

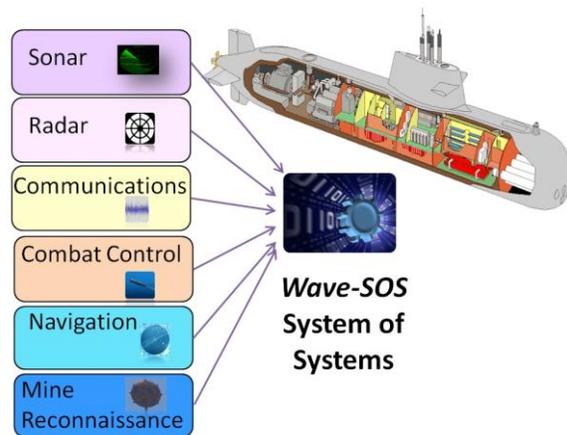
Wave SOS: Wave for Systems of Systems

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PROBLEM STATEMENT

Maintaining situational awareness on a submarine poses significant challenges. When attempting to identify underwater contacts, the water distorts the light and sound waves, causing estimates of positions and velocities to be inaccurate. While movement in the sub-surface world is three-dimensional, presentations of the sensor data, usually in the form of computer screens, are two dimensional, and there is often no single display that provides a composite picture based on data from all available sensors.

The control room personnel on a submarine rely strongly on the sensor systems as they make decisions. Providing them with a composite or “fused” picture of all available sensor data would significantly increase the ability of these personnel to make more timely and more accurate decisions. Because the submarine uses a complex network of sensor, weapon and navigation systems, it is a challenge to share information and capabilities among these systems. Finding and correlating mission-relevant information from these data streams is complex. Multi-intelligence (multi-INT) data will further complicate the task as they come online.

To exploit the U.S. Navy’s sensor superiority, the discovery and fusion of information within the AN/BYG-1 combat system of Navy submarines must be automated to:

- Identify mission-relevant information
- Fuse information from multiple sources
- Improve situational awareness by reducing the areas of uncertainty (AOUs) regarding positions of potential submarine threats
- Effectively present information to operations staff and commanders to aid in the decision-making process

The Wave SOS approach, developed by Modus Operandi (MO), addresses these needs using a combination of probabilistic and semantic processing algorithms, which improves upon existing

methods by bringing additional information to bear on the problem. This additional information includes not only other sensor types (e.g. infrared search-and-track and electronic support measure sensors) but inferences made from semantic representations of sensor metadata and inherent sensor characteristics such as accuracy and tolerance.

WHO CAN BENEFIT?

The Wave SOS architecture's net-centric, service oriented architecture (SOA) approach aligns with the goals of Program Executive Office, Submarines (PEOSUB), the U.S. Navy, and the other branches of the armed forces, to provide a scalable commercial-off-the-shelf / government-off-the-shelf (COTS/GOTS) friendly framework that promotes interoperability among disparate systems. It allows submarine personnel access to relevant data in a consolidated display within the AN/BYG-1 combat system (the initial transition system for Wave SOS).

The Wave SOS solution can be used in any situation that requires multi-INT sensor fusion and decision support, beyond the command center of a submarine. It can also be used as a training platform for command personnel. Storage and playback of the sensor data can be fed into a simulator for developing new missions and strategies.

Other potential platforms that might benefit from the Wave SOS technology include the Space and Naval Warfare Systems Command (SPAWAR) in support of the Program Executive Office - Command, Control, Communications, Computers and Intelligence (PEO-C4I), Networks, Information Assurance (IA), and Enterprise Services Program Office (PMW 160) in the Consolidated Afloat Network and Enterprise Services (CANES) program; Distributed Common Ground Surface/Systems (DCGS); Tactical Mobile Systems (TacMobile); Broad Area Maritime Surveillance (BAMS); and other Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) applications in the Department of Defense (DoD) community.

BASELINE TECHNOLOGY

Most fielded sensor systems are legacy systems that were not designed to function in a net-centric environment or to facilitate fusion of information from multiple sensor systems. Current fusion attempts impose artificial limits to the number of contacts that can be fused together. Several previous attempts at fusion algorithms have failed, with only one fusion algorithm, an Expectation Maximization (EM) algorithm, remaining. There are also massive amounts of information trapped in documents, reports, email messages, and application messages that can be of help in deconflicting the sensor data. Current Virginia Class submarines have a consolidated display that any new solution must plug into, so the Wave SOS solution must be designed for interoperability with the AN/BYG -1 interfaces and fit into the consolidated display.

TECHNOLOGY DESCRIPTION

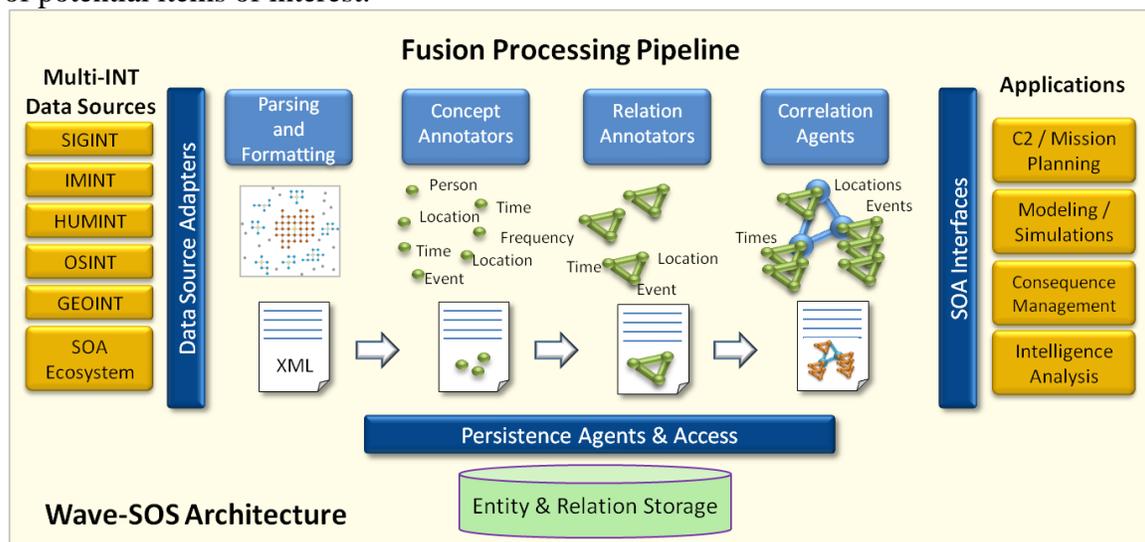
MO is developing a software technology portfolio, called the Wave® Exploitation Framework (Wave-EF), which uses natural language processing and machine learning

techniques to automate the discovery of mission specific intelligence from unstructured text with significant improvement over traditional technologies. Data that has been identified as being relevant to an analyst's mission is automatically tagged and semantically enriched, enabling quick retrieval, correlation, and fusion with other structured and unstructured data. The result is more rapid access of actionable intelligence to commanders. This technology can be applied to develop new applications, or enhance and refresh existing applications in order to improve performance and extend the life of legacy technologies. Regardless of the program or customer, the applications are designed to be flexible, adaptable and reusable; resulting in technology that can be quickly applied to existing government legacy applications. Because the Wave-EF technology being developed is government-off-the-shelf (GOTS), it can be provided at no cost.

MO is extending Wave-EF for this effort through development of Wave System of Systems (Wave SOS), an innovative SOA framework for accomplishing multi-INT fusion of information from multiple disparate environmental, planning, and sensor sources, i.e., sonar, automatic identification system (AIS), electronic surveillance measures (ESM), navigation, and radar, and performing text analysis, semantic enrichment, and metadata annotation of text-based information sources.

Wave SOS will provide submarine control room personnel, and ultimately commanders with a vastly improved common operating picture allowing them to perform more mission types with greater confidence. With the improved situational awareness provided by the multi-INT fusion, Wave SOS will use the Commander's Intent, where available, to provide consistent recommendations for actions based on the current mission parameters.

The following figure illustrates the enrichment and fusion of data in a SOA environment. Commanders Intent is parsed and enriched and available for decision support. Sensor and intelligence data from multiple sources are fused and used to improve identification of potential items of interest.



The following table describes the features, advantages, and benefits of Wave SOS.

Features	Advantages	Benefits
Adaptable	Open framework	Reduces development costs Easy to upgrade
Reuse	Leverage legacy applications	Reduces development costs
Flexible	Design can support future systems	Easy integration with existing systems
Ease of use	Minimal disruption to existing applications	Easy to train
Scalable	Accommodates littoral and deep water missions	Reduces sustaining costs

The following table compares Wave SOS technology features with the current baseline.

Feature	Current	Wave SOS
Sensor fusion	Semi-automated with limits	Semi-automated
Multi-INT fusion	Manual	Semi-automated
Decision support	Manual	Provide recommendations

CURRENT STATE OF DEVELOPMENT

An initial prototype was developed during Phase I of the contract, and enhanced during the Phase I Option. This prototype demonstrates the feasibility of using Wave-EF technology to perform the fusion operations. This evolutionary prototype is being expanded to test the data fusion and decision support algorithms. The resulting system will be integrated within an AN/BYG-1 testbed at the CACC Alternatives Study and Experimentation (CASEX) Lab, Naval Undersea Warfare Center, Newport, RI.

Milestone	TRL	Risk	Measure of Success	TRL Date
Initial prototype developed	2	Low	Technology concept demonstrated	3/31/2009
Prototype enhanced with geospatial visualization	3	Low	Advanced prototype concept demonstrated and reviewed	9/20/2009
Initial fusion prototype application installed in the CASEX Lab	4	Moderate	Successful integration in lab for feedback	TBD
Fusion engine implemented	4	Moderate	Deployment validated in CASEX Lab	6/1/2011
Full decision support and fusion engine implemented	5	Moderate	Deployment validated in CASEX Lab	12/1/11

REFERENCES

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Program Executive Office, Submarines (PEO-SUB) 425
Technical Point of Contact
202-781-4981

DCGS-MC Project Officer
U.S. Marine Corps Systems Command
703-221-0200, X51182

DCGS-SIGINT Metadata Project Manager
410-854-1769

WHEN IS THE TECHNOLOGY READY FOR USE?

Our plan to achieve TRL9 is to first integrate and demonstrate Wave SOS in the Naval Undersea Warfare Center (NUWC) CASEX Lab. Because the simulators in the CASEX Lab produce realistic sensor data, we will achieve TRL5 there as noted in the table above. The next step will be integration into a specific build of the AN/BYG-1. We are currently targeting the technology insertion 11 (TI-11) which is the next opportunity to integrate new software into this combat system. Successful integration into AN/BYG-1 TI-11 within the Future Attack Center (FAC) will allow Wave SOS to be tested in a real environment resulting in TRL9. To achieve the goal of TRL9 will require time, interface specifications, and funding to integrate with AN/BYG-1 systems in the FAC. In addition, run time in the CASEX Lab with hands-on access for end-users to provide feedback. Incorporation into the FAC would achieve TRL7. Once TRL7 is achieved, Wave SOS must be scheduled for sea trials aboard a Virginia Class submarine to achieve TRL9.

ABOUT THE COMPANY

Modus Operandi (MO) is a command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) software technology company focused on accelerating information discovery, integration and fusion for customers in the defense and intelligence community. MO provides products and services in the areas of semantic data representation and integration, real-time and event-driven semantic data enrichment, ontology-based query and retrieval of structured and unstructured information, and machine reasoning. MO's services are focused on application development, deployment, training, system sustainment, and modernization of C4ISR data integration applications. In addition, under multiple Navy, Army, and Air Force contracts, they perform research and development focused on developing leading edge data fusion and semantic enrichment technologies. These technologies are part of the Wave® Exploitation Framework that enhances the ability to search and filter over large amounts of structured and unstructured data, resulting in more timely and accurate decision analysis by application users. This technology is ideally suited for the development of new applications as well as the migration of legacy C4ISR systems to SOA.

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