Sea Node

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LONG-TERM GOALS

Improve Ship & Battle Group Situational Awareness: Provide to operators of the Navy's AN/SSX-1 (SEI) system several additional categories of information available within the Electronic Support (ES) environment. Integrate the processing of data provided from other shipboard systems.

Reduce Operator Workload: Provide intuitive displays that minimize the need for operators to perform cross-system operations. This includes providing intuitive and dynamic map displays, enabling auto-tracking of AIS contacts and operator-defined static locations, and minimizing the work necessary to geolocate coastal radars of interest.

Enable FORCEnet operations, Such as Ship-to-Ship Collaboration for Geolocation & Future Data Fusion Applications: Assigning nanosecond-level time stamps to pulse-level data enables cross-platform processing for all applications that require precision time stamps. Although the current implementation of Searchlight-based geolocation requires only microsecond-level timing, the Sea Node design enables time stamping to 10s of ns.

Note: The Sea Node is a sub-task in a broader Space INP, "Steady Lookout" Task. The complete Steady Lookout is a multi-platform prototype working together to advance FORCEnet operations by bringing to bear the best characteristics of each platform to address Naval needs such as Communications-on-the-Move and Maritime Domain Awareness.

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14. ABSTRACT
Improve Ship & Battle Group Situational Awareness: Provide to operators of the Navy?s AN/SSX-1 (SEI) system several additional categories of information available within the Electronic Support (ES)environment. Integrate the processing of data provided from other shipboard systems.

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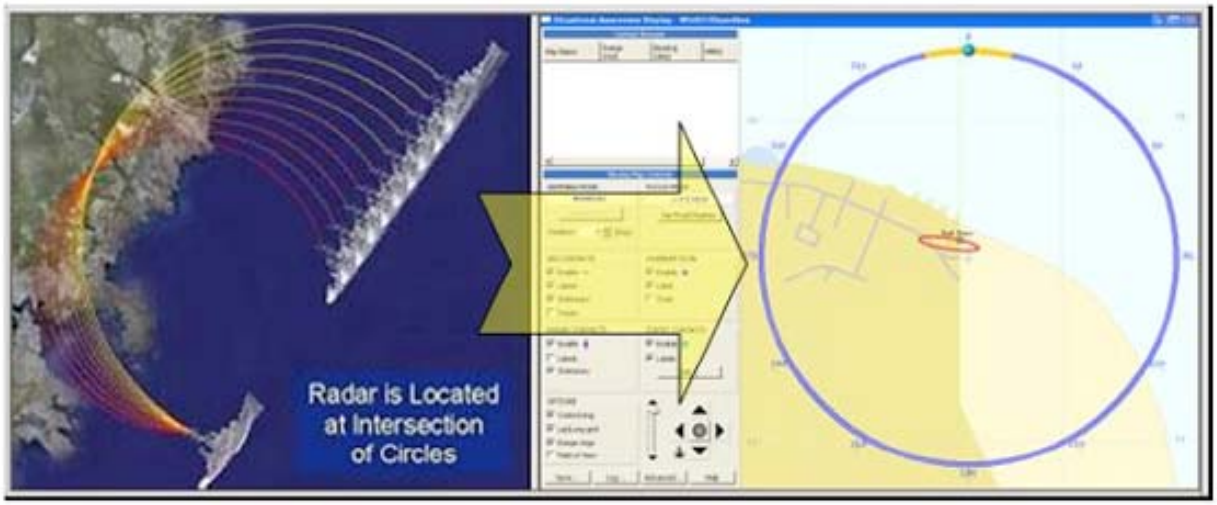
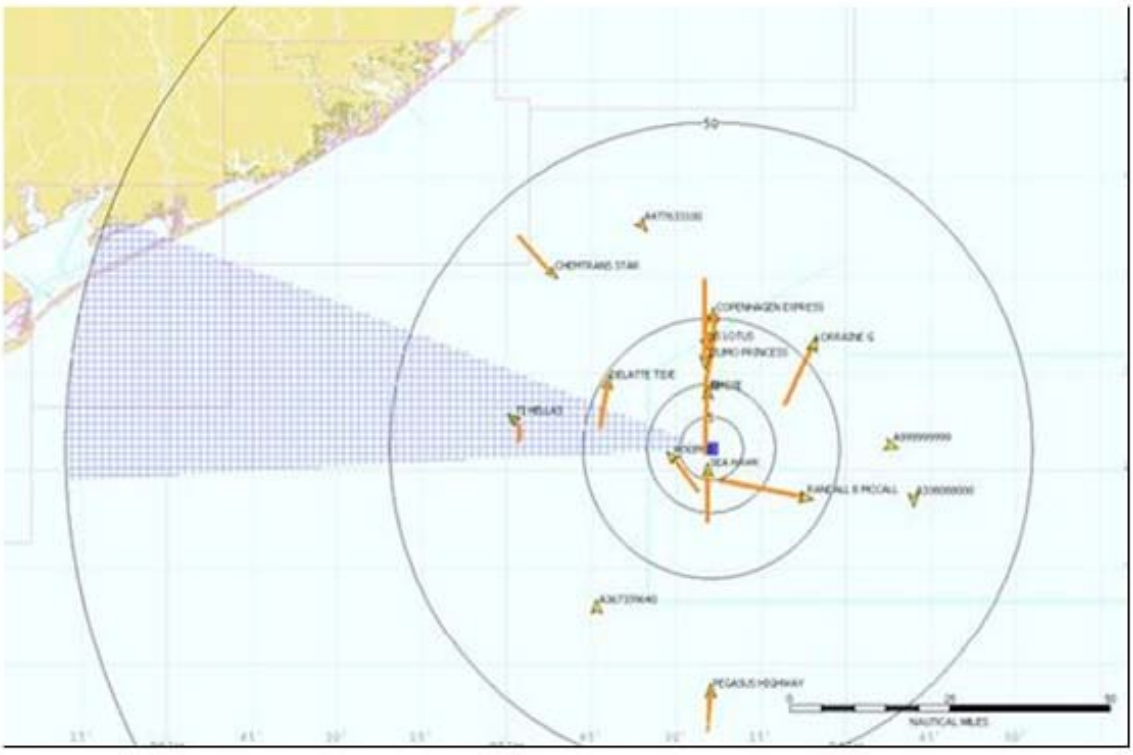
OBJECTIVES

Enable Sharing of Precision Time Stamped Data: Precision time is enabled by adding to the AN/UYX-4 Processor Unit a VME-based rubidium time standard. A firmware upgrade manages the 10-MHz output and assigns precision time to pulse-level data. An additional VME-based IRIG-B reader interprets the time-of-day signal made available from the ships' NAVSSI system.

Develop and Verify Geolocation Techniques and Algorithms that are Practical for Shipboard Implementation: Processing of data collected collaboratively by different platforms requires that pulse-level data are assigned with high-precision time. The Sea Node augmentation of the Navy's AN/SSX-1 system enables keeping time to tens of nanoseconds; Time Difference Of Arrival (TDOA) methods require such precision. Accuracy of the time assigned depends on many variables, primarily related to the degree to which the timing signals available to the AN/UYX-4 Unit are calibrated. Methods such as Searchlight, used during Trident Warrior 09, require time-assignment precision to only the microsecond level, easily achieved aboard ships and without extensive calibration processes. The Figure below shows the Searchlight geolocation concept and how the locations are displayed with an associated confidence ellipse on the improved Situational Awareness Display available within the WinSEI 7.1 software.



Ingest AIS Data; Display Ship Tracks and Vessel Information: Situational awareness is significantly enhanced by data beyond those collected by specific Electronic Support (ES) Systems. The Sea Node augmentation of the AN/SSX-1 System enables ingestion of AIS data in standard NMEA format and displaying of the data and tracks for AIS contacts in the collector's vicinity. Adding AIS contacts to the same display as that used to control the ES System helps to put the ES data in relative geographic context. Given the signals collected and geolocated by the ES System, one might also gain useful information from AIS data failing to show contacts where they should be expected. The Figure below shows the updated Situational Awareness Display.



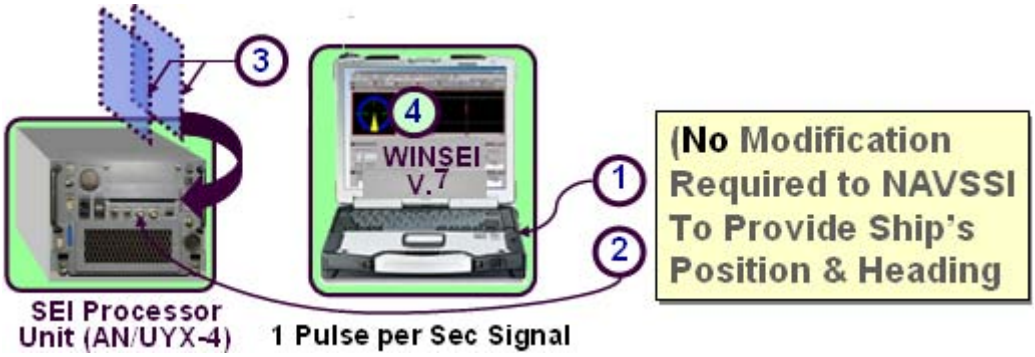
The cross-hatched triangle represents the ES system's antenna pointing angle and beamwidth. The orange tracks close to the own-ship position are time-sequenced AIS contacts. The displayed AIS contacts can be managed by the operator to enable shorter or longer persistence of the tracks. Detailed geographic information is depicted dynamically as the ship is underway. ES antenna tracking can be set to automatic. The viewing radius is operator-controlled.

Implement Several Situational Awareness Displays and Operational Tools to Reduce Operator Workload and Increase Effectiveness: Currently, ES operators need to look to other systems that provide information to put the ES data collected in relative context to the overall, local electronic environment. These cross-system operations are inefficient and often lack resolution or geographic context to the display. The Sea Node augmentation of the AN/SSX-1 ES System includes own-ship-centered, dynamic map displays, with an operator-definable radius. Icons on this display can be selected to slave pointing of the ES antenna to that location, regardless of whether own-ship position and/or contacts of interest are stationary or mobile. This auto-tracking feature lets operators concentrate on tasks other than constant updating of the ES-antenna's pointing angle—and it results in higher-quality signals being collected. The Searchlight geolocator was also added to the AN/SSX-1 system. Searchlight was proved conceptually during the Steady Lookout 07 Experiment and proved ship-worthy during Trident Warrior 09. The Searchlight algorithm is robust under practical at-sea conditions and requires minimal operator workload to geolocate coastal radars of interest, especially useful in littoral areas. The Searchlight technique is notably less work than traditional cross-fixing techniques and notably more robust than precision time of arrival techniques. Searchlight's mean geolocation accuracy was 0.21nm (380 m) during TW09. Detailed results are available in the TW09 Sea Node Report.

Ensure Compatibility with Existing Hardware & Software to Minimize Expense & Transition Time to Deploy Upgrade: The Sea Node augmentation of the Navy's AN/SSX-1 systems is a low-impact, high-value upgrade; see the Approach section, below.

APPROACH

The Naval Research Laboratory developed the SEI system currently carried aboard US Navy ships, and the Lab is familiar with the details of form, fit, size, weight, power, and software requirements of the AN/SSX-1 System. Given this background, NRL designed a minimum-impact process to augment the AN/SSX-1 system with the Sea Node capabilities described in this paper. Form, fit, and size are unaffected by the augmentation; additional weight and power requirements are minimal, and adequate spare VME slots are available in the chassis of the AN/UYX-4 unit to accommodate the two additional cards. One of the three cables needed from the ship's NAVSSI system is already connected to the AN/SSX-1 system; adding the other two during Trident Warrior 09 cost about $5k. The final upgrade simply involves replacing the existing WinSEI 5.2d software with WinSEI 7.2. The Figure below shows the components affected by the modification.



The two components within the AN/SSX-1 system that require minor modification to enable Sea Node capabilities are the AN/UYX-4 SEI Processor unit (left in the Figure above) and the laptop computer, which requires that the WinSEI software be upgraded from version 5.2D to version 7.2. The following steps are required to implement the changes:

1. Accept the Time Mark Data Message (TMDM) from the ship's NAVSSI system

2. Receive 1-PPS signal from NAVSSI

3. Add a VME card providing a precision, 10 MHz, clock reference and a VME-based IRIG-B reader within the existing SEI processor box

4. Upgrade software from WinSEI 5.2D to WinSEI 7.2

NAVSSI's TMDM provides own-ship GPS position and heading. The Sea Node uses the IRIG-B signal to ensure that UTC is kept to the correct second. The 1-PPS signal from NAVSSI provides the second-counting strobe that is the basis for assigning precision time. The 10-MHz clock disciplines the 1-PPS signal and provides quantized time to the SEI Processor unit. Finally, WinSEI 7.2 enables functionality of all Sea Node capabilities.

Enhancements to the capabilities of the existing ship's ES system:

1) Precision Time Stamps & GPS Added to AN/SSX-1: Allows data sharing in FORCEnet fashion for multiple applications such as geolocation.

2) Multiple WinSEI Software Enhancements for Improved SA & Reduced Operator Workload: High-resolution maps with dynamic updating and full control by operator; ingests AIS data and displays AIS tracks; auto-tracks mobile and stationary contacts and positions—vice manually updating antenna position.

3) Searchlight Algorithm for Collaborative Geolocation of Targets of Interest: The Searchlight geolocator was produced by NRL and proved its potential during the Steady Lookout 07 Experiment in October 2007. Since then, and prior to Trident Warrior 09, NRL enhanced Searchlight's performance by improving the initial location to which iterative adjustments are made on the way to the finally derived geolocation. NRL also improved for use during TW-09 the Earth parameters used within the algorithm, as well as the method of surface projection during the geolocation process. The method of producing confidence ellipses about the derived geolocation was also upgraded for used during TW-09. Several software-configuration variables, e.g., time-calibration delays and antenna-offset, were added to enable accurate geolocations to be produced on various ships.

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WORK COMPLETED

Work completed during FY09 on the Sea Node project includes all of the preparation necessary to participate in the Trident Warrior 09 Experiment, conducting the Experiment, and producing reports that summarize the results of the Experiment. Throughout this process, testing was performed to ensure that the system will work aboard US Navy ships. For example, NRL tested a Sea Node System in the NAVSSI Lab at SPAWAR San Diego. NRL and NAVSSI engineers worked through the technical details of ensuring that the Sea Node System can properly accept the signals and data required from NAVSSI, and process them in a coordinated fashion that enables production of precision-time stamped pulse data.

NRL also performed detailed analyses of data collected from previous experiments to characterize the geolocator's performance. The results of these analyses led to implementing modifications that significantly improved the geolocation accuracy. Ellipse containment, the degree to which the radar's actual location falls within the Searchlight-produced confidence ellipses, was also improved significantly via iterative analyses conducted prior to TW-09.

RESULTS

The results of work performed on the Sea Node project this year culminated in concluding that minimal technical risk is associated with upgrading the Navy's AN/SSX-1 system to yield all of the capabilities described in this paper. No new technology needs to be developed to transition the Sea Node capability to the Fleet. Significant improvements to operability, interoperability, and functionality were proved during TW-09. Passive geolocation is now achievable at minimal per-unit, up-front, and long-term cost to the Navy. This combination of significantly improved ES capabilities might well represent the lowest cost/benefit ratio available in the Navy.

IMPACT/APPLICATIONS

The Sea Node augmentation improves the overall EW-related operations aboard US Navy ships. The most obvious improvements include the ability to collaboratively geolocate radars with minimal effort, using low communications-link bandwidth and minimal coordination; geographically contextual displays that are automatically and dynamically updated; automatic tracking of static and mobile targets; and improved awareness of the electronic environment via display of AIS data. Less obvious, but important, are the composite benefits to the operator—being able to use a single system to yield much greater overall insights to the ship's EW environment.

TRANSITIONS

The primary organizations required to transition the capability to the Fleet are NRL, OPNAV N865E, IWS-2E, and NSWC Crane. NRL designed the upgrade and would provide initial consultation services during the transition process; OPNAV N865E owns surface EW requirements for the Navy; authorization for augmentation would be required by IWS-2E; and implementing the upgrades would be managed and performed by NSWC Crane.

Prior to requesting participation in the Trident Warrior 09 Experiment, NRL engaged OPNAV N865E regarding the lack of a Navy requirement to passively geolocate radars from US Navy ships. Although many Navy requirements imply that such a parent requirement exists, one has not been found. OPNAV N865E agreed that such a requirement should exist. NRL submitted a proposal for participation in ONR's Rapid Technology Transition (RTT) program for 2009. Although it was viewed as beneficial, OPNAV did not identify "logistics tail" funding for the program, thus denying the transition. Since then, NRL produced and submitted to OPNAV an estimate for transitioning the Sea Node capabilities to existing AN/SSX-1 systems in the Fleet. CDR Jonathan Bartel at OPNAV N865E recommended Trident Warrior participation to improve Fleet awareness and support for a specifically called out (vice implied) requirement. ONR then provided Warfighter Experimentation funding to Participate in TW09. NRL then worked with NETWARCOM to exercise Sea Node in the TW09. NRL will work with OPNAV and ONR in FY10 to assure a sound transition plan, likely involving the RTT program.

RELATED PROJECTS

NRL's development and improvement of the Searchlight technology is expected to continue and pursued for implementation on various collection platforms.

PATENTS

NRL has a patent pending on the Searchlight geolocation method.