

# Automated Marine Mammal Detection and Classification

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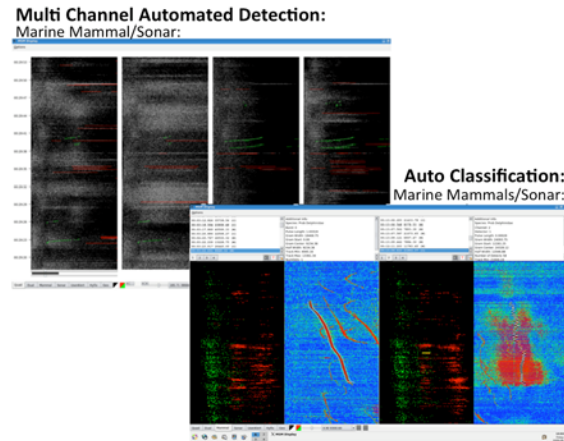
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**Command: NAVAIR**

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## PROBLEM STATEMENT

The United States Navy has instituted 29 measures which are designed to support marine mammal mitigation when using active sonar/EER/IEER systems. Item 15 under these mitigation measures requires sonar operators to passively monitor for marine mammal vocalizations. Unfortunately, current systems and most sensors used by Navy platforms (Air and Ship) do not have the bandwidth required to detect marine mammal vocalizations. In addition, this is a very manpower intensive operation which is not viable in an era when the Navy is trying to reduce manning requirements.

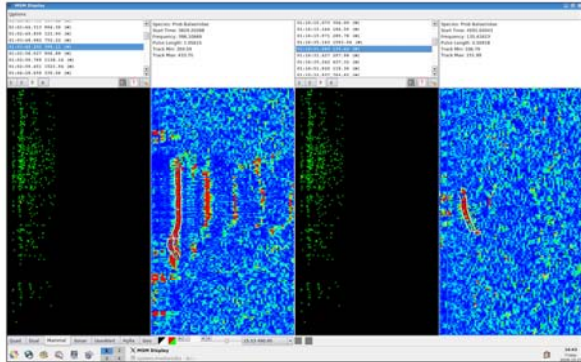
## WHO CAN BENEFIT?

Our technology benefits all three of the Navy's major ASW platforms which include fixed wing aircraft (P-3C and P-8A), ASW helicopters (SH-60B and SH-60R), and surface ships including Arleigh Burke class guided missile destroyers (DDG), Ticonderoga class guided missile cruisers (CG) and Littoral Combat Ships (LCS)..

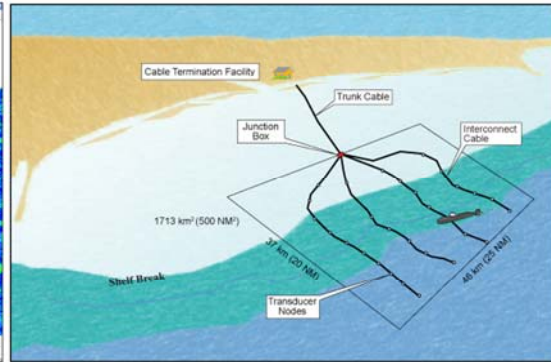
The other community which can benefit from our technology is the Navy's training ranges. The United States Navy has identified an area off the coast of Mayport, Florida, as the preferred site for the Undersea Warfare Training Range (USWTR). The USWTR will cover approximately a 500-square nautical mile area of the ocean and will enable the U.S. Navy to effectively train in a shallow water environment at a suitable location for Atlantic Fleet units.

Recently, environmental groups and state agencies from Florida and Georgia have expressed concern about the Navy's plan because this area is near the Southeastern Critical Habitat for the North Atlantic Right whale (*Eubalaena Glacialis*). The North Atlantic Right whale is one of the most endangered species of marine mammals in the world and migrates to the coastal areas of Georgia and Florida during the calving season from about November through April each year.

During at sea tests we deployed a long-term sensor off of Mayport and recorded the ocean noise 24/7 from January through May 2009. Using our multi-channel system we automatically detected and classified North Atlantic Right whale vocalizations when we conducted post-mission processing of this data. The automatically detected and classified Right whale vocalizations are shown in Figure 1. This demonstrates that our technology effectively detects Right whale vocalization and can be integrated and used by the USWTR range shown in Figure 2 to protect this endangered species as well as other marine mammals.



**Figure 1. Auto Detection and Classification**



**Figure 2. USWTR**

## **BASELINE TECHNOLOGY**

The baseline technology used by the Navy is based on narrowband processors that do not have the bandwidth or the update rates required for an operator to visualize or hear the majority of marine mammal vocalizations. Because of this, the Navy's current approach to passive monitoring is inefficient and is not effective in identifying marine mammal vocalizations. Because current processors do not automatically detect or classify marine mammal vocalizations there are no baseline metrics to compare our technology against.

## **TECHNOLOGY DESCRIPTION**

The primary technology we have developed under this program is a multi-channel signal processing system designed to automatically detect and classify marine mammal vocalizations. This technology can be backfit into a wide variety of naval platforms (Air/Surface Ship and Navy ASW Training Ranges). In addition, the technology can be used as a standalone system for use for by the U.S. Navy or other industries when required to monitor for marine mammals. The multi-channel capability also supports the localization of marine mammals after they have been detected and classified.

Table 1 below is a Feature Advantage Benefit (FAB) table for our automated detection and classification technology.

<b>Feature</b>	<b>Advantage</b>	<b>Benefit</b>
Wideband (100 kHz) Processor	Process wideband sensors	Detect marine mammals
Automated Detector	Operator Not Required	100% Automation
Automated Classifier	Operator Not Required	100% Automation
Classification to Taxonic/Species Level	Operator Not Required	Identify High Risk Mammals
Supports Localization	Range To Whale	Mitigate Harming Whale
Real Time Displays	Visualize Vocalizations	Situational Awareness
Real Time Audio with Translate	Hear Vocalizations	Situational Awareness
Classification Displays	Validate Classification	Easy To Use
Classification Audio with Translate	Validate Classification	Easy To Use
Process Various Sample Rates	Use Multiple Sensors	Supports Integration

**Table 1. FAB Table**

Table 2 below is a comparison of our technology against current Navy narrowband processors.

<b>Feature</b>	<b>MSM System</b>	<b>Navy System</b>
Wideband (100 kHz) Capability	Yes	No
Automated Detector	Yes	No
Automated Classifier	Yes	No
Classification to Taxonic/Species Level	Yes	No
Supports Localization	Yes	No
Real Time Displays	Yes	Yes
Real Time Audio with Translate	Yes	No
Classification Displays	Yes	No
Classification Audio with Translate	Yes	No
Process Various Sample Rates	Yes	No

**Table 2. Comparison Table**

Working with UnderSea Sensor Systems, Inc. we have also developed wideband sonobuoy sensors which can be used for real time monitoring by Naval ASW aircraft. Working with Teledyne-Benthos we have also developed a long-term sensor that can be deployed to identify if marine mammals inhabit areas of interest to the United States Navy. As noted, this sensor was deployed and recovered during our at sea demonstration.

Our signal processing technology can be readily interfaced into current platforms. Two approaches can be implemented: one is a standalone system using commercial-off-the-shelf (COTS) hardware which can be deployed as needed onboard ships or aircraft. The other approach will entail integration into current processors as part of the spiral development process under the Acoustic-Rapid COTS Insertion (ARCI) program. For a standalone system we will require an interface to the digital output of the sensor, be it a sonobuoy on an aircraft or the Calibrated Reference Hydrophone (CRH) on a ship. For integration into the ARCI program we will work with the program sponsor and system integrator to integrate our open architecture software into current processors.

For integration into training ranges we will expand the current multi-channel system to support a large field of sensors. This large field multi-channel system will monitor all of the hydrophones on the range and provide end users a visual cue of hydrophones which have marine mammal activity. A drill down display will allow end users to quickly access and confirm vocalizations as required.

## **CURRENT STATE OF DEVELOPMENT**

Our signal processing technology is currently at a Technology Readiness Level (TRL) 6. We have developed a prototype multi-channel processor which has processed real world data in a high fidelity laboratory. The data was recorded from a wide array of Navy platforms and sensors which include sonobuoys (Air), CRH sensors (Ship) and AUTEK/PMRF sensors (Navy acoustic ranges). In regard to the sensors, they are at a TRL 7. They have been deployed and used in an operational environment.

For a standalone system it will take approximately six months to develop and integrate into a current aircraft or shipboard platform. The cost to integrate a standalone system is approximately \$350,000 - \$500,000. Please note that these are only estimates and could be lower once we are able to discuss integration requirements with a platform sponsor. After the first system is complete it is estimated that additional systems would range from \$50,000 - \$100,000 depending on sensor calibration/grooming requirements. We do know that, onboard the ships, the CRH sensors have not been maintained and that additional work may be required. For standalone aircraft systems the cost should be much lower. These costs also include training and forward area support as required.

For Acoustic-Rapid COTS Insertion (ARCI) into current processor we estimate it would take between 12 to 18 months. This schedule would be driven by the prime integrator. Under this effort, AD&D engineers and software developers would support the integration and testing of our software into current processor. We estimate that the costs for this effort would range from 1.0 - 1.5 million dollars.

For the air program, PMA-290 and Lockheed Martin would play a key role. Analysis, Design & Diagnostics, Inc. would work with Lockheed Martin to integrate our Marine Mammal Detection and Acoustic Intercept technology into the P-3 aircraft as part of the USQ-78B Acoustic Processor Tech Refresh. Once integrated this technology could be inserted into the P-8A program during future processor updates.

For the surface community PEO IWS will be the program sponsor and the system integrator(s) will be the key player(s).

To integrate into the USWTR we would require multiple processors (one processor for every 4 channels). This would also require us to develop the front end displays to handle a large number of sensors. Costs for this effort are estimated to range from 1.5 - 2.5 million dollars.

## REFERENCES

NAVAIR's Advanced Acoustic Technology Assessment Group (AATAG) conducted an independent assessment of acoustic intercept and marine mammal detection and classification technology developed by several companies. Our technology (AD&D) was rated number one and far superior to all others in regard to detection, classification and automation (AATAG Meeting, November 7, 2008). In addition, PEO IWS 5B conducted an independent peer review evaluation as part of a step two evaluation of our detection and classification technology. The evaluation focused on our ability to detect and classify marine mammals while operating in various sonar environments. The data sets used for the evaluation were from recordings made during several real-world missions. The U.S. Navy conducted ground-truth analyses of these data sets using subject matter experts and scored our performance against this ground-truth analysis. The data in Table 3 is a summary of our overall performance. It should be noted that we had a total of 27,156 detections that had to be correctly evaluated to achieve this unprecedented performance.

<b>Data File</b>	<b>Verified Mammal</b>
RIMPAC 4	34
RIMPAC 12	4
RIMPAC 20	123
Silent Fury 6	2629
TASWEX 81	18
TASWEX 82	14
Total	2822
Metric	
Probability of Correct Classification (Pcc)	0.96
Probability of False Classification (Pfc)	0.007
Probability of Missed Classification (Pmc)	0.033

**Table 3. Step II Evaluation of Detector and Classifier**

## ABOUT THE COMPANY

Analysis, Design & Diagnostics, Inc. (AD&D) is a Veteran Owned Small Business established in 1992. Since the company's inception we have provided technical support services and developed technologies for automated detection and classification primarily in the field of Anti-Submarine Warfare (ASW). AD&D received an Excellence Award in 2004 from PEO IWS. AD&D was also recognized as a small business success story by the Office of Naval Research (ONR) in 2007 for technology we developed under a Phase I-III Small Business Technology Transfer (STTR) program.