Good morning. It's a pleasure to be here this morning at the inaugural Human/Systems Integration Symposium. As NAVSEA's Product Area Director for Undersea Warfare Command and Control Systems, I'm happy to see such a group of prominent engineers and scientists present to address the challenges, opportunities, and implications of HSI for undersea warfare. In any capacity, it's always gratifying for me to welcome distinguished guests from industry, academia, and government who bring a wealth of knowledge and experience to share.

Undersea warfare is essential to the execution of our Nation's security strategy and to the Navy's strategic vision, Sea Power 21. Ensuring undersea superiority is critical to provide the competitive advantage of gaining and sustaining battlespace access, developing and sharing knowledge, and projecting power. Sea Power 21's pillars of Sea Strike, Sea Shield, and Sea Basing, along with the supporting initiatives of Sea Warrior, Sea Trial, and Sea Enterprise, all of which are enabled by FORCEnet. FORCEnet, an architecture and operational framework of sensors, networks, decision aids, weapons and supporting systems will make network-centric warfare a reality. The focused, timely, and accurate information or knowledge delivered by FORCEnet will help synchronize the activities of Navy and Marine Corps elements with joint, Allied, and coalition forces

throughout the battlespace to achieve the greatest possible impact. The Sea Warrior will be the most critical elements of our 21st Century Navy. As the CNO wrote in the October 2002 issue of the U.S. Naval Institute Proceedings, "The Warrior is a premier element of all operating systems." And without implementation of the Human Systems Integration into the systems engineering process, the full operational capabilities of FORCEnet will not be realized.

For the undersea warfare community, Sea Power 21 and FORCEnet promise to enhance our contributions to the joint fight. During the Cold War, the submarine service was known as the "silent service" because the submarine represented the ultimate stealth weapon that was capable of patrolling the seas undetected and alone. In the post-Cold War era, the emphasis in undersea warfare has shifted from open ocean operations to those in the littoral waters and from platforms to off board sensors. This presents many challenges to our scientists and engineers. In response, we've adapted our technological portfolio to include revolutionary unmanned vehicles, distributed off-board sensors that provide continuous surveillance over wide geographic areas, supervelocity weapons, high data-rate communications and advanced combat system technologies for improved decision making and contact management.

These technologies will continue to provide the platform, Battle Group Commander and Theatre level commander significantly more information and knowledge of the undersea battlespace.

We are also developing concepts to tie systems together in a network for battlespace management. Mutually shared information and a common tactical picture will permit the use of the entire naval force as a single synergistic entity. Before we can successfully achieve these capabilities, however, a number of issues will have to be resolved. For example, we frequently hear about the potential "information overload" warfighters may face as they are flooded with data in the common operating picture, which threatens to blend tactical, operational, and strategic perceptions into one overwhelming "mega picture". In fact, it's not so much that there is a threat of information overload as there is a potential failure to integrate the right information at the right time, and in the right format to enable the right actions, up and down the chain of command and across the spectrum of warfighting tasks. This needs to be done before the bad guys to survive in future engagements.

Among key issues the USW community needs to address, include those that appeared in the Strategic Studies Group 21 report:

Shared awareness, finding a common perception and understanding of the tactical battlespace and of the roles, responsibilities, and actions of other warfighters.
Efficiency of asset utilization – the length of time needed to assign an asset, complete a mission, or other number of tasks.
Speed of command - the time from when an event occurs until the action is completed; and
Adaptability, or the extent and speed of an organization's change in response to changing tactical situations.

Of course, this is a beginning list. The state of practice must consider more.

Addressing these topics in order to fully implement Sea Power 21 is complicated by the unique characteristics of the undersea environment. Complexity, variability, uncertainty, and the unknown are all hallmarks of this environment, and the targets that operate within it. The undersea warfighter faces complex acoustic environment that will include varying bottom characteristics, reverberation effects, non-homogeneous water masses, and sea surface effects. Proximity to coastal

waterways, harbors, and shipping lanes increase ambient noise as and make contact management increasingly complex. Currents, tides, and temperature gradients, bottom type or slope, and salt water/fresh water convergence zones further complicate the acoustic picture. Ever improving technologies on the open market continue to make the submarine threat more complex. Add this with a local knowledge of the environment and tailored tactics and this complexity increases again. The complexity of the operating environment and the physics of underwater object detection prevent unambiguous clarity from any one system. That is the power and promise of netted system.

What are the specific challenges for the Sea Warrior in this environment? What is he trying to do? The joint commander has a mission. The anti-submarine warfare commander has a mission. The commanders of an ASW Helo or DDG or SSN or SSGN all have tasks, as do the men and women who serve under their commands.

For us in the systems engineering community, a key challenge is to reduce manning. This is a critical driver in the future Navy. Carefully designed and implemented, automation and autonomy are key. We must be cognizant of what the human can do, and what machines ought to do. But human systems integration is more than the man-machine interface. . . We must also understand

and optimize human performance in terms of accuracy, timeliness, availability, workload, and situational awareness. This extends to the many forms of collaboration and Command and Control, from the platforms that conduct undersea warfare operations today, to the management and coordination of offboard systems, and the coherent operations of a total undersea force executing its tasking for the joint force commander. This implies understanding the operational needs, and crafting information tools and processes to support the warrior for planning and execution of the full spectrum of USW missions.

Now that I've completely inundated you with this litany of challenges that lie ahead, let me tell you about some of the opportunities that we can look forward to and what I hope we'll bring away from this symposium. First and foremost, we have a unique opportunity here to join with members of government, academia, and industry to share our knowledge about a topic that brings different disciplines together, draws techniques from all walks of life, and affects us daily. At Division Newport, for example, we were recently reminded of the need to balance automation with human operator intervention when -thanks to a word processing spellchecker- we found ourselves announcing in our monthly NUWCSCOPE publication that we had just appointed Dr. Susan Kirschenbaum as the ***HIS*** coordinator. I'm pleased to say

that we've enjoyed considerably more success in other endeavors! We participate in Fleet Battle Experiments as a virtual undersea platform, which allows us to test out concepts and processes at an early stage that would be too costly to conduct at sea. For FBE-India, we created a netted `virtual SSGN based on a modernized Trident platform, complete with Control Room, Navigation Center and Missile Control Center compartments and operated it as an integral element of the live forces participating in the Pacific. We hope to take the opportunity over the next few days to share some of our other experiences with you, because the Navy in general and the undersea warfare community in particular have continued to organize ourselves into a community of practice to address HSI. This Undersea HSI Symposium provides an ideal forum for discussing the implications of HSI for USW systems design, operation and maintenance of undersea systems, and to showcase some of the special HSI capabilities of the undersea Navy community here in Southern New England.

As you are all well aware, HSI has become a central theme of the system engineering process throughout the DoD. It optimizes the human part of the total system equation by integrating human factors of engineering, manpower, personnel, training, safety, and personnel survivability into the system acquisition process.

HSI is crucial for maximizing performance and reducing lifetime cost. One of our primary goals is to maximize information throughput from distributed sensors, processors and displays it for the USW team. HSI can be used to help the Sea Warrior of today and tomorrow sift through the influx of sometimes conflicting or incomplete information to define possibilities and understand limits. HSI professionals like all of you are critical to improving our USW capabilities by:

- Developing or improving the human interfaces of our USW systems to maximize their effectivness
- Addressing the economical demands upon personnel resources, skills, training, and costs for both the operators and maintenance folks.

As the Product Area Director for Command and Control Systems, I have a particular interest in applying HSI at the operator-to-sensor level in order to better integrate tactical-level USW efforts with other FORCEnet factors. This will produce operational SEA Warriors who not only make the right decisions, but make decisions right. I'm reminded of a story told by Bran Ferren, Walt Disney Imagineering President of R&D and Creative Technology. Ferren got to spend two days on board the Los Angeles class submarine ALEXANDRIA and his experience led him to

conclude that two different types of people had designed the boat. The propulsion people had designed a beautifully conceptualized and implemented system where systems engineering ruled. Things were designed to be accessible and intuitive as to what they did and how they did it. The Command and Control area, however, looked quote "like a weekend at Radio Shack and a mega welder." Technology was introduced as a series of progressively nicer boxes that didn't talk to each other, weren't interoperable, and most importantly, weren't integrated into the sensibility of the people in the leadership position. Basically, Ferren said, the philosophy of the Command and Control designers seemed to be that technology makes a nice decorative contribution, but shouldn't otherwise interfere with the operation of the boat.

I'm pleased to say that our philosophy has evolved considerably since Ferren was on the ALEXANDRIA. We've successfully addressed a number of critical areas including analysis, software improvements, Command and Control display technology, metrics and assessment, and Concept of Operations but more is needed. The Concept of Operations and warfighting strategy for anti-submarine warfare is currently being transformed. As the next generations of technology are introduced to achieve and accelerate improvement, metrics and assessment for both systems

and human performance will need to expand from a traditional focus at the tactical operational level and address equal attention to the operational levels.

So as you can see, there are a tremendous number of challenges, opportunities, issues, and options for us to consider over the next two and a half days. We won't be able to come up with all the answers during that time, nor should we feel obligated to. Rather, this initial Human/Systems Integration Symposium allows us the luxury of asking questions of one another and posing as research questions any that go unanswered here. While we're together, we'll be focusing on three broad HSI areas that are all very important, very challenging, and relatively new: **modeling and simulation, metrics, and netted warfare.**

Modeling and simulation is invaluable to the USW community because they give us a way to safely and economically test concepts, equipment, and people. M&S can help guide the development of a system from the "top down" and facilitate a better understanding of the current and proposed systems. While much of USW command and control decision making remains more of an art than a science, a key challenge for HSI in this area is developing a cognitive model to better understand and reflect how the USW warfighter interacts with the information available.

Military theory and the science of war are among the key disciplines that offer insights into cognitive, behavioral, and social factors. Physiology, psychology, sociology, organizational theory, and management science also play important roles in HSI M&S. The willingness to acknowledge this is undergoing something of a revival in the undersea warfare community, as a matter of fact. Admiral Rickover, who's known as the father of the nuclear Navy, asked human factors engineers for help laying out the power plant of the Nautilus. The story goes that the psychologists gave him volumes and volumes of material to consider . . . too much to be useful, so Rickover shelved it and for nearly a generation human factors weren't considered in the development of the Navy's submarines. Of course, Rickover is also rather well known for his horror at having psychiatrists assigned to serve onboard submarines. He once told Congress quote, "We are doing very well without psychiatrists because the men don't know they have problems. But once a psychiatrist is assigned, they will learn that they have lots of problems."

**This may have been fine in a platform centric environment but not in the future fully netted force of the future.**

My point is that we look to HSI to achieve a balance between incremental changes and dramatics changes. Technology now makes it possible to do more, but we need to ask how much change can be tolerated by the system. Decision makers have a greater need for adaptive/automated decision aids. Speed and accuracy are of paramount importance, with the need to get it right, and get it inside the other guys decision loop.

The USW HSI community needs metrics to measure the performance of people in different systems and processes. Without metrics, how do we know what we've accomplished? The machines may have the answers, but the warfighter might not. Or the warfighter could receive the right answer 20 minutes late. None of these scenarios is an acceptable one for the USW community. Nor do we have the luxury of accepting some predefined level of system crashes, the way a computer software giant might. We have to focus on safety and reliability and find the balance between these and human factors. As I mentioned earlier, however, metrics have traditionally been focused at the operational level and must now be applied to the tactical level. Some possible values for HSI metrics in this regard might be centralization, formalization, interdependence, reciprocity, and trust.

HSI in netted warfare is a new and challenging application, especially for USW. Our expertise in developing HSI enhancements to FORCEnet and the integration of distributed, netted off-board assets and autonomous vehicles will be critical in answering the question of how we control the proliferation of nodes in the undersea battlespace.

One promising area of focus is operational human systems integration, which is a coherent, systematic approach to enhancing operational-level warfighter performance and decision making. Operational HSI meshes the enablers of selection, learning, augmentation, and organization with FORCEnet factors at the operational level. This breaks down stovepipes and gives the warfighter the methods, strategies, and tools to move freely among different scales of space, force, time, and effects.

What does all of this mean for the accomplished HSI experts gathered here? Well, we're looking at an HSI paradigm shift from sensor-based to tactics-based that invokes environmental adaptation and automates detection, classification, localization, planning and response. This shift will require changes in training, increasingly reliable and robust automation, and new ways of displaying information so that the human operator understands uncertainty. The multiple levels and

dimensions of data that are increasingly available to the warfighter are both a challenge and an opportunity for us. How do we ensure that information is presented correctly in a way that makes sense and is actionable? How do we avail ourselves of the tremendous opportunities offered by new and emerging technologies? I'm going to borrow a story from Dr. Kirschembaum's first years here. At the time, the use of color was being considered as a change from our traditional green waterfall sonar display screens to something better. She walked into a lab and saw an engineer designing a display with 256 colors. She asked, "Why would you use all 256 colors?" and he said, "Because I can." As and engineer designing something it sounds correct but gives HSI experts like you something to watch for and continue to educate us against. Just because the technology is available, does it make sense to use it all? We need to ask this question about nearly every area we work in. In some cases, what's really required is a new way of looking at things. We have all heard the tragic story of the submarine that struck a civilian surface ship during a baffle clear. One of the folks responsible for training came to us and asked us some really good questions. He asked, "We've been doing Target Motion Analysis the same way for 25 years. Is it really that good, or is there a better way?" As a result, we worked with the training community to reevaluate TMA and come up with

different solutions to address it. This was a real success story for the application of visualization techniques and HSI.

I'm entirely confident that there will be many more success stories to come. By drawing on the combined expertise of you who know so much, we will further fit HSI into the USW domain. Improving the HSI interface will allow us to leverage and extend the capabilities of USW to ensure that fielded systems will exploit the fullest potential of the warfighting team. We will ensure that HSI is applied during development and acquisition of our USW systems; equipment and facilities to more effectively integrate personnel into the system acquisition process.

I thank you very much for your kind attention.