainable base knowledge of operation and employment of these systems and allow for quality responsive training in each homeport.

The Initial Solution

The NTSP is the best guess of what training will be required for operators and maintainers for a new system. Though reviewed annually, it does not directly cover emergent training for technical insertion, training for fleet shortfalls, or officer training. To close this gap, the SLC directed the establishment of a Modernization Training Team (MTT) at each learning site, with modernized system training as its primary responsibility.

Since these teams are actually part of each local schoolhouse staff, they also conduct staff training as well as responsive training in the Submarine Multi-Mission Team Trainer (SMMTT) and pre-deployment training as directed by the local schoolhouse commanding officer. The specific composition of each MTT varies slightly from site to site depending on the configuration and type of submarines in that homeport, but the typical team consists of one lieutenant, two sonar technicians, two fire control technicians, and one or two electronics technicians for communications and electronic support (ES) training.

Regardless of location and exact makeup, the goals of the MTT are the same:

1. Establish and maintain a broad base of knowledge and experience within the shore training establishment for both enlisted and officers
2. Maintain the high quality of installation training that the TSDITs established
3. Provide timely, accurate, and responsive training on modernized tactical systems to ships during new installation or follow-on and to the schoolhouse staffs
4. Rapidly integrate into the training pipeline the new equipment, tactics, and technology learned as part of the modernization training process

The establishment of the MTTs resulted in a broader base of expertise, served the fleet well, and prompted the next logical step: ensuring that the training given to a ship being modernized in Norfolk is the same, in terms of quality of curriculum and instructors, as the training given to a ship in Bangor, Groton, Pearl Harbor, Kings Bay, San Diego, Guam, or any of the shipyards.

Today and the Future

In our new Modernization Training Model, the TYCOM, SYSCOM, and the SLC have partnered with formal memoranda of agreement. In these agreements, the SYSCOMs provide civilian Subject Matter Experts (SMEs) with extensive operational experience to work with the SLC's Modernization Training Director, forming a Modernization Training Support Team (MTST). In addition, the SYSCOM provides training for the MTT members to build the initial expertise in the active duty instructor base.

The SYSCOM, MTST, and MTT are engaged early and often and jointly develop and deploy an approved curriculum residing at each learning site allowing for advanced preparation, in-time delivery, and post-event refresh as well as pipeline training update. The MTST aims to improve liaison between the program offices and the SLC to enhance development of training materials and Interactive Electronic Technical Manuals, support delivery of installation training by the local MTT, and assist in transitioning that knowledge into the training pipelines. Additionally, the MTST assists DEVRON 12 Tactical Analysis Group in development of the System Employment Manuals, mentors MTT instructors, and monitors the delivery of the training to continuously improve the process.

So today, in practice, the modernization training process spans the entire Advanced Processor Build (APB) cycle from development through step testing, integration, and at-sea testing to installation on each submarine. The MTT instruction serves both enlisted Sailors and officers for system operation and employment and results in local military SMEs who are both a school and waterfront resource and eventually return to sea aboard a modernized submarine. Because the active duty MTT instructors follow the normal sea/

shore rotation, the civilian MTST provides the long-term stability critical for continued success of the process.

The MTST is made up of SMEs from NAVSEA PMS 401 (Sonar), PMS 425 (Combat Systems), PMS 435 (Imaging and ES), and PEO C4I PMW 770 (Common Submarine Radio Room) with over 150 years of active duty submarine experience. These dedicated and highly motivated professionals are the absolute key to the long-term success of modern systems employment training. They are able to adeptly translate between scientist, system engineer, and employment guidance developer to operationalize new design concepts using a variety of knowledge transfer methods including printed material, video, and hands-on demonstration tailored to individual Submariners and watch teams.

Over the past two years, the MTTs have trained boats in every homeport and on every submarine type and class. In addition to training boats being modernized, MTT has taken on operations training for new-construction *Virginia*-class boats, starting with the future USS *North Dakota* (SSN 784).

Current Process Example

The rate and pace of the deployment and employment of the MTTs is derived from the fleet modernization schedule. This schedule is developed and updated at the quarterly Command, Control, Communications, Computers, Collaboration, and Intelligence (C5I) conferences by TYCOM, SYSCOMs, resource sponsors, and training representatives. The output of that conference is the modernization schedule for each boat and makes our training process and scheduling predictable.

With instructors at each site, the MTT network can deliver modernization training to more than one ship in more than one homeport simultaneously. This includes the ability

Photo by William Kenny



“The establishment of the MTTs resulted in a broader base of expertise, served the fleet well, and prompted the next logical step: ensuring that the training given to a ship being modernized in Norfolk is the same, in terms of quality of curriculum and instructors, as the training given to a ship in Bangor, Groton, Pearl Harbor, Kings Bay, San Diego, Guam, or any of the shipyards.”

to have a team made up of instructors from different sites conduct a training event in port or at sea.

As a team, we develop and execute training for the boats as systems are installed and as directed by the TYCOM. A typical A-RCI/BYG-1/BLQ-10/CSRR install training is conducted in three phases. During the availability, before the system is installed and tested, the local MTT conducts classroom and individual skills training in the Multi-purpose Interactive Trainer, Submarine Electronic Warfare Suite, and the CSRR Mission Reconfigurable Training System.

Each training event is tailored to the ship, but the average schedule for the current Advanced Processor Build (APB-11) calls for a week for officers, two weeks for STs, two weeks for FTs, and two weeks for ETs to cover the new system operation and some hands-on individual skill development. After the system installation and testing, the MTT goes to the submarine and conducts about five days of team training on the ship using the system onboard training tools and covering multiple mission areas. This also serves to continue the over-the-shoulder training for individual skills that can't be trained as efficiently in the trainer.

Sometime after sea trials, the MTT returns for an additional three to seven days of at-sea, over-the-shoulder training to reinforce the basic skills and further enhance some of the advanced team skills. The local squadron is invited to participate in all of the training so that, as each of the submarines in the squadron are modernized, the staff can stay current and reinforce the training during subsequent events as the ship works up for deployment.

What Hasn't Changed

The end result still has to be a trained Sailor who can get the most out of the capability of the system. For that to happen, first and foremost, the Sailor must come to the training engaged and ready to learn. Second, the instructor must be prepared and have a high-quality curriculum as well as the experience to make the topic interesting. Third, Sailors need to know that their feedback matters.

We have shown since APB-07 that the teaming arrangement with the SYSCOM, SLC, TYCOM, and DEVRON 12 has resulted in engaged Sailors, high-quality approved curriculum with well trained instructors, and a feedback loop from the ships and instructors to DEVRON 12 that produces well thought-out changes to the employment manuals as the systems are developed and operated.

Future Success

To remain successful, modernization training requires a commitment by the Submarine Force to provide billets to the schoolhouses—for the schoolhouses to continue to provide high-quality instructors as members of the MTTs—for the SYSCOMs to continue to provide SME and instructor training support for the MTST and MTT and for the SLC to remain committed to its long-term success. It must be a team effort.

The CO of a recently modernized submarine summed it up by saying "I think we have finally cracked the nut with regard to modernization training. The Naval Submarine School MTT was excellent; the instructors knew the system inside and out, tailored the training to the strengths and weaknesses of my crew, and were flexible in supporting our schedule perturbations. The three-phased approach to training provides the necessary revisit rate to ensure that the training is absorbed and that the watch teams understand how to employ the system."

Technical innovation demands continual learning of new sets of skills to successfully convert system capability to mission readiness. Our training must continue to support rapid technical insertion so that our 21st Century undersea warriors remain the world's finest Submarine Force.

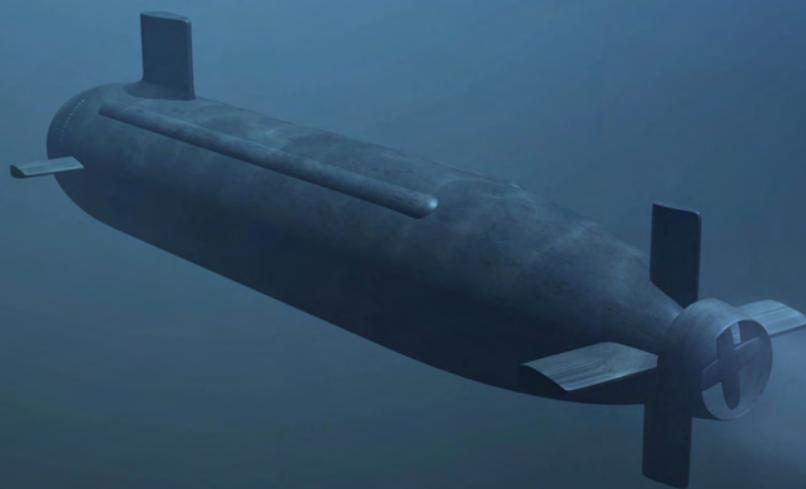
Cmdr. Randy Craig USN, (Ret.), served 25 years as a Submariner to include sea assignments on USS *Von Steuben*, USS *Sand Lance*, USS *Seawolf*, and USS *Miami*. Shore assignments included NROTC Penn State University, OPNAV N77 staff, and Deputy, Naval Submarine School.



Photo by William Kenny

"Technical innovation demands continual learning of new sets of skills to successfully convert system capability to mission readiness. Our training must continue to support rapid technical insertion so that our 21st Century undersea warriors remain the world's finest Submarine Force."

Google Earth Team Develops Navigation Tools



Adding Depth and Dimension to Subsurface Operations

Whether you're mapping the best routes around a new city, looking up how to get to a restaurant, or deciding which trail to take on a hike, chances are you'll pull out your smartphone for directions.

But in a submarine, getting directions, data, and information is a much tougher—and more time-consuming—task. Situational awareness (SA) flows in on several screens, each sourcing data differently and each presenting a different perspective.

The challenge to integrate these perspectives and improve the speed and ease of submarine SA to near-smartphone levels drove a team, headed by Google Enterprise, to develop a solution now being tested for Virginia-class subs.

The highly collaborative development process would come to engage many partners, large and small, and involve many of the venues for developing and demonstrating innovations. Google's prior experience with clients including the National Geospatial-Intelligence Agency and the Office of Naval Intelligence, as well as its long-term cooperative research and development agreements already in place, made it the right partner to help the U.S. Navy find an answer.

The project began two years ago when Mark Steele, Information and Knowledge Manager at COMSUBLANT in Norfolk, Va., got underway with a few submarines. The retired surface warfare line officer had spent his career on ships, but his role as knowledge manager in the submarine force required he learn how information flows while underway—beneath the seas. As he stood in the sub's control room watching the information flow, he was struck by the difference. He asked: *How can the commander get improved situational awareness in less time? Is there a more natural way to display navigation information while submerged?*

"Four hundred feet below the surface, there are no bridge wings to look out from to get contextual data—just flat-screen displays of paper charts," he says. "Current navigation tools (Voyage Management System) display a submarine's position in two dimensions, while the submarine is operating in a three-dimensional environment."

Screens with multiple data streams

In a submarine, a crew's SA is limited to what comes in on its system screens. The commander could be looking at 6 to 36 control screens, each providing different and critical data, and many functioning as digitized versions of a paper chart. One screen might show sonar, another fathometer data, another GPS or radar data, depending on vessel submergence.

To make navigation and tactical decisions in real time, data from multiple screens must be rapidly blended, comprehended, assessed, and analyzed. Where does the synthesis of these complex data streams take place? Solely in the submarine commander's



Above, a multi-screen Google Earth mock up environment used for training and testing. At right, the full picture of testing innovation: views show external surroundings of sub together with the integrated systems, coupled with tablet and 'joystick' control for digital periscope.

or the officer of the deck's brain.

Granted, technology developers and crew alike say that's a pretty good place for such analysis to happen. The combination of experience, expertise, and understanding of mission doesn't get much better.

But even the sharpest leader can experience fatigue and human error. Understanding and communicating data among humans takes time. And that "server space" in the commander's brain might be better used another way—in executing a speedier critical decision cycle, for instance, and executing that uniquely human facility: judgment.

As with all technology, separating what's better done by machine than by humans and managing the user interface are the keys. Submarines had long relied on stovepipe-style systems, with data coming in on independent, non-coordinated streams. The challenge was not only to integrate the streams, but to tap the most complete and unified data—and to make the results as easy as possible to apply to the decision-making process.

That is, it would be like getting directions and traffic information on a smartphone—but in a tougher environment, with more complex data and much higher stakes.

Steele had partnered with Google in the past, exploring potential use cases for search engines onboard submarine networks. As he

considered subsurface navigation after his submarine trip, he asked: *Can we employ Google Earth technology that everyone knows and trusts in the terrestrial plane and render existing certified navigation data to provide a more natural view of the submarine navigational picture?*

So Steele reached out to Google again to explain his hypothesis. In creating the solution, Google and its partners worked with the Navy and key mission partners from Lockheed Martin Area 51 and Johns Hopkins University (JHU) Applied Physics Lab (APL) seeking a rich mission-planning tool that would:

- **Reduce the margin for error:** Let machines do what humans had done.
- **Shrink the decision cycle:** The less time spent building a mental picture, the more time is available to focus on the decision cycle.
- **Decrease speed-to-capability:** Get a solution that will reduce training time and stand up quickly.

The goal was, in essence, to reproduce part of the integrative function of the commander's brain—and to get it on the screen quickly using modern data visualization techniques, fully visualized, and in a way that didn't take a lot of training resources.

But also important in development were attempts to realize savings in time and money and increase mission success.

Flexible software meets massive data

What's happening around you? Where are you going? How will you get there? Geospatial information is a blanket term that condenses these basic navigation questions and others. On a sub, these classic queries were being answered with contextually disconnected data sets. Each screen represented an independently operated, disparate baseline-referenced system. Another hitch: the different tools and interfaces used to gather and present the data tended to have been developed at different times—meaning they often had differing frames of reference as well.

In addition, the current software didn't represent the global dimension of SA needed. To navigate safely, a car or a ship needs to consider two spatial dimensions—what's on the same level as the vehicle and what's above. For submarines and aircraft, the challenge is upped to three dimensions: what's around, what's above, and what's below. This demands a data solution that can handle multiple layers of information.

Google worked with Steele, taking a minimalist and no-cost approach to developing the initial concept. The Google Enterprise team also engaged longtime partner Thermopylae Sciences + Technology, a small and highly innovative service-disabled veteran-owned technology company. While Thermopylae worked on developing the

application, Google provided the massive data capability and spatially rendered framework using Google Earth.

Initially a small company called Keyhole Inc. and funded by In-Q-Tel, Google Earth has become a widely used virtual globe, map, and geographical and geospatial information program. Google Earth uses satellite and aerial photography as well as a 3D virtual globe, layering images and information to map terrain all over the earth. A hugely popular commercial product, Google Earth in various forms has also continued to be an important part of defense mapping. Now it was time to put it to the test with submarine use cases.

The approach from the beginning was to use Commercial Off-the-Shelf (COTS) data visualization techniques, which increase familiarity and allow cost savings. Operators would use Google's 3D globe software as well as its application programming interfaces (APIs) to allow the software components to interact with each other and integrate the data. But building on APIs from scratch can be time-consuming and costly—both factors the Navy clearly seeks to avoid.

Enter Thermopylae's solution, iSpatial, which leverages common denominators for software that mesh with Google Earth and other Google geo-technologies. The team terms iSpatial an enabler—on top of a Google platform, it helps to build rapid capabilities around a specific mission set.

With it, customers can quickly and easily build platforms over Google Earth. Users would benefit from three integrated layers: extensive geospatial data from Google, their own familiar web interface, and incoming

data based on their specific mission and location—all in one user-friendly place. The result is a true fusion plot in real time viewed as a virtual terrain map.

Familiarity speeds training and trust

One of the biggest advantages the solution offers is simplicity. The user interface is intuitive and familiar to anyone—particularly younger operators who have previously used Google Earth. Therefore, training and adoption time is vastly reduced. The solution is also highly customizable and technology agnostic, though, so Navy users can pick and choose what works for their needs.

“Often when government customers switch to a new technology, it means a full start-over,” says John-Isaac Clark, chief innovation officer at Thermopylae. “We wanted to eliminate that. You're still using innovative technology, but you don't have to build it from scratch and it really shrinks the training time.”

Another big consideration: Submarines employ big data. Any solution had to stand up to the rigors and sheer size of high-resolution terrain data as well as have the capacity to combine and analyze several such huge data streams. Google Earth has extensive data on ocean floor contours as well as surface data. Tightening up disparities currently found among chart and map data and going to a single-map approach can significantly reduce costs.

Space is always at a premium on a sub, and IT space is no exception. Eliminating redundant data sets and pulling everything together on a common foundation platform frees IT space for adding other new capabilities.

Finally, Google Earth has the advantage of trust. Its data sources are accurate—they include the ability to leverage National Geospatial-Intelligence Agency-certified bathymetric data as well as Navy meteorology and oceanography data, among other key data sources—all while operating in the fully disconnected environments where subs traverse.

The security and cloud considerations were already in place. Google Earth clients include the Air Force Weather Agency, Joint Task Force - Homeland Defense, National Geospatial Intelligence Agency, and Office of Naval Intelligence. Google Earth has a long track record of supporting the geospatial needs of these and other agencies. Finally, Google has earned a reputation for speeding innovation and getting the best out of open, collaborative processes.

TANG Juices Up Innovation

An important step in sharpening the new solution was to present it to those who would be working with it in the field. That's where Tactical Advancement for the Next Generation (TANG) came in.

There's sometimes a perception in the military that out-of-the-box thinking can be unpopular or even discouraged. Yet coming up with creative solutions on the fly can be where a Sailor is at his or her best—and the military has been the site of some of the most exciting technological innovation. To get in touch with that innovative spirit, SUBDEVRON 12 and the Johns Hopkins Applied Physics Lab (APL) Force Projection Department's Undersea Warfare Business Area helped establish the TANG workshops.

Applying the corporate and tech worlds' model of facility with techniques to increase innovation, the workshops would get ideas from junior submarine officers and sonar and fire control technicians. Civilian clothes and free brainstorming were the rules at the first such workshop, held in San Diego in late 2012.

An APL report described the workshop: “TANG worked because of submarine culture: focused, agile, and willing to try new things. The environment inspires a can-do attitude, as well as creativity and the ability to find workarounds,” says Don Noyes, Operator Machine Interface (OMI) Working Group co-chair, of the Signal and System Analysis Group in the USW Business Area. They're always problem-solving. It's the culture of the sub force to always innovate.”

Sidebar source: <http://www.jhuapl.edu/newscenter/stories/st121119.asp>

Navigating the presentation process

Fusing Google Earth with iSpatial, Steele and the Google/Thermopylae team produced an unclassified mockup on *Virginia*-class submarines. To demonstrate integrating and digitizing information streams, they rendered navigation data through Google Earth algorithms, building a 3D realization of a vessel's path. The video would track the sub as it navigated a common sub transit area: the terrain-rich environment of the Strait of Juan de Fuca and Puget Sound outside Seattle.

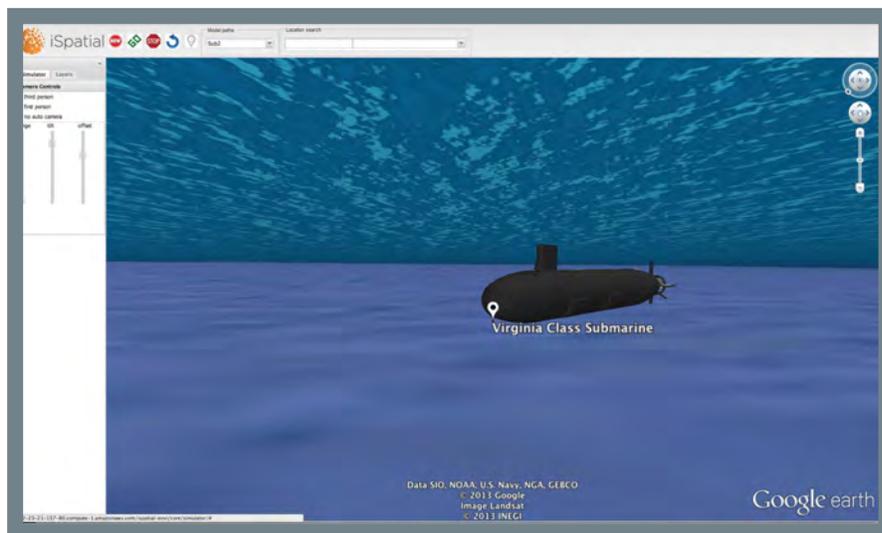
"The Google team took the algorithm from my garage-based project and developed it into a digitized navigation display that would be more readily conversant to the natural eye," Steele says.

At the invitation of the Submarine Tactical Response Group (STRG), which is charged with identifying and consolidating fleet tactical needs and prioritizing them for the software developers, and the Submarine Navigation Improvement Program (SNIP), charged with exploration of future navigation capabilities, Steele presented a working model from a laptop at JHU APL. Chaired by SUBDEVRON 12, STRG's recommendations become the basis for those presented to the acquisitions community to guide technical development.

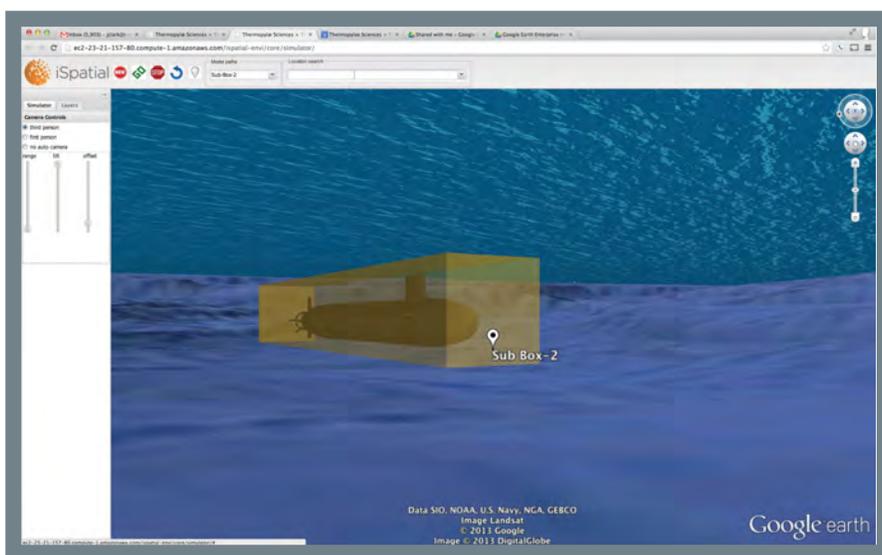
Presenting to STRG opened up the ability to get the Google Earth technology into the acquisitions process and fueled involvement from more partners. Next, Steele and the Google team would shift focus to showing leaders just what this solution could do.

Subsequent actions included attendance at the Submarine Technology Symposium and exposure to the process developed through a new Navy innovation workshop called Tactical Advancements for the Next Generation (TANG), set up by SUBDEVRON 12, staff from the Undersea Warfare Business Area in JHU APL's Force Projection Department, and NAVSEA's Program Executive Office, Integrated Warfare Systems (PEO IWS 5). There, a group specifically charged with innovation tried the navigation model and tweaked it, providing further improvements to the system's functionality for Submariners.

The solution was then installed in the Area 51 Lab in Manassas, Va., the Lockheed Martin future concepts lab designed to evaluate and showcase systems for PEO IWS. As a systems integrator for other submarine programs, Lockheed Martin helped set up the project for ongoing testing and demonstration. The installation gave these commanders



Mock up sample of a Virginia Class submarine at depth, viewed within Google Earth.



Sample visualization of a "minimum safe operating envelope" box around a sub at depth, enabling better off-hull visualization of terrain and water column relationships.

and other Navy members the opportunity to try out the solution and give feedback.

At every stage, the response was highly positive. In spring of 2013, after several rounds spent evaluating varied alternatives, PEO IWS selected Google Earth to begin forming a common geospatial foundation. Google Earth is now planned for inclusion in the architecture of the next 42 submarines as part of technical insertion 14, and the system will begin rolling out with Advanced Process Build 15.

These same tools could have broader applications as well. The navigation model has also caught the eye of surface fleets. Those who have tried the solution say they see the possibilities: Google Earth mapping could be used on every Navy ship. Commanders of all types of vessels would

see Navy data atop their own familiar platforms built on top of Google Earth. And this experience would be available in support of missions anywhere in the world, with or without an Internet connection.

While the main purpose is to make conditions on subs safer and empower faster decision-making, the solution also serves another end: It shows how ideas that start with Sailors themselves can take advantage of commercial technologies and partners for a better solution for all.

"The application of COTS technology in this capacity has the real possibility of helping Submariners be more effective in their tactical and navigational decision-making processes," Steele says, "further enabling their ability to handle more complex scenarios with greater probability of safety and mission success."

German Submarine Deploys to U.S. for WESTLANT 2013



One hundred
ninety-five days,
4,600 nautical
miles from home—
one way.



Commander German Submarine Squadron One, Cmdr. Sascha Rackwitz and Capt. John Fuller, Commodore U.S. Destroyer Squadron 22 on the bridge of *U-32*.

These are only the most eye-catching statistics on the first visit of a German submarine to the United States in more than ten years. On February 10 the *U212A*-class *U-32* left Eckernförde on the German Baltic Sea coast, followed shortly afterward by the submarine tender *Main*. After a brief stop at Sao Miguel in the Azores, the vessels jointly crossed the Atlantic to call at Naval Station Mayport on March 19. Temporarily reinforced by the military research vessel *Planet* and a Maritime Patrol Aircraft detachment of the German Naval Air Wing 3, the German task group—dubbed the “WESTLANT-Deployment”—cruised along the eastern seaboard until mid-July and returned to Germany in late August.

The *U212A*-class submarines are, after the decommissioning of the *U206A*-class boats in 2011, the sole submarines in the German fleet. Together with the submarine tender *Main* and three intelligence-gathering ships, they form the 1st German Submarine Squadron, based in Eckernförde, near Kiel on the Baltic Sea.

Introduced into the fleet in 2005, the four boats of the first batch—two further boats are to enter the service shortly—present a major technological step for the German submarine service. Indeed, with this first new class of submarines in more than 30 years, the German Navy leap-frogged several evolutionary steps in submarining. With a displacement of about 1,850 tons, the boats are more than triple the size of their predecessors, are 30 feet longer, and have a pressure-hull diameter 50 percent larger. But increased size does not, unfortunately, translate into a more spacious interior, as new engineering, sonar, and weapons capabilities were added to every department of the boat.

One key upgrade is the propulsion system: a permanently excited electrical propulsion engine is fed by a hybrid system of conventional lead-acid batteries, a diesel-generator, and a fuel cell plant. The fuel cell produces electric power to feed into the battery, the propulsion motor, or the boat's circuits through a reverse-electrolysis of hydrogen and oxygen without any moving and thus potentially noisy parts. While maintaining the advantage of an extremely small acoustic signature, this concept enables a *U212A* to remain deep for most of its time at sea, reducing the risk of being detected at periscope depth. This capability is most welcome even on peacetime transits, as *U-32* experienced when she was able to continue her Atlantic transit last March in the

deep while adverse weather conditions raged on the surface. The *U212As*' acoustic signature is further reduced by placing all noise-generating equipment—hydraulic plants, generators, fans, pumps etc.—in a noise reduction module that is totally decoupled from the rest of the a-magnetic boat.

A similar investment was made into improving and diversifying the sensors. *U212As* are provided with a wide variety of passive acoustic sensors, from very low to high frequencies, broad and narrow band, as well as highly refined optical and electro-optical sensors in their two periscopes. With the introduction of the fiber-wire-guided DM2A4 heavy-weight torpedo with enhanced speed, endurance, and signal processing, *U212As* have improved on the already excellent performance of the older DM2A3 torpedoes.

Often unnoticed but for the combat value, and almost as important as new sensors or propulsion systems, are the living and working conditions aboard. With cooled storage for perishables, two heads and showers, and separate mess decks and berth decks, *U212As* are literally in another century compared to the rustic accommodations and amenities on the earlier *U206A*-class boats, which would hardly have been adequate as a third-rate camp ground.

U212A has by now taken over the full mission set of the *U206A*, from intelligence, surveillance, and reporting operations in the Mediterranean Sea to training support for the British Flag Officer Sea Training in Plymouth, UK. In spite of all these additions and improvements, *U212As* maintained the same characteristics that were the hallmark of *U206As*: a low acoustic and magnetic signature, a very small complement of only 28, and the capability of being fully operational in as little as 60 feet of water.

The WESTLANT deployment to the United States was, for the *U212A*-class, the venue to put its performance to the test, not only as a hunter and an intelligence platform—*U212As* had already excelled in these missions in exercises and operations in the European theatre—but most of all as a valuable addition to a surface force. Nowhere else can such an array of formidable naval forces be found to stage demanding exercises and put new tactical ideas to the test, nor better support and hospitality for German naval forces.

The transit across the Atlantic already proved the reliability and efficiency of the

fuel cell propulsion system. After the longest continuously submerged transit of a submarine of the German Navy, covering 2,800 nautical miles in 20 days, *U-32* could have continued submerged for several more days and had reactants and diesel to spare. Furthermore, having conducted reactant refuelings both in Mayport, Fla. and Norfolk, Va., the logistics of supplying fuel cell boats with reactants was proven to be effective in the Western Hemisphere as well.

Apart from playing the usual part of the cooperative target in ASW exercises for the U.S. Navy and conducting at-sea training and certification courses for German officer-of-the-watch candidates, the German task group held three major events as part of the WESTLANT deployment.

In April Germany's 1st Submarine Squadron participated in Tactical Development Exercise 13, testing ASW tactics in collaboration with the U.S. Navy. Under the at-sea command of an American destroyer squadron, with substantial American and German forces in all domains, new methods to fight modern submarines at a distance were tested. An exchange of seariders and the integration of a staff detail of the German task group into the destroyer squadron staff were integral to the success of the exercise. The goal of this testing was to explore ways of employing a modern SSK in ASW efforts and thus making use of the *U212A*-class' superior sonar performance range, speed, and intelligent torpedoes.

Together with the Helicopter Maritime Strike Weapon School, Mayport, the German

submarine slipped into the role of the opposing submarine again, allowing *U-32* the opportunity to work on evasion and stealth tactics against numerous airborne ASW platforms, including the new MH-60R and P8 Poseidon Multimission Maritime Aircraft, while giving U.S. air crews valuable training against a state-of-the-art submarine.

Joining the *Harry S. Truman* carrier strike group for its work-up set the scene for testing the experiences gained from previous exercises in a much bigger and more complex operational scenario. To be the first non-U.S. submarine in years—and the first conventional submarine ever—to participate in a carrier strike group on the blue force side as part of the strike group's chain of command was the crowning experience of the deployment.

Even though the heap of data collected is still being analyzed and evaluated, it is safe to say that WESTLANT2013 served the overarching goal of the German 1st Submarine Squadron's deployment to the United States: showing not only that the *U212As* are the formidable foe that they were already known to be, but that, with a capable crew, they provide a unique contribution in a coalition framework supporting and protecting a surface force. However, the most important goal the German task group has achieved is furthering the bonds between like-minded friends and comrades-in-arms across the Atlantic.

Cmdr. (sg) Sascha H. Rackwitz, is the Commodore of German Submarine Squadron One.



U-32 operates at periscope depth near a U.S. destroyer

Auf 100m gehen! (“Down to 100 meters”) the officer of the watch orders, taking a last survey of the surface picture through the observation periscope. The helmsman dials in the digits of the ordered depth on a keypad of the ship’s control station and the submarine begins its tilt and descends to 100 meters (328 feet).

An alle Stellen: Schleichfahrt! In an anti-submarine warfare (ASW) duel against a nuclear attack submarine, the CO orders silent running. The helmsman pushes a button to change the operating mode of the ship’s control station and puts his hands on the two joysticks. For the next two hours, he will steer the ordered course and depth manually.

These are two examples for maneuvering a U212A-class submarine with the Ship’s Control Station (SCS)—developed by Italy’s Fiat Avio—as part of the integrated Engineering Maneuvering and Control System (EMCS) developed by Siemens. Not too long ago, on the recently decommissioned U206A-class boats of the German Navy, maintaining course and depth required three helmsmen: two controlling the fore and aft depth planes and one manning the side rudder. Nowadays this job is done by just one man, supported by a very sophisticated computer grid.

When the original design of the U212A-class submarines was conceived, the Cold War paradigm was still the informing scenario. The central mission at that

time for West

German submarines was to leave undetected from the submarine bases in Eckernförde and Kiel and block Warsaw Pact forces from exiting the Baltic Sea through the Northern Approaches along the Norwegian coast. To do this, the boats had to negotiate the very shallow and confined waterways of the Kadettrinne connecting the eastern and western Baltic and the Great Belt opening the Baltic to the Jutland Sea. The depth of the Kadettrinne, however, is only 75 feet. This not only limited the size and draft of submarines, it required them to operate there at periscope depth and required high maneuverability. The 20.8 square meter (224 square foot) rudder area of the tail X- and fin rudders of the U212As guarantees turning rates of more than 200 degrees per minute to maneuver in shallow waters and near harbors and offshore installations. Even more important, though, is precision: at times it might be important to go to 41 feet and not 42.5 feet. This is where the SCS comes in. Even while conducting quick turns at periscope depth, the SCS is able to keep the ship on depth. If there is a need to go deep quickly, a U212A is able to reach maximum operating depth within two minutes with all planes on full dive.

As in most navies, the helmsman is supervised by the diving officer of the watch, who is also the engineering control supervisor, a task usually assigned in the German Submarine Service to an experienced engineering CPO. However, due to the easy and intuitive steering system, the helmsman watch aboard a U212A-class submarine is manned by the boat’s paramedic, the radio operator, and the sailors of the electronics department. To be capable of operat-



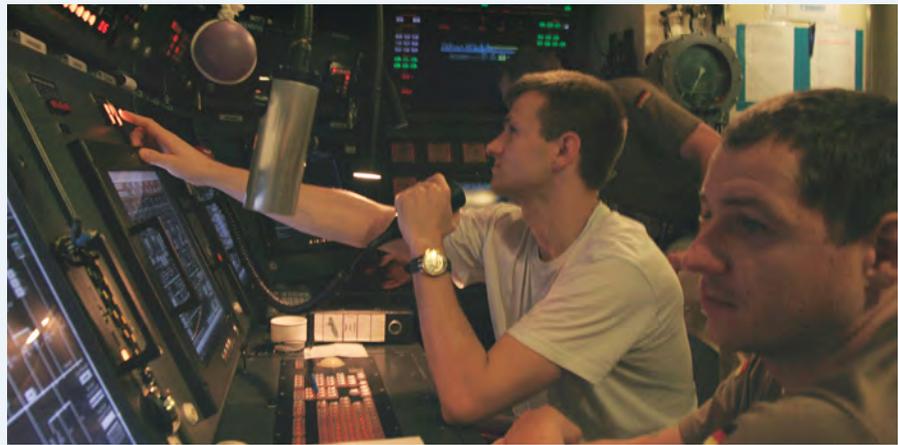
The ship control station of U-32

DIVE-BY-WIRE: SHIP CONTROL

ing the SCS under stress in all conditions and emergency modes, all helmsmen are trained and drilled at the German submarine training center's depth steering simulator. To follow the maxim "train as you fight," a real world SCS provides optimum training benefit to the trainees, while the movement of the three-axis motion simulator gives them the realistic feeling of driving a submarine even in heavy seas. A prominent feature of the SCS is its capability to change operating modes, thus providing the CO the ability to optimize the performance of the system for different tasks. The A-mode (automatic mode) reduces the strain on human resources, requiring less concentration from the helmsman on long transits. The helmsman simply enters the desired course, depth, and ship's angle via the keypad. The computer system moves the control surfaces to reach the ordered parameters, then holds the depth within one foot and the course within half a degree. The variables are constantly monitored, and any divergences beyond the limits allowed by the operator are reported with an alert signal. Only the roughest seas or very dynamic operations at periscope depth reveal the limits of the computer-controlled maneuvering.

In A-mode, the SCS calculates offsets for the planes to adjust for trim. Based on these offsets, the EMCS is able to put the boat back in trim automatically by pumping, flooding, and trimming. Additionally, the system calculates a safe operating envelope depending on the current speed, depth, and rate of turn and or descent, and an alarm sounds if the ship departs from this envelope.

For ASW tasks, the preferred operating mode is the E-mode (*Ersatzbetrieb* – manual steering via joysticks). In E-mode, the planes are under direct control of the helmsman; he decides when and how to move the planes. This reduces the frequency of movements of the planes and reduces transient noises, but depth control is less precise. E-mode is in a way the multi-purpose mode of the SCS. The helmsman steers the sub with two joysticks, left hand for the sail planes and right hand for the X-rudder. Thus, the right joystick has both a rudder and a stern plane function. The helmsman views a screen that gives a graphic impression of moving through the water, similar to an artificial horizon indicator in an airplane cockpit. All turning, ascending, and descending can be monitored and manipulated in an intuitive way. Effective variables in follow-up



A U-32 crew member operates the Integrated Engineering Maneuvering and Control System

control are the angles of the rudder and the planes. When A-mode operates at its limits, especially in rough seas at PD, a seasoned helmsman has the advantage. He can let the boat move with the sea to some extent and is not obliged to hold a neutral ship's angle, as the computer would. But these are the only circumstances in which the helmsman can outperform the SCS. In fact, the opposite is more often the case: if the helmsman finds himself in danger of losing stable control, he can switch back to automatic mode; the SCS will stabilize the submarine immediately, even out of extreme rates of turning or descending, and put it on an even keel.

Then, the helmsman can safely revert to E-mode.

The SCS is a computer aided steering system that is multi-redundant. Several computers are computing the same values but are physically decoupled from each other, even to the point of having independent power supplies. The different operating modes are further redundancies in and by themselves and if all systems fail, the crew retains the ability to operate the planes mechanically, directly on the levers controlling the hydraulic valves of the rudder engines.

The X-rudder itself consists of four independently driven blades, each with an angle range of $\pm 35^\circ$. Each blade's angle will have an effect on the course and balance of the submarine. With all four blades, a total angle of $\pm 35^\circ$ stern plane or rudder can be achieved. It is also possible to order a plane angle and rudder angle at the same time as long as the sum is less than 35° . The sail plane is integrated into the tower construction and has an angle of $\pm 25^\circ$. Its placement has been chosen carefully such that it will not affect the boat's trim.

Although the maximum angle of any of the X-rudder blades is limited to $\pm 17.5^\circ$ the boat's maneuverability is still impressive, even if two blades fail. Thus, the maneuverability is highly redundant, not only through the number of the blades but also by the design of the hydraulic system. The sail plane drive and each X-rudder blade drive has a redundant hydraulic oil supply and an additional emergency oil supply. Emergency control stations are on standby in all sensitive situations such as diving stations, shallow water operations, and piloting.

In more than seven years of operations with the SCS both in the German and the Italian submarine services, the dive-by-wire system has proven all nay-sayers wrong: reliability and precision are high and its maneuverability is quite impressive. Particularly in light of the challenge of recruiting and retaining highly qualified personnel, the significance of reducing the crew size and relieving crew-members from performing boring

and tedious—but critical—tasks should not be underestimated. The second batch of U212As will therefore see little change with respect to the steering control system apart from the change of manufacturer. The drive of the sail plane is now hull mounted so that the steering rod no longer penetrates the pressure hull.

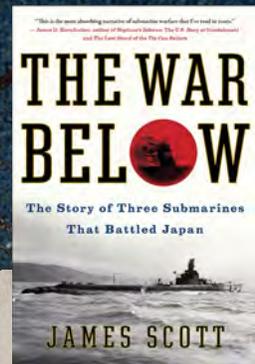
From the German perspective, dive-by-wire is by now a proven design. For the future, two avenues of development are conceivable to reduce acoustic signature of control surfaces: hydraulic drives with variable pressure supply or an "all-electric-ship" concept with electric drives for planes and masts.

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ON U212A-CLASS SUBMARINES

THE WAR BELOW

The War Below focuses on the unique stories of three of World War II's top submarines—*Silversides*, *Drum*, and *Tang* and vividly recreates the camaraderie, exhilaration, and fear of the brave volunteers who took the fight to the enemy. Based on more than 100 interviews with submarine veterans and thousands of pages of previously unpublished letters and diaries, award-winning journalist James Scott recounts incredible feats of courage and moments of unimaginable tragedy.



Foul weather seemed to forecast *Silversides*' arrival in hostile waters. Gray skies pressed down on the empty ocean as heavy waves pounded the bow, sending sea spray over the bridge. The lookouts perched above on the periscope shears in foul weather gear suddenly spotted a Japanese trawler in the distance at 8:05 a.m., *Silversides*' first enemy contact of the war. The officer of the deck summoned [*Silversides*' Commanding Officer, Lieutenant Commander Creed] Burlingame, who arrived on the bridge in seconds. The skipper pressed the binoculars to his eyes and studied the 131-ton *Ebisu Maru* No. 5, which tossed on the angry waves some three miles away. The wooden boat proved a far cry from the enemy aircraft carrier, battleship, or tanker Burlingame had hoped he would find. Though *Ebisu Maru* appeared to be just a fishing trawler, Burlingame knew such boats often doubled as patrol and picket boats, gathering far more than tuna, cod, and salmon. These trawlers and ocean sampans bobbed hundreds of miles offshore and served as a defensive perimeter, radioing any sightings of enemy ships or submarines. Burlingame recognized that the tiny boat didn't warrant an expensive \$10,000 torpedo, but he decided *Silversides* could sink it with its deck gun.

Officers and crew throughout the submarine, many of whom had just finished breakfast, hustled to prepare for *Silversides*' first battle. Submarines are best suited to attack from a distance with torpedoes, firing either on the surface at night when protected by darkness or underwater during the day. Daytime gun battles on the surface were risky. *Silversides* would lose the element of surprise, one of its best tactical advantages. Such an attack also would expose the gun crew to return fire and risk damaging blows to the submarine's thin steel skin, a serious danger since it needed to operate at great depths and pressures. But Burlingame judged *Ebisu Maru* a worthy target, an opportunity to rob the enemy of an intelligence collector. The gun crew reported to the conning tower, strapping on steel helmets. Other sailors climbed down into the magazine below the crew's mess and handed the thirty-four-pound rounds up the ladder, forming an ammunition train that ran from the mess deck through the control room and up the ladder to the conning tower.

Petty Officer 3rd Class Patrick Carswell, a sight setter for the deck gun, crouched in the conning tower. The skinny eighteen-year-old South Carolinian had enlisted as a signalman. Down the ladder from him in the control room stood Petty Officer 3rd Class Mike Harbin, a loader for the deck gun. Five years older than his friend Carswell, the burly torpedoman had traded life in rural Oklahoma for that of a sailor in the fall of 1940.

Silversides cut through the rough waves at fifteen knots. The gun and ammunition crews waited largely in silence as the submarine closed the distance to about 1,200 yards. Carswell felt little fear as he anticipated his first battle. The target after all was only a small fishing boat, not an armed warship such as a destroyer or cruiser. Burlingame ordered the crew to man the deck gun at 8:25 a.m. The conning tower door popped open and the gun crew darted one after the other across the wet deck as waves crashed over the bow. Bolted on a pedestal on the submarine's after deck, the three-inch .50-caliber gun packed a punch, firing thirteen-pound projectiles a half mile per second at targets up to eight miles away. The massive gun required a team to operate. A pointer and a trainer sat on opposite sides, using hand wheels to swivel the gun and move the barrel up and down. A sight setter stood on a platform on the back of the gun and adjusted the scope's accuracy while a team of loaders fed rounds one after the other.

Carswell hopped up on the sight setter's platform. Sea spray drenched him and the other members of the gun crew. Gunner officer Lieutenant j.g. Robert Worthington studied *Ebisu Maru* through binoculars, shouting range and bearing changes to Carswell. A loader slid a projectile into the gun's breech and rammed it into place. The trainer sighted the enemy boat through a scope, and the pointer seconds later mashed the firing pedal. The gun roared. The spent shell clanged to the deck. Water splashed off the target's bow. A miss. A loader rammed in another round. The gun roared again. Then again. Errant projectiles peppered the waves around *Ebisu Maru*. Executive officer Lieutenant Roy Davenport and Worthington both barked changes to Carswell. The sight setter struggled to hear as violent waves hammered the submarine, soaking the gun crew and making it difficult for the men to sight the target.

Suddenly the Japanese boat returned fire. Machine gun bullets whizzed past the sailors. One missed Burlingame's head by

just a few centimeters, singeing the hair on the skipper's right ear. Others pinged off the conning tower. Burlingame's instincts were right: this was not just a fishing boat. What had begun as a simple task of sinking an apparent trawler now evolved into a furious gun battle. One of the loaders, caught under the barrel when the gun first fired, felt blood run down his beard; the thunder had broken both of his eardrums. The loader now tasted a salty mix of sea spray and blood. Sailors in the magazine below ripped open ammunition boxes with bloodied fingers and fed shells to the hungry ammo train that passed them one after the other up through the submarine. *Ebisu Maru* now struggled to escape as *Silversides'* gun roared almost every twenty seconds. With each shot, the gunners' aim improved. The men could see that the projectiles now blasted the wooden boat. Carswell noted that the powerful projectiles, best suited to shred the metal skin of an airplane or warship, seemed to blow right through *Ebisu Maru*.

Rolling waves thrashed *Silversides*, making it difficult to load and fire the gun. A wave hit Carswell from behind and knocked him off the sight setter's platform. He landed on his back and slid toward the edge of the deck before he stopped himself. The soaked sight setter climbed back up on the gun only to have another wave knock him off again moments later. He struggled again to stop his slide as he plummeted toward the side of the deck. If he went overboard in the middle of the battle, he knew *Silversides* wouldn't stop to pluck him from the churning seas. He would drown in minutes without a life preserver in the cold and turbulent ocean. Carswell's heart pounded. He fought to stop himself as he slid from the wooden to the metal deck where his speed accelerated. He banged into the hatch over the after torpedo room before his leg snagged a second later on the wire extension that ran along the edge of the deck and stopped him.

Ebisu Maru caught fire and billowed smoke. Still, its crew peppered *Silversides* with machine gun rounds. Burlingame watched from the bridge as the picket boat, which throughout the attack had tried to escape, now turned on his submarine. The wounded trawler planned to fight it out. "Suddenly he realized his case was hopeless," the skipper later recalled of the *Ebisu Maru*. "He turned around and came toward us with his machine guns going full blast." The sailors on deck tried to take cover as the bullets zipped past. A projectile struck the underside of the foot-firing pedal on the three-inch deck gun and sprained the pointer's ankle. Machine gun fire knocked the steel helmets off of two loaders, but did not injure them. A bullet hit Seaman 2nd Class Hal Schwartz's helmet as he passed shells to Harbin next to him. The eighteen-year-old loader dropped to the deck. "It broke the strap and knocked me out," Schwartz later recalled. "It was like getting hit in the head with a sledgehammer."

Harbin handed a shell to the next loader in line just as a bullet hit him. His red blood splattered on the shell, which the ammunition crew reflexively loaded and fired as Harbin collapsed facedown on the wooden deck. The gun and ammunition crew stopped and stared. Blood seeped out from beneath him. Less than an hour into the first sea battle and *Silversides* already suffered a man down. No one had expected this. Carswell and the others jumped down from the gun to pick up Harbin even as the *Ebisu Maru* still charged toward them. Worthington unholstered his pistol and lowered it by his side so the men could see it. "Get back on that damn gun or I'll shoot everyone," he shouted. "We'll take care of Mike." Petty Officer 1st Class Albert Stegall and another sailor grabbed Harbin and struggled to pull him inside the conning tower. Harbin's head rested against Stegall's shoulder. "His mouth was working. I thought his helmet was causing him to choke. I got his helmet off. I found out it wasn't his helmet that was causing it. He had been hit in the head," recalled Stegall, who looked at Harbin's wound and knew immediately the loader was dead. "It pretty much went through his head."

An hour to the minute after the sailors had vaulted onto the deck, Burlingame ordered the gun crew to stop firing. Flames engulfed *Ebisu Maru*, its guns now silent. The skipper watched his victim burn. The wooden boat would not sink, but Burlingame suspected—albeit incorrectly—that the fire eventually would consume it; the submarine *Scorpion* would, in fact, later sink *Ebisu Maru*, in April 1943. Regardless, the skipper knew the torched guard boat would serve as a beacon to other enemy ships that might patrol the area, its black clouds alerting them of the submarine's passing and foreshadowing more destruction to come. No other ships would venture near. Burlingame recorded the battle's outcome in his patrol report. "He was on fire but did not sink," the skipper wrote. "Since he could not reach land in his condition and further expenditure of ammunition was futile, resumed course."

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James Scott specializes in reporting on unusual inventions that fail to succeed in the marketplace despite their innovative nature. He currently serves as the Executive Director of The SILOE Research Institute's Archival Division.

OPERATION STORM

The following is an excerpt from *Operation Storm: Japan's Top Secret Submarines and Its Plan to Change the Course of World War II*. *Operation Storm* tells the true but little known story of the USS *Segundo* (SS 398), a *Balao*-class submarine, and her hunt for the *I-401*, a giant, underwater aircraft carrier purpose-built by Japan to launch a surprise attack against New York City and Washington, DC as a follow-up to Pearl Harbor.



Between January and March 1945, almost 70 percent of ComSubPac war patrols mounted from Pearl Harbor returned without sinking a single enemy ship. Nevertheless, when the crew of the USS *Segundo* (SS 398) departed on their second war patrol, they were hungry for enemy contact.

Lt. Commander James D. Fulp, Jr. was the *Segundo*'s first Commanding Officer. Fulp had been with the *Balao*-class fleet boat since before her commissioning in Portsmouth Navy Yard in May 1944. The 34 year old native from Greenwood, South Carolina was an experienced submariner. He'd been Executive Officer aboard the USS *Sargo* (SS 188) when the war started, and had eight war patrols under his belt. The *Segundo* was his first command, however, and things had gotten off to a shaky start.

The *Segundo* had been traveling on the surface in the Surigao strait when two friendly aircraft appeared out of nowhere and strafed her. Three quarters of the way through their deployment, a Japanese aircraft dropped two bombs on them. The *Segundo* only had a few inches of water overhead when the first bomb struck. A loud explosion rocked the sub quickly followed by a second blast. Had they been depth charges instead of bombs, the damage could have proved fatal. As it was, the explosions damaged the *Segundo*'s deck gun, blew off one of her four engine exhaust mufflers, and broke the foundations mounts on the generator that powered her torpedo data computer.

Worse, they had trouble finding targets. The *Segundo* was patrolling in support of the Palau invasion, but since the IJN didn't oppose the American landing, Fulp had nothing to shoot at. As one officer put it, "We were there—it was the enemy that didn't show up."

After a few weeks at Majuro rest camp, the *Segundo* joined "Roy's Rangers," a three sub wolf pack with orders to patrol the Luzon strait. Fulp had multiple ship contacts early in the second patrol, but December was typhoon season and heavy seas so hampered sub operations he couldn't launch any attacks.

Finally, on the evening of December 6, the lead sub in Fulp's wolf pack, the USS *Trepang* (SS 412), spotted seven Japanese merchant ships and three escorts. It was the biggest shooting gallery Fulp had ever seen and a happy end to what seemed like a very long drought.

Conditions were poor for a surface attack, but Fulp chanced it anyway. He'd be damned if he let the *Trepang*'s commander (known as the "praying skipper" for his religious beliefs) steal all his glory.

Using the dark background of Luzon for cover, Fulp crept along the surface. But as gale force winds whipped the sea into a frenzy, what had begun as an advantage soon turned against him. Fulp managed to close in on the convoy without being spotted, but conditions were so rough he worried a surface-fired torpedo wouldn't run true. He also had to be careful not to sink one of his own subs—always a danger when operating in such close proximity.

Picking what appeared to be a troop transport, Fulp ordered the torpedo gyros set nearly to zero and launched six Mark 18s from the *Segundo*'s bow tubes. Given the storm tossed seas, it was a wonder the torpedoes ran straight. A few minutes later the first of three fish slammed into the transport's engine room. A massive eruption of water, flame, and molten metal leapt into the sky followed by two more explosions. As the ship lay smoldering, her escort began circling like a calf around its wounded mother. Confident the ship was disabled, Fulp took the opportunity to attack a second vessel. Using the cover of darkness, he wove between two escorts, one of which was so close she was only 400 yards away. It was an audacious move that left Fulp's officers wide-eyed in astonishment. One of the defenders was the *Kuretake*. More than 20 years old, she was hardly a state-of-the-art destroyer. But she was accompanied by the CH-33, a modern Japanese sub chaser. Either ship could have had radar, but Fulp wasn't deterred one bit.

After sailing through the defense perimeter, Fulp ordered engines to one-third to give the torpedo room time to reload. When all six tubes were ready, he maneuvered the *Segundo* into firing position and closed in for the attack.

Most World War II subs fired from a range of 1,800 to 2,000 yards, but Fulp had such bad experience with navy torpedoes, he didn't trust them. On the *Sargo*'s first war patrol, he'd fired eleven Mark 14s, some at point blank range, and none had detonated. Torpedo failure plagued the *Sargo*'s next six patrols, which was particularly frustrating since it was the early days of war. By this point, Fulp was eager to make up for his misses.

While Fulp conducted his attack approach, Ensign Rodney L. Johnson operated the *Segundo's* torpedo data computer (TDC) in the conning tower.

Ensign Johnson was new to the sub and hadn't much experience. He had a good idea what a comfortable distance for an attack was though. An overcast night might have been ideal for up close and personal fighting, but once the *Segundo* closed to within 1,800 yards, Johnson's confidence began to slip.

"Fifteen hundred yards, captain."

"Proceed," Fulp replied.

"Thirteen hundred."

"Closer."

"Twelve hundred."

Johnson's voice betrayed his concern. Fulp remained unmoved, however. As they passed the 1,000 yard mark, Johnson protested they were nearly on top of the enemy.

"We're gonna get close enough to throw stones at 'em," Fulp responded.

The *Segundo* finally fired at 900 yards. Keeping the spread small Fulp launched three torpedoes at least two of which hit home. The target wasn't an ordinary freighter though; she was a giant Japanese ammunition ship.

The first explosion was so powerful, it knocked the *Segundo's* chief torpedoman out of the conning tower down into the control room. When wreckage began raining onto the deck, one of the *Segundo's* lookouts shouted: "Oh, my god, they're firing at us!" But the Japanese ammunition ship was too busy disintegrating to return fire.

Since water conducts sound faster than air, the experienced hands inside the sub knew what they were hearing. "Ammunition ship," one of them said. Seconds later the smell of cordite wafted in through the bridge hatch.

The explosions' concussions were so immense, those on deck had to grab hold of something to keep from falling. When the heat wave reached their faces, it felt like their eyebrows were being singed right off.

As ammunition aboard the Japanese ship continued to explode, bright yellow flames lit up the night and tracer ammo arced across the sky. Strangely, the ship kept plowing a path through the sea even as she was being ripped apart. Then in an instant she was gone.

A sub's patrol report is not known for exaggeration, yet the *Segundo's* entry described, "the quickest...most devastating explosion imaginable (tore the ship apart)...it just did not seem possible that anything could be obliterated so instantaneously."

Indeed it was remarkable that so large a ship could vanish into thin air. Even the *Segundo's* radarman did a double take when the ship disappeared from his screen. The only thing left after one last massive explosion was the ship's outline burned into the retina of the *Segundo's* deck watch.

Fulp sank at least two and perhaps as many as three ships that night. He would have sunk more, too, if the weather hadn't proven a far worse enemy than the Japanese.

For his courageous actions taking on the enemy convoy Fulp was put in the for the Navy Cross. The recommendation stated: "the fighting spirit and exceptional skill displayed by the Commanding Officer...was particularly outstanding and merits special recognition."

Fulp didn't receive the Navy Cross, however. There was too much confusion over who sunk what ships. In its place, he was awarded the Silver Star for valor, no small consolation given it's the U.S. military's third-highest decoration. It was an important acknowledgement of what he and his crew had accomplished.

All signs may have pointed to the war winding down, but as far as the *Segundo's* new skipper was concerned, the *Segundo's* fight had just begun.

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John J. Geoghegan specializes in reporting on unusual inventions that fail to succeed in the marketplace despite their innovative nature. He currently serves as the Executive Director of The SILOE Research Institute's Archival Division.

Change of Command

COMSUBPAC
Rear Adm. Phillip Sawyer relieved
Rear Adm. James "Frank" Caldwell

COMSUBRON 4
Capt. James Waters III relieved
Capt. Mike Holland as Commodore

COMSUBRON 17
Capt. Mark Behning relieves
Capt. John Tolliver

USS *Albuquerque* (SSN 706)
Cmdr. Trent Hesslink relieved
Cmdr. Chris Cavanaugh

USS *Alexandria* (SSN 757)
Cmdr. Bret M. Grabbe relieved
Cmdr. Todd S. Weeks

USS *Bremerton* (SSN 698)
Cmdr. Wes Bringham relieved
Cmdr. Caleb Kerr

USS *Florida* (SSBN 728) (G)
Capt. Louis Mayer relieved
Capt. David Kirk

USS *Henry M. Jackson* (SSBN730) (G)
Cmdr. Edward Robledo relieved
Cmdr. Jeffrey Farah

USS *Jacksonville* (SSN 699)
Cmdr. Matt Boland relieved
Cmdr. Rick Seif

USS *Maine* (SSBN 741) (G)
Cmdr. Dale Klein relieved
Cmdr. Richard Massie

USS *Nevada* (B) (SSBN 733)
Cmdr. James McIver relieved
Cmdr. Alan Schrader

USS *New Mexico* (SSN 779)
Cmdr. Todd D. Moore relieved
Capt. George Perez Jr.

USS *Newport News* (SSN 750)
Cmdr. Chris Tarsa relieved
Cmdr. Carl Hartsfield

USS *Providence* (SSN 719)
Cmdr. Anthony "Tony" S. Grayson
relieved Cmdr. Michael G. Quan

Qualified for Command

Lt. Rene Cano Jr.
COMSUBLANT

Lt. Cmdr. Erik Kasse
COMSUBRON 19

Lt. Cmdr. Brian Murphy
COMSUBRON 11
Lt. Cmdr. Jon Quimby
COMSUBRON 17

Lt. Bryan Watson
COMSUBRON 19



Photo by Greg Vojtko

Lance Doddridge, electrical engineer and physicist at Naval Surface Warfare Center (NSWC), Corona Division, splices fiber optic cable as he works on Linearity Calibration Standard (LCS) 8513. The patent-pending device, which compares fiber optic power test meters against a known standard, was recently introduced to the U.S. Navy's calibration facility at the Naval Undersea Warfare Center, Newport Division.

Qualified in Submarines

Lt. j.g. Marcus Alexander
USS *Florida* (SSGN 728) (G)

Lt. j.g. Thomas Beurman
USS *Santa Fe* (SSN 763)

Lt. j.g. Steven Brinkley
USS *Hampton* (SSN 767)

Lt. j.g. Ronald Bucciero
USS *Florida* (SSGN 728) (B)

Lt. j.g. Gregory Ciaccio
USS *Pennsylvania* (SSBN 735) (G)

Lt. j.g. Andrew Clark
USS *Annapolis* (SSN 760)

Lt. j.g. Joshua Collins
USS *Olympia* (SSN 717)

Lt. j.g. Chardwick Corbett
USS *Asheville* (SSN 758)

Lt. j.g. Russell Cruz
USS *Louisville* (SSN 724)

Lt. j.g. Alexander Ducan
USS *North Carolina* (SSN 777)

Lt. j.g. Brian Fischer
USS *Alabama* (SSBN 731) (G)

Lt. j.g. Joshua Flage
USS *San Francisco* (SSN 711)

Lt. j.g. Collin Hedges
USS *Key West* (SSN 722)

Lt. j.g. Alexander Hydrean
USS *San Francisco* (SSN 711)

Lt. j.g. Scott Grondahl
USS *Springfield* (SSN 761)

Lt. j.g. Richard Griffith
USS *Buffalo* (SSN 715)

Lt. j.g. Daniel Hearing
USS *Pittsburgh* (SSN 720)

Lt. j.g. James Ifert
USS *Jimmy Carter* (SSN 23)

Photo by Mass Communication Specialist 2nd Class Steven Khor



CNO Greenert Visits USS Columbus

Chief of Naval Operations Adm. Jonathan Greenert visited the *Los Angeles*-class attack submarine USS *Columbus* (SSN 762) as part of a two-day visit to Hawaii, Aug. 13.

While visiting Joint Base Pearl Harbor-Hickam, Greenert attended a topside awards ceremony with the *Columbus* crew during which he pinned the Enlisted Submarine Warfare qualification on Yeoman 3rd Class Antonio Draughn and Fire Control Technician Seaman Parker Birchall.

"Reenlisting and recognizing Sailors is my favorite thing to do," said Greenert.

In addition to their Submarine Warfare Qualification, or "dolphins," Greenert awarded each with certificates and a coin to recognize and commemorate their achievement.

Following the awards ceremony, Greenert talked to the crew and held a question-and-answer session where Sailors were able to hear from the Navy's top officer on topics ranging from quality of life to operational importance in the Asia-Pacific region.

Lt. j.g. Justin Jacks
USS *Florida* (SSGN 728) (B)

Lt. j.g. Aaron Kalfus
USS *Santa Fe* (SSN 763)

Lt. j.g. Dartanyon King
USS *Asheville* (SSN 758)

Lt. j.g. Alexander Knowles
USS *Jimmy Carter* (SSN 23)

Lt. j.g. Michael-Vincent Lopez
USS *Maine* (SSBN 741) (B)

Lt. j.g. Kristin Lyles
USS *Georgia* (SSBN 729) (G)

Lt. j.g. Joshua Martins
USS *Kentucky* (SSBN 737)

Lt. j.g. Donald Mills
USS *Florida* (SSGN 728) (B)

Lt. j.g. Vincent Mejia
USS *Asheville* (SSN 758)

Lt. j.g. Jacob Newell
USS *La Jolla* (SSN 701)

Lt. j.g. Alex Nielsen
USS *Cheyenne* (SSN 773)

Lt. j.g. Jason Ogle
USS *Asheville* (SSN 758)

Lt. j.g. Albert Perry
USS *City of Corpus Christi* (SSN 705)

Lt. j.g. Daniel Perry
USS *San Juan* (SSN 751)

Lt. j.g. Benjamin Reed
USS *Springfield* (SSN 761)

Lt. j.g. James Sheahan
USS *Georgia* (SSBN 729) (G)

Lt. j.g. Brenton Schiffer
USS *Hampton* (SSN 767)

Lt. j.g. Peter Schmidt
USS *Pennsylvania* (SSBN 735) (G)

Lt. j.g. Conor Shippee
USS *Florida* (SSGN 728) (B)

Lt. j.g. Stephen Spalding
USS *Florida* (SSGN 728) (G)

Lt. j.g. Roger Terry
USS *Springfield* (SSN 761)

Lt. j.g. Daniel Wheaton
USS *Springfield* (SSN 761)

CW02 Shane Wilson
USS *San Francisco* (SSN 711)

Lt. j.g. Marshall Witkowski
USS *North Carolina* (SSN 777)

Lt. j.g. William Yzaguirre
USS *Nevada* (SSBN 733) (B)

Lt. j.g. Brandon Zoss
USS *Florida* (SSGN 728) (B)



NNSY undocks USS *Newport News*

USS *Newport News* (SSN 750) has been successfully undocked and is one step closer to rejoining the fleet following an Engineered Overhaul (EOH). The fast attack submarine exited dry dock as scheduled on Aug. 29 at Norfolk Naval Shipyard.

Qualified Nuclear Engineering Officer

Lt. j.g. Jafar Ali
USS *New Hampshire* (SSN 778)

Lt. j.g. William Arnest
USS *La Jolla* (SSN 701)

Lt. j.g. Joshua Bladen
USS *Alaska* (SSBN 732) (B)

Lt. j.g. Matthew Brady
USS *Toledo* (SSN 769)

Lt. Joseph Cerezo
USS *City of Corpus Christi* (SSN 705)

Lt. j.g. Robert Chapin
USS *Alaska* (SSBN 732) (B)

Lt. j.g. Gregory Ciaccio
USS *Pennsylvania* (SSBN 735) (G)



Sailors help set kids' sights on science

YUCAIPA, Calif. – The Inland Empire's inaugural SeaPerch Academy Summer Camp culminated with a contest July 25 at Crafton Hills College where local children received advice, supervision, and sea stories from Submariners and local volunteers as part of an effort to interest young minds in scientific careers.

Retired Navy Chief Warrant Officer Tim Duffy and Chief Petty Officer Ron Humphrey, both Submariners assigned to Naval Surface Warfare Center, Corona Division in Norco, came at the outset of the contest to drum up excitement about Navy subs and life at sea.

They fired off jokes and factoids to and fielded questions from 36 kids.

"They show that they're very intelligent children and they could go far in this world," said Humphrey, an electronics technician and father of two. "With just a little bit of work and some dedication, I'm confident in their ability to succeed."

Humphrey, who grew up in Oklahoma, said there could have been better science-related opportunities available to him in his youth, and that he would have benefited greatly from an earlier start in science, technology, engineering and mathematics disciplines, also known as STEM.

Photo by Mass Communication Specialist 1st Class Ahron Arendes

Photo by Petty Officer 1st Class Christopher Okula

Lt. j.g. Brian Dahl
USS *Montpelier* (SSN 765)

Lt. j.g. David Fitzgerald
USS *Pennsylvania* (SSBN 735) (B)

Lt. j.g. Rodrigo Flores
USS *Texas* (SSN 775)

Lt. j.g. Matthew Freeze
USS *Miami* (SSN 755)

Lt. Sean Genis
USS *Jimmy Carter* (SSN 23)

Lt. j.g. Nathan Greenwood
USS *Tennessee* (SSBN 734) (G)

Lt. Paul Gholson
USS *Nebraska* (SSBN 739) (B)

Lt. j.g. Michael Gumpert
USS *Jacksonville* (SSN 699)

Lt. j.g. Andrew Hutchison
USS *North Carolina* (SSN 777)

Lt. j.g. Gary Kisselback
USS *Montpelier* (SSN 765)

Lt. j.g. Christopher Johnson
USS *La Jolla* (SSN 701)

Lt. j.g. Christopher Kagehiro
USS *Providence* (SSN 719)

Lt. j.g. Alexander Knowles
USS *Jimmy Carter* (SSN 23)

Lt. j.g. Ralph Lary
USS *Cheyenne* (SSN 773)

Lt. j.g. Luke Leveque
USS *West Virginia* (SSBN 736) (G)

Lt. Alexander Ludington
USS *Providence* (SSN 719)

Lt. j.g. Michael Marker
USS *Henry M. Jackson* (SSBN 730) (G)

Lt. j.g. Eric Moore
USS *Nevada* (SSBN 733) (B)

Lt. Andrew Mueller
USS *Oklahoma City* (SSN 723)

Lt. Mitchell Nelson
USS *Hawaii* (SSN 776)

Lt. j.g. Michael O'Connor
USS *Michigan* (SSBN 727) (G)

Lt. j.g. Daniel Olson
USS *Pittsburgh* (SSN 720)

Lt. j.g. Kenneth Parsons
USS *Albany* (SSN 753)

Lt. j.g. Merritt Pearson
USS *Oklahoma City* (SSN 723)

Lt. j.g. Jeffrey Rauen
USS *New Hampshire* (SSN 778)

Lt. j.g. Baden Reed
USS *Tennessee* (SSBN 734) (G)

Lt. j.g. Max Reitblatt
USS *Buffalo* (SSN 715)

Lt. j.g. Saunak Shah
USS *Mississippi* (SSN 780)

Lt. j.g. Joel Sholar
USS *Maine* (SSBN 741) (G)

Lt. Danny Slover
USS *Ohio* (SSGN 726) (G)



Photo by Paul Farace, USS Cod Director

USS *Cod* makes some noise

On Monday, Sept 3, 2013, the USS *Cod* Submarine Memorial honored the men and women who built the 312-foot submarine 70 years ago by firing its cannons and starting its engines.

The Labor Day Sea Show aboard the WWII submarine was in response to the cancellation of the Cleveland National Air Show.

The 312-foot long submarine started to fire hourly salutes from her 5-inch deck gun at 11 a.m. and continued until 5 p.m. Her diesel engines were fired up at noon, 2 p.m., and 4 p.m.

For more information, go to www.USSCod.org.

Lt. j.g. Jonathan Stecko
USS *California* (SSN 781)

Lt. j.g. Shawn Stelzel
USS *Boise* (SSN 764)

Lt. j.g. Shane Stumvoll
USS *Ohio* (SSGN 726) (G)

Lt. Timothy Swanson
USS *Maine* (SSBN 741) (G)

Lt. Jonathan Valeri
USS *San Juan* (SSN 751)

Lt. j.g. Matthew Vegel
USS *Tennessee* (SSBN 734) (G)

Lt. j.g. William Yzaguirre
USS *Nevada* (SSBN 733) (B)

Supply Officer Qualified in Submarines

Lt. j.g. Aaron Deanon
USS *Pennsylvania* (SSBN 735) (G)

Qualified Surface Warfare Officer

Lt. Michael Asche
USS *Frank Cable* (AS 40)

Ens. Jarroo Hancock
USS *Frank Cable* (AS 40)

Ens. Michael Peoples
USS *Frank Cable* (AS 40)

CW04 Troy Lowery
USS *Frank Cable* (AS 40)

Qualified Strategic Weapons Officer

Lt. Jeremy Medlin
USS *Maine* (SSBN 741) (B)



USS *Minnesota* (SSN 783) commissioned

The Navy's newest *Virginia*-class attack submarine was commissioned into the fleet at Norfolk, Va., on Saturday, September 7. *Minnesota* is the 10th *Virginia*-class submarine to be commissioned.

Minnesota provides the Navy with the improved stealth, sophisticated surveillance capabilities, and special warfare enhancements required to maintain U.S. undersea supremacy well into the 21st century. She is built to excel in anti-submarine and anti-ship warfare, special operations, intelligence gathering, and other missions and is capable of operating in the world's shallow littoral areas as well as at depths exceeding 800 feet.

Photo by Mass Communication Specialist Seaman Andrew Schneider

NOW HEAR THIS!!!

Calling for all Entries!

**15th Annual Photo Contest
Sponsored by
The Naval Submarine League**

UNDERSEA WARFARE Magazine is looking for this year's top submarine-related photos for the 15th Annual Photo Contest.

The best of the best will be published in the Fall 2013 issue.

Cash Prizes for the Top 4 Photos

<u>1st Place</u>	<u>2nd Place</u>
\$500	\$250
<u>3rd Place</u>	<u>Honorable Mention</u>
\$200	\$50

All entries must be received no later than September 28, 2013. Photos must be at least 5" by 7", at least 300 dots per inch (dpi) and previously unpublished in printed media. Limit of five submissions per person. Email photos in JPG or other digital formats to: underseawarfare@navy.mil, or mail printed photos to:

**Military Editor
Undersea Warfare CNO
2000 Navy Pentagon
Washington, D.C. 20350-2000**



Submarine Museums and Memorials



USS *Drum* (SS 228)

Mobile, Alabama

USS *Drum* (SS 228), a *Gato*-class, diesel-electric, fleet-type submarine, was built by Portsmouth Naval Shipyard, Kittery, Maine. She was launched on May 12, 1941 and commissioned on November 1, 1941, with Lt. Cmdr. Robert H. Rice in command.

Due to severe depth charge damage to her conning tower during her 8th war patrol, *Drum* was sent to Mare Island for an overhaul and a new, thicker-hulled *Balao*-class conning tower. This makes *Drum*, a *Gato*-class submarine with a *Balao*-class conning tower, unique among U.S. WWII-era submarines.

Drum was among the first *Gato*-class boats in combat. On her first war patrol from Pearl Harbor in April 1942, she sank the Japanese Navy seaplane tender *Mizubo* and three merchant ships. She made two more patrols in 1942, sinking three ships and damaging three more. In 1943, she damaged the Japanese aircraft carrier *Ryugo*, sank three merchant ships, and damaged another on her 4th through 8th patrols. On her 9th through 12th patrols in 1944, she sank four merchantmen. On her 13th patrol, she provided lifeguard services and reconnaissance for air operations in support of the Iwo Jima and Okinawa invasions. *Drum's* 15 sinkings, totaling 80,580 tons, ranked her 20th in number of ships sunk and 8th in tonnage sunk among U.S. submarines.

After earning 12 battle stars for her WWII service, *Drum* was decommissioned on February 16, 1946, and on March 18, 1947 joined the Atlantic Reserve Fleet, where she conducted training operations. *Drum* was reclassified as an Auxiliary Research Submarine (AGSS) on December 1, 1962 and was struck from the Naval Register on June 30, 1968. On May 18, 1969, she arrived under tow at Alabama's Battleship Memorial Park and was opened to the public on July 4 of that year. She was moved to a permanent berth ashore in 2001.

During all of her post-war operational years, *Drum* had some minor modifications, but never underwent a GUPPY conversion. Despite being the oldest American WWII submarine in existence, *Drum* is in excellent condition and is now moored with the WWII battleship USS *Alabama*. The *Drum* exhibit saw more than 300,000 visitors in its first year.

This 175-acre memorial park is dedicated to Alabamians who served or are serving in the U.S. armed forces. In addition to USS *Drum* and USS *Alabama*, visitors can also see a Mach 3 A-12 Blackbird spy plane, the B-52 Stratofortress "Calamity Jane," an original plane that was used by the Tuskegee Airmen, plus 22 other aircraft and weaponry from all branches of the military, including a Mark 27 electric "cutie" torpedo.

www.ussalabama.org/uss_drum.php