



# NAVSEA Warfare Centers

## *The Knowledge Points*

March 2021

Distribution Statement A – Approved for Public Release



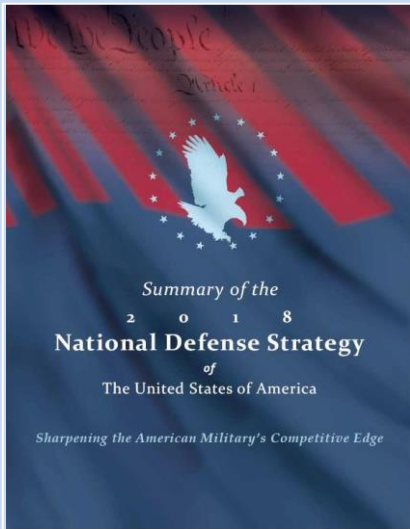
# Knowledge Points



- Developed in 2018 as part of the conversation between NSWC-NUWC Executive Director with CNR (Chief of Naval Research)
  - Way to portfolio-ize the S&T investments for better discussion with outside world
  - NR&DE collaboration forums organized around the Knowledge Points (KPs)
- Senior level leaders have been identified across the NSWC-NUWC to act as Knowledge Point Champions (KPCs)
  - Understand and articulate Navy's needs in these areas
  - Discuss NAVSEA Warfare Centers (WC) NISE (Naval Innovative Science and Engineering) Portfolio with outside world
  - Guide NSWC-NUWC NISE Investment planning and execution in Knowledge Point areas
  - Lead discussions and articulate WC Division efforts at NISE reviews and NR&DE collaboration forums

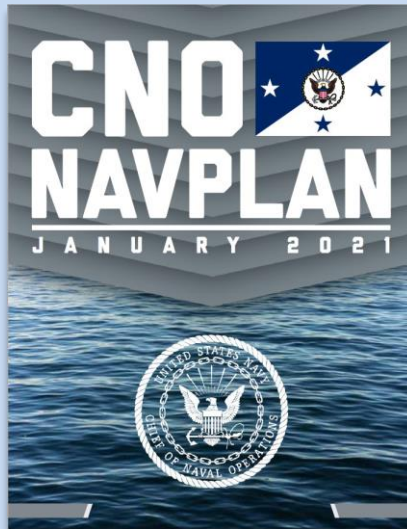


# Strategic Alignment



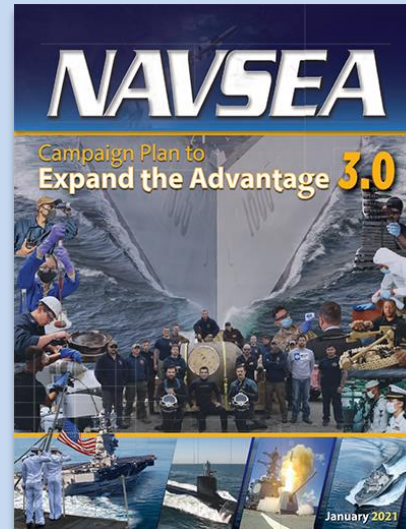
## NDS STRATEGIC APPROACH

- ☐ Build a More Lethal Force
- ☐ Strengthen Alliances & Attract New Partners
- ☐ Reform the Department for Greater Performance & Affordability



## ALL-DOMAIN NAVAL POWER

- ☐ Deliver a More Ready Fleet
- ☐ Deliver a More Lethal, Better-Connected Fleet
- ☐ Deliver a Larger, Hybrid Fleet
- ☐ Develop a Seasoned Team of Naval Warriors



## FORCE BEHIND THE FLEET

- ☐ Deliver Combat Power: On-Time Delivery of Combat-Ready Ships, Submarines and Systems
- ☐ Transform Digital Capability
- ☐ Build a Team to Compete and Win

## Knowledge Points

- AI/Machine Learning
- Autonomy / Unmanned Systems
- Cybersecurity
- Digital Science
- Directed Energy
- Electromagnetic Spectrum Operations
- Hypersonics
- Integrated Power and Energy Sciences
- Lethality – Mission Effectiveness
- Lethality – Ordnance Systems
- Live Virtual Constructive
- MBSE/SBD
- Ocean Sciences and Sensing
- Platform Design Science
- Quantum Sciences
- Sustainment and Repair
- Trusted Electronics
- Cycle of Assessment
- ANTX

***One Team: Expanding the Advantage***



# AI/Machine Learning

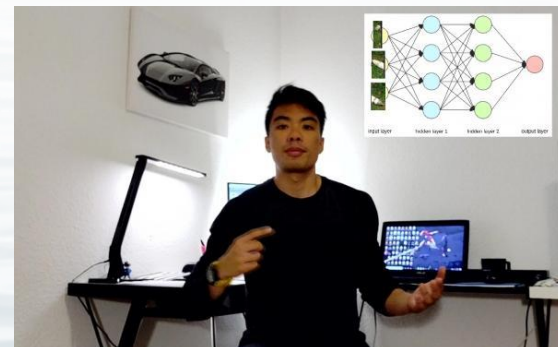
Artificial Intelligence (AI) - The ability of machines to perform tasks that normally require human intelligence - more specifically the study and design of intelligent agents; where an intelligent agent is a system that perceives its environment and takes actions which maximizes its chances of success. Machine Learning (ML) – A subset of AI where algorithms and architectures autonomously learn patterns in data or can be trained to learn a task. The machine has the ability to learn without being explicitly programmed. Learning might be “off-line,” (performed with data before the system is fielded), or “on-line,” i.e., the system learns (or adapts) while fielded from the data it acquires as it performs its tasks. Deep Learning (DL): An approach to ML characterized by network based models (nodes and edges) with a number of internal layers

## Research Areas of Interest

- Reasoning – Studying methods for hybrid systems to bridge the gap where reasoning methods such as expert systems work in concert with ML methods for higher level decision making. Research in novel methods towards Artificial General Intelligence – stage in the evolution of AI wherein machine will possess the ability to think and make decisions just like humans.
- Explainable AI – In attempting to build trust in AI systems, conduct research in developing methodologies to help explain why Deep Learning systems make their decisions (what happens in the black box).
- AI Optimization – Develop methods to explain differences in performance of employing various AI architectures (why 1, 3, 10, 50, 100 hidden layers are optimal) and various ML training approaches.
- Marine Mammal Monitoring – perform localization in-situ and provides population monitoring to the fleet
- Automated Processing of Finite Element Data

## Knowledge Point Champions

- Dr. Denise Crimmins (NP); Dr. Tory Cobb (PC); Dr. Jeff Solka(DD)







# Autonomy / Unmanned Systems

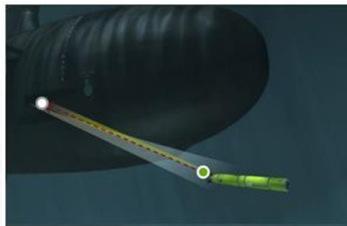
The NAVSEA Warfare Center Autonomy & Unmanned Systems (A&UxS) portfolio is focused on developing technologies to improve the capabilities of unmanned systems delivered to the U.S. Navy and Marine Corps. The A&UxS knowledge point supports all domains (underwater, surface, air, and land) across Navy and Marine Corps mission sets.

## Research Areas of Interest

- High interest research areas include: intelligent autonomous systems test and evaluation, high-density power systems, verification & validation, modelling & simulation, reliability, durability, maintainability, commonality, low cost and expendable systems for high volume production.

## Knowledge Point Champions

- Chris Egan (NP); Dan Kucik (PC); Gustavo Rivera (DD) and Reid McAllister (CD)





# Cybersecurity

Cybersecurity - Prevention of damage to, protection of, and restoration of computers, electronic communications systems, electronic communications services, wire communication, and electronic communication, including information contained therein, to ensure its availability, integrity, authentication, confidentiality, and nonrepudiation.

## Research Areas of Interest

- Approaches to improve the capabilities and efficacy of the cyber workforce
- Applications of behavioral sciences to the cyber domain

## Knowledge Point Champions

- Cyber SSTMs: Dr. Rob Templeman (CR), Steve Canup (DD), Tim Krell (KP), Rebecca Chhim (NP), Dr. Ken Fischer (PD)





# Digital Science

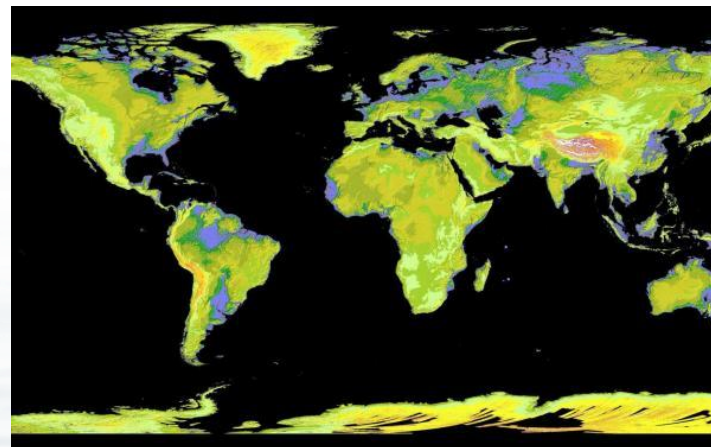
Digital Science describes the contemporary discipline of applied Data Analytics and Systems Engineering in data-rich IT infrastructures to improve system performance, availability and agility. This interdisciplinary field focuses on extracting knowledge from generally large data sets. Digital Science is critical to the success of the NSWC/NUWC mission in its ability to enable rapid delivery of repeatable, informed capabilities across all mission areas.

## Research Areas of Interest

- This field covers a variety of specific technologies such as data management, advanced analytics (machine learning and statistical analytics), data visualization, robotic process automation, and digital twins.

## Knowledge Point Champions

- Nathan Hagan (CD); Dr. Jeff Solka (DD); Dr. Rob Liu (CO)





# Directed Energy



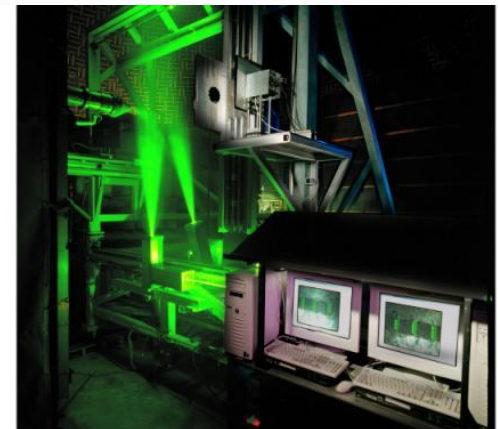
Directed energy — An umbrella term covering technologies that relate to the production of a beam of concentrated electromagnetic energy or atomic or subatomic particles. Also called DE directed-energy weapon — A weapon or system that uses directed energy to incapacitate, damage, or destroy enemy equipment, facilities, and/or personnel. Directed energy weapons (DEWs) are defined as electromagnetic systems capable of converting chemical or electrical energy to radiated energy and focusing it on a target, resulting in physical damage that degrades, neutralizes, defeats, or destroys an adversarial capability. Navy DEWs include systems that use High Energy Lasers (HEL) that emit photons, and High Power Microwaves (HPM) that release radiofrequency waves. The U.S. Navy uses DEWs for power projection and integrated defense missions.

## Research Areas of Interest

- Investigation of new technologies and effect mechanisms
- The ability to focus radiated energy while producing measured physical damage
- Conversely, capabilities to increase the resilience or survivability of platforms or Sailors from DEW threats.

## Knowledge Point Champion

- Dr. Brian Hankla (DD)



# Electromagnetic Spectrum Operations

The electromagnetic spectrum is the range of frequencies (the spectrum) of electromagnetic radiation and their respective wavelengths. It is the invisible, essential, and physical foundation of every battlefield - it unifies all the warfighting domains: land, air, sea, space, and cyberspace. The EMS is the only physical space shared by every warfighter. A space where energy and information is exchanged rather than bullets and bombs, and a weapon that moves at the speed of light, enabling the joint force to achieve asymmetric advantages against any adversary.

## Research Areas of Interest

- Autonomous and Intelligent Electronic Warfare (EW); Unmanned Surface Vehicle (USV)/Unmanned Underwater Vehicle (UUV) EW capability development and Advanced Off-Board capabilities

## Knowledge Point Champions

- Tom Dalheim (CR); Darlene Sullivan (NP); Alan Tolley (DD)





# Hypersonics

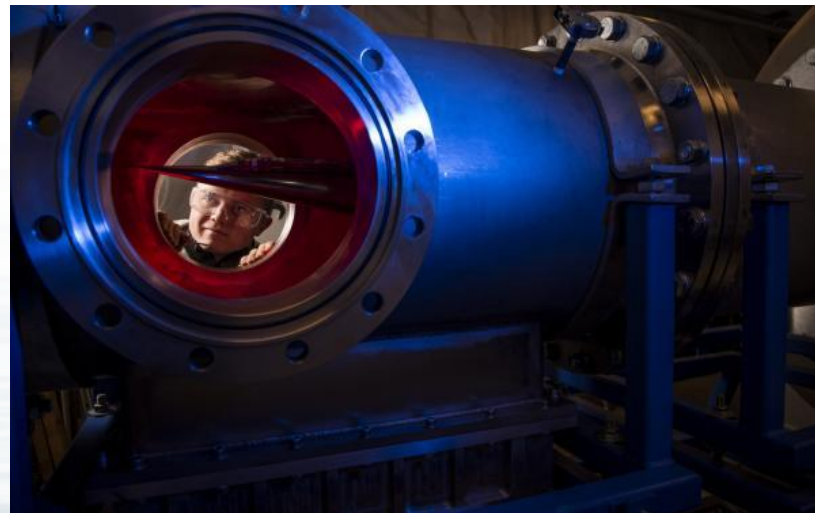
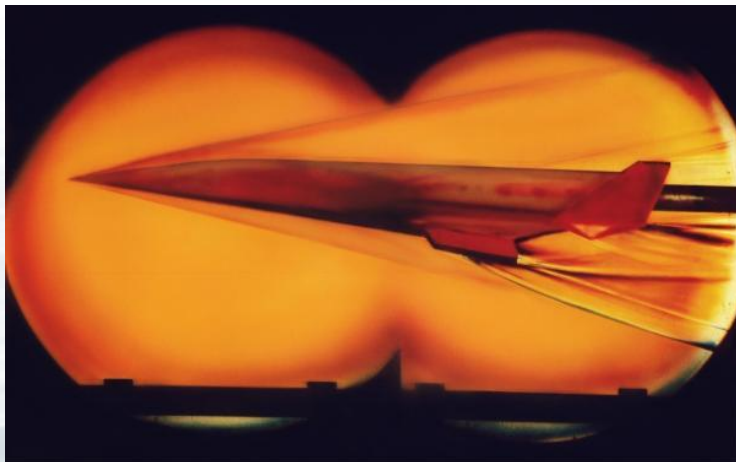
The hypersonics knowledge point is concerned with all efforts and enabling technologies associated with the design, development and testing of offensive and defensive hypersonic (speeds of Mach 5 or greater) weapons systems. The knowledge point covers a broad range of disciplines that include aerospace and materials engineering and is supported by many other knowledge points where the particular conditions of hypersonic flight impose extreme sensing, design and computational requirements. This involves collaboration with multiple entities within the DoD as well as academic, research and industry partners.

## Research Areas of Interest

- Aerospace engineering research including areas of controlled hypersonic flight, and materials engineering including thermal protection systems and high temperature material

## Knowledge Point Champions

- Pat Shaffer (CR); Ashby Hall (DD)







# Integrated Power and Energy Sciences

Power and Energy is a broad technical area which is a fundamental element of any system. Generally speaking this can be considered as the embodiment from the drop of fuel in, to the capability provided out. Design attributes and bias align to platform/user requirements and applications, including for mobility, operational time, power magnitude, and size/weight. Requirements often also require point design solutions to meet specific needs. Technologies are rapidly changing based upon consumer electronics, electrification, controls enhancements, and geopolitical trends. This creates challenges associated with diverse technology approaches, and constantly facing changes in products and opportunities to the warfighter. The technical area also requires competency improvements to support system design, integration, and operation, in order to achieve the breadth of warfighting capabilities that are desired.

## Research Areas of Interest

- Research areas include power generation, distribution, protection, energy storage, controls, thermal management, and assessment of phenomena associated with these areas, both physically and via modeling

## Knowledge Point Champions

- Dr. John Heinzl (PD); Dr. Joseph Fontaine (CR)





# Lethality –Mission Effectiveness

The Lethality Mission Effectiveness Knowledge Point explores methods to improve system level weapon effectiveness and lethality for surface and undersea launched Navy weapons. Weapon effectiveness provides the measure of performance or capability of a weapon system to achieve a defined level of target kill. The Knowledge Point includes any concept or innovation supporting an improvement in the weapon system capability from launch to intercept or impact. The Lethality Ordnance Systems Knowledge Point is focused on improvements in lethality through advances in the performance of the ordnance and energetic components in the weapon system. Focusing on ordnance systems' dependence on energetic materials to reach and engage a target in this Knowledge Point across all Naval warfighting domains.



## Research Areas of Interest

- Hypersonic materials characterization
- High Power Microwave effects modelling and simulation

## Knowledge Point Champions

- Brian Kiser (DD); Steve Plunkett (NP)





# Lethality – Ordnance Systems

The Lethality: Ordnance Systems Knowledge Point is focused on improvements in lethality through advances in the performance of the ordnance and energetic components in the weapon system. Focusing on ordnance systems' dependence on energetic materials to reach and engage a target are priorities in this Knowledge Point across all Naval warfighting domains.

## Research Areas of Interest

- Research in high energy density chemicals, materials and ingredients
- Controllable propulsion and advanced engines

## Knowledge Point Champion

- Dr. John Wilkinson (IH)







# Live Virtual Constructive (LVC)



**Live** = Real people operating real systems;  
**Virtual** = Real people operating simulated systems;  
**Constructive** = Simulated people and systems

LVC (Live Virtual Constructive) M&S (modeling and simulation) creates a common system-of-systems (SoS) engineering and experimentation environment which will facilitate more rapid, more informed, more robust development of cross-domain warfighting capabilities for the Fleet.

LVC M&S can serve a wide variety of roles – including concept exploration, experimentation, analysis and assessment, concept of operations/Tactics, Techniques and Procedures (CONOPs/TTP) development, system engineering, Capabilities Based Test and Evaluation (T&E), Integration and Interoperability (I&I) assessment, war gaming, training, mission rehearsal

## Research Areas of Interest

- Computer science technologies such as immersive visualization, gaming technologies and data management

## Knowledge Point Champion

- Marie Bussiere (NP)



# NAVSEA WARFARE CENTERS

## Model Based Engineering (MBSE) Set-Based Design (SBD)

Model Based Systems Engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases. A Model Based Systems Engineering (MBSE) Environment consists of: The Language in which people express models, (i.e., SysML); The Tools that people use to build and manipulate models; The Methods - that people follow to build models; Synthesis – the varying ways to bring language, tools and methods together.

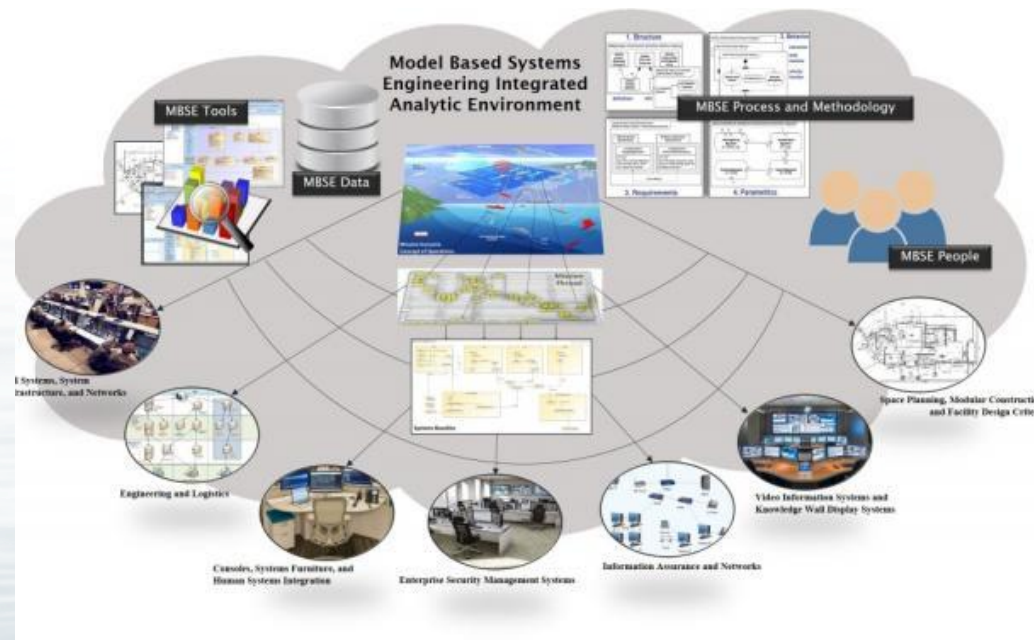
Set-Based Design (SBD) is a practice that keeps requirements and design options flexible for as long as possible during the development process. Instead of choosing a single point solution up front, SBD identifies and simultaneously explores multiple options, eliminating poorer choices over time. It enhances flexibility in the design process by committing to technical solutions only after validating assumptions, which produces better economic results.

### Research Areas of Interest

- Supporting infrastructure to empower MBSE including new data management, data transfer, data storage research

### Knowledge Point Champions

- Jeff Thelen (DD); Alex Gray (CD);  
Dave Woodward (PD)





# Ocean Sciences and Sensing



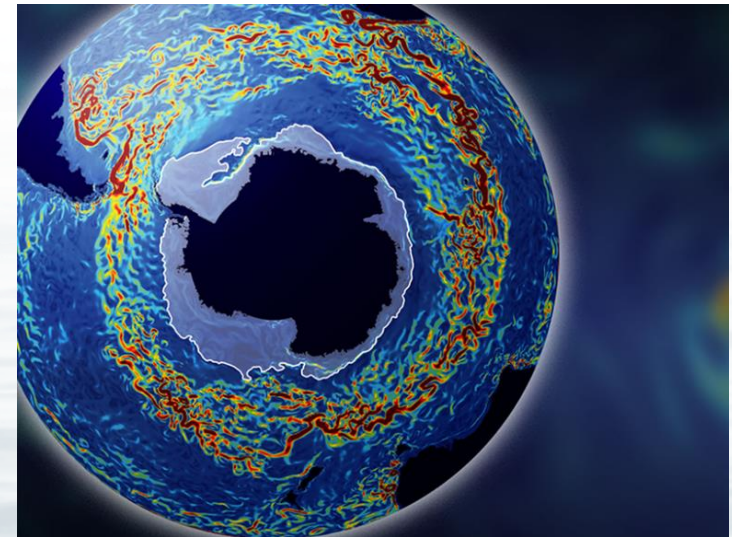
Ocean Sciences is to understand and predict the dynamical evolution of ocean phenomena and processes. Applying ocean science research to maritime operations requires rigorous interdisciplinary efforts that integrate evidence-based, multi-modal analyses and effectively employs systems thinking to understand complex processes. We seek to increase the number of technical personnel with advanced degrees/training in both oceanographic sciences and naval systems.

## Research Areas of Interest

- Research in understanding of oceanographic parameters from operational platforms and off-board systems to constrain and validate oceanographic and acoustic models.

## Knowledge Point Champions

- Dr. Joy Lapseritis (NP); Dr. Andy Greene (NP); Dr. Dan Sternlicht (PC); Dr. Anne Fullerton (CD)



<https://eos.org/research-spotlights/notorious-ocean-current-is-far-stronger-than-previously-thought>



# Platform Design Science & Capabilities

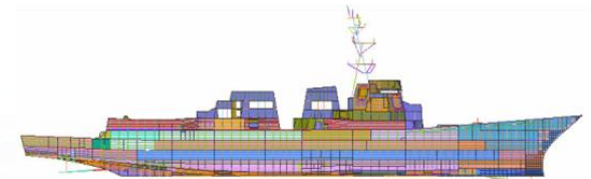
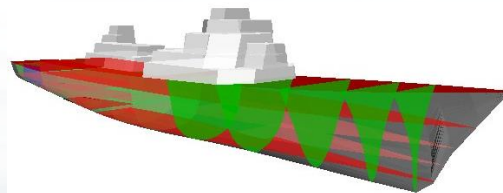
Platform Design Science and Capabilities – Efforts that increase or sustain the US Navy’s in-house capabilities to design and analyze surface ships, submarines, and unmanned surface and underwater vessels and vehicles. Naval platform design science and capabilities involves basic and applied research for all stages of the life of a marine vehicle. Stages of the vessels include design (exploratory, engineering (preliminary & contract), and production (detail) design), construction (including launching, testing & sea trials), operation and maintenance. Surface ships, submarines, and unmanned surface and underwater vessels must operate in more severe environments than commercial ships.

## Research Areas of Interest

- Research into improvements in ship, submarine and unmanned vehicle design and analysis tools. Research into better predictive models to improve ship capability, operability and survivability. Research into improved design processes including greater use of digital engineering. Improved understanding of complex interaction between ships and severe ocean environments.

## Knowledge Point Champion

- Jeffrey Hough (CD)



# Quantum Sciences

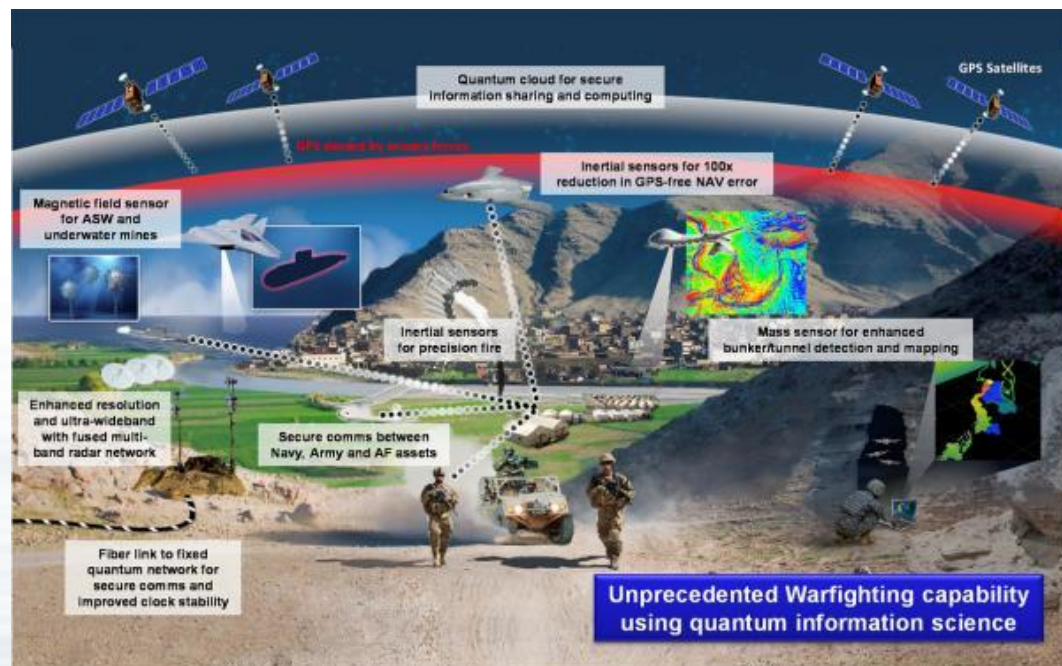
Quantum Mechanics or QM, describes how the Universe works at the level smaller than atoms. It is also called "quantum physics" or "quantum theory". Quantum is the Latin word for 'how much', and mechanics is the area of science concerned with motion. A quantum of energy is a specific amount of energy, and Quantum Mechanics describes how that energy moves and interacts at the sub-atomic level. Atoms used to be considered the smallest building blocks of matter but modern science has shown that there are even smaller particles, like protons, neutrons and electrons. QM is the part of physics that describes how the particles that make up atoms work. QM also tells us how electromagnetic waves (like light) work. Much of modern physics and chemistry can be described and understood using the mathematical rules of Quantum mechanics. ([https://simple.wikipedia.org/wiki/Quantum\\_mechanics](https://simple.wikipedia.org/wiki/Quantum_mechanics))

## Research Areas of Interest

- Five research areas which are of interest to the Navy include:
  - Quantum cryptography and communication;
  - Quantum algorithms and computing;
  - Quantum sensing;
  - Quantum metrology; and
  - Quantum energy transport and heat engines

## Knowledge Point Champion

- Dr. Jeff Solka (DD)





# Sustainment and Repair

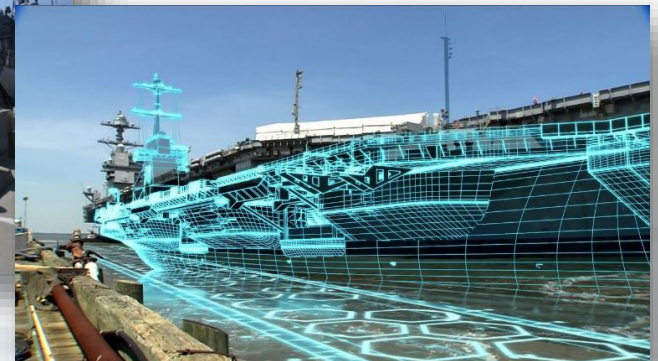
The Sustainment and Repair Knowledge Point comprises of NAVSEA Warfare Centers research in technologies that drive improved availability and readiness of Fleet Systems. Technologies that are primarily focused on rapid reconstitution and restoration of warfighter capability to keep ships in the high end fight fall within this knowledge point. The framework of this KP includes the key focus areas of material science and additive manufacturing, maintenance and repair, availability and readiness, distributed logistics, and lab revitalization.

## Research Areas of Interest

- Notably this knowledge point is looking for research in advanced materials, health monitoring and prognostics, product lifecycle management, additive manufacturing, predictive analytics, immersive technologies, networked labs and autonomous logistics

## Knowledge Point Champions

- Michele Burk (KP); Jason Bickford (PH); Dr. Cindy Waters (CD) / Bryce Weber (KP) / Patrick Violante (PD)





# Trusted Electronics

Trusted Electronics Knowledge Point: Microelectronics are fundamental to essentially every technology and capability in the Defense Department and more broadly in the commercial world. While Moore's Law has guided the industry's focus on performance for decades, for DoD use we must also consider access to (given the globalization of the semiconductor industry) intellectual property protection and security as well. The Trusted Electronics technical area focuses on leveraging the billions of dollars of commercial sector investments to provide access to and ensure the integrity of state-of-the-art and specialized DoD microelectronics to meet DoN operational and environmental requirements.

## Research Areas of Interest

- Research interests include determining the robustness of state-of-the-art (SOTA) commercial-off-the-shelf (COTS) microelectronics components to perform in harsh environments including environmental stress and radiation

## Knowledge Point Champions

- Dr. Matt Kay (CR)

