

## **Auto-Adaptive Whale Detection**

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## **PROBLEM STATEMENT**

Open ocean training and testing activities are often suspended or curtailed due to the possibility of harm to marine species in reference to the Marine Mammal Protection Act. Maritime patrol aircraft need all-weather, all-light sensors that can detect and track whales as they breach the ocean surface at extended collection ranges. Commercial maritime search radars have been demonstrated to be able to detect whale breaches in low sea states (<3). However, there is no data on how well these radars can detect whale breachings in higher sea states (>3). Additionally, there is a need to develop whale detection systems that will allow the use of automated techniques that make affordable radar systems a cueing sensor for high-resolution systems such as electro-optic (EO)/infrared (IR) cameras. Brainlike, Inc., has developed automated techniques to detect and track maritime objects utilizing a multi-sensor approach that performs range clearance with a minimum set of sensors.

## **WHO CAN BENEFIT?**

While this project has not been designated to any specific platform, it is assumed that it will be used by commercial service organizations that currently perform marine mammal searches. Two other federal agencies that may find the technology useful for marine mammal searching are NOAA and the National Mineral Management Service. The solution can also be used elsewhere in the Defense community for other applications including terrestrial unmanned aircraft systems (UAS) sensing, passive and active sonar submarine detection, submerged magnetometer sensing and underwater mine detection.

## **BASELINE TECHNOLOGY**

Currently, the U.S. Navy employs numerous mitigation measures during sonar exercises. These measures include, among other things, stationing specially trained lookouts to search for marine mammals, utilizing passive acoustic monitoring for marine mammals, establishing safety zones around ships where sonar power is reduced and stopping an

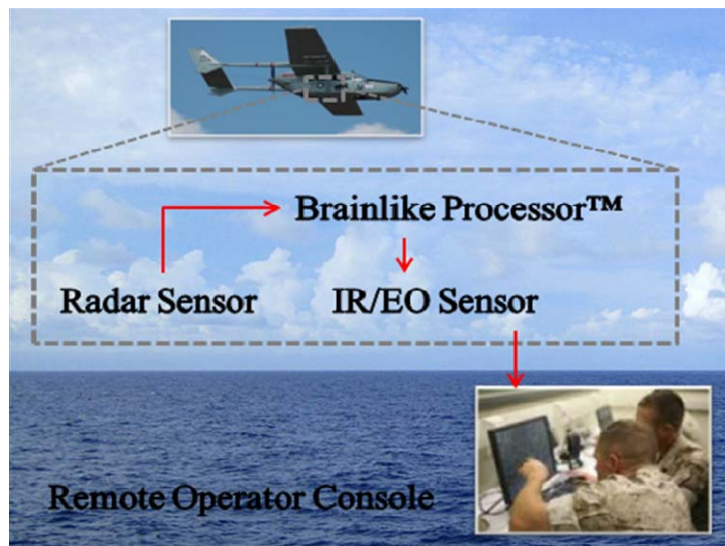
operation if marine mammals are sighted, and employing extra precautions during chokepoint exercises (<http://www.defenseindustrydaily.com/us-navy-reviews-research-marine-mammal-mitigation-measures-04487/>). These mitigation efforts are comprehensive and unquestionably have served to protect countless marine mammals during sonar training missions; however, they are time and manpower extensive. Further, trained lookouts are restricted to daytime fair weather operations; thereby drastically limiting the effectiveness of the Navy's most used mitigation technique.

While it is difficult to estimate the total cost of these various mitigation measures, the Navy has spent \$100 million on marine mammal research over the past five years, including \$26 million this year.

([http://www.enviro-navair.navy.mil/currents/winter2009/Win09\\_Marine\\_Mammal\\_Science.pdf](http://www.enviro-navair.navy.mil/currents/winter2009/Win09_Marine_Mammal_Science.pdf)).

## TECHNOLOGY DESCRIPTION

Brainlike, Inc., has developed automated detection techniques using the Brainlike Processor™ and low-cost radar systems to engineer an aerial radar platform, Auto-Adaptive Whale Search Radar (WSR). The Brainlike name comes from the capacity of its signature process to identify unexpected events by continuously learning what to expect from changing background clutter, much as animals continuously habituate to changing conditions while sensing threats. Like animals, which can effectively pinpoint predators under changing background conditions, the Brainlike process relies on continuous learning to reduce clutter, improve clarity, and afford better decisions.



The platform will detect and track maritime objects utilizing a multi-sensor approach that performs range clearance with a minimum set of sensors. The tracking system utilizes patented automatic target recognition (ATRs) algorithms to identify the presence of marine mammals in a variety of sea states and light conditions, and acts as a cueing sensor for high-resolution systems such as electro-optic (EO) / infrared

(IR) cameras. With ATR and reduced false alarm rates (FARs), this system will detect and track breaching whales as vector icons that plot with periodic updates on a moving map display system using all-weather, day-night sensors. Besides reducing distracting clutter and false alarms, Brainlike sensing reduces transmission costs when installed on remote sensors, upstream of telemetry.

Brainlike Processor™ technology continuously learns to distinguish meaningful events from background clutter. Brainlike technology runs a patented software process that learns expected values from sensor measurements, in real time. Concurrently, Brainlike sensing highlights only comparatively deviant values while filtering out expected values. In the process, Brainlike sensing reduces cluttered sensor data to valuable information.

The Brainlike team has determined that various features of whale radar returns will allow for differentiating between whales and other clutter objects. The Brainlike process has been designed so that feature and output values are both fast and auto-adaptive. High speed is achieved by creating feature and likelihood functions that depended only on nearest neighbor values in time and space and by creating window driver functions that traverse the input with high efficiency. Auto-adaptivity is achieved by basing likelihoods on differences between actual and expected feature values and by continuously adapting expected feature values to changing background conditions.

The Brainlike process produces event recognition signals in real time. The process does so by efficiently receiving information, producing event detection signals, updating learned information about background clutter, and correcting for background clutter. The process also refines target likelihoods and related displays immediately upon new data arrival. The technology produces alerts when within-cell intensity values are unexpected, relative to recently learned expectations, all in real time. In this way, the Brainlike process can produce alert signals that are robustly accurate against changing background noise, which it continuously learns to expect and remove.

Features will be extracted from the raw data in order to remove clutter objects and highlight whale returns. These features may be as simple as window averaging or more complex, such as differences between time intervals. These features will be automatically and continuously calculated and updated. The Brainlike process will learn normal background activity for these features in time and space, allowing for the effects of sea state and other environmental variables to be removed. With this ATR algorithm, anomalies will represent whale activity.

The following table outlines the features, advantages, and benefits of the solution:

Feature	Advantage	Benefit
Fully automated deployment	Makes radar cueing sensor for high-resolution cameras	Eliminates need for highly trained operators or expensive radars
Auto-adaptive learning	Identifies marine mammals when background conditions vary	Improves detection in varied sea states
Remote telemetry and sensor control	Deploys on remote sensor platforms Rapid, compact, and energy efficient operation	Increases accuracy Reduces telemetry
Identifies simple features	Allows robust performance	Enables fast development

	over varying target configurations Enables simpler understanding of target recognition results	cycles No need for highly trained data analysis experts
High target hit rates with low FARs	Provides for stand-alone ability for remote sensor platforms	Increases detection rates Reduces operator fatigue

Feature	Baseline Technology	Brainlike Technology
All-weather detection capability	No	Yes
Day-night detection capability	No	Yes
Automatic target recognition algorithms	No	Yes
Long range detection	No	Yes
Operator fatigue	Yes	No
Cue sensor for high-resolution electro-optic (EO) / infrared (IR) cameras	No	Yes
General, multi-sensor approach	No	Yes

**CURRENT STATE OF DEVELOPMENT**

Two key experiments as well as a significant amount of engineering have determined that it is feasible to detect and identify marine mammals using the Brainlike Processor™ running ATR algorithms with a commercial Furuno FR 8252 12" Color LCD Display radar with 25KW transceiver and 24" Dome waveguide antenna and a low-cost infrared / electro-optical camera installed on a Cessna Skymaster.

Marine mammals were detected with an APS-504(V)5 Airborne Radar System installed on a Super Beech King Air 200 in Canada's St. Lawrence Seaway and with a Furuno FR 8252 12" Color LCD Display with 25KW transceiver and 6' antenna on a fishing vessel off the coast of Santa Barbara, CA. Engineering studies have determined that this radar and an electro-optical / infrared camera will fit on a Cessna Skymaster. Implementing a marine mammal survey capability on a Cessna Skymaster will allow the Navy to keep flight hour cost under \$1,000 per flight hour, which is far less than any alternative. The current TRL for this hardware and Brainlike Processor™ software system is 4.

There are two further tests scheduled to assess technical feasibility and operational efficacy. The Hawaii cliff tests are scheduled for October 2009 through March 2010. These are further tests of the Furuno radar system, simulating an aerial platform. The test will be conducted from a stationary platform 1,000 ft. above the ocean. This test will be run concurrently with an investigation into the effectiveness of binocular use to detect and identify marine mammals. The two detection methods will be compared examining costs and efficiency. This will be a joint investigation involving PMA-264, the University of Hawaii, Scripps University and Brainlike, Inc. Seminal systems tests on a Cessna Skymaster are scheduled for early summer 2010.

## REFERENCES

Office of Naval Research, Group Head, 703-588-2427

Office of Naval Research, Program Officer, ONR 321, 703-696-4112

Technical Point of Contact, 301-342-2121

## ABOUT THE COMPANY

Brainlike, Inc. is a small high-technology company that delivers software-based smart sensing solutions. The company focuses on improving decisions and saving money by reducing real-time sensor data to valuable information. Brainlike sensing solutions reduce clutter by continuously and automatically adapting to changing conditions. Brainlike products and services include analysis tools and real-time monitoring products, analysis support, and real-time product integration. Since beginning research and development work for the United States Navy in 2005, the company has expanded its monitoring products and services for general purpose use.

Brainlike, Inc., with offices in Atlanta, GA and San Diego, CA, focuses on delivering auto-adaptive monitoring value for defense and homeland security applications and is a Veteran-Owned Small Business, registered as such on ProNet. Since the day it was founded in 2005, the company has been aggressively pursuing partnerships in the national defense and homeland security community. The company constantly interacts with defense industry leaders who deliver surveillance solutions and also is establishing partnerships with related government departments throughout the country, most notably ONR, NAVAIR, SPAWAR Headquarters, and SPAWAR Systems Center, San Diego. These connections are leveraged into partnerships that will allow fast and seamless development, delivery, and integration of Brainlike surveillance solutions.

Brainlike products and services are driven by a strong business case for reducing total operating costs. The company has developed and evaluated sophisticated cost analysis models for real-time surveillance systems. These cost models include parameters reflecting FARs and costs, missed incident detection rates and costs, product development costs, and a variety of delivery process risk factors. The models point clearly toward two key ingredients that Brainlike technology provides for reducing total operating costs: (1) the ability of Brainlike product managers to converge quickly on operator and commander situational awareness needs during product development, delivery, and deployment; and (2) the capacity of the Brainlike process to reduce clutter and improve operational awareness by adapting automatically to changing conditions.

The company management team has a successful track record for venture capitalization, commercial company incubation, and industrial market penetration. The established ties with defense procurement programs, most notably the Navy's SPAWAR and PEO for C4I & Space, will serve as a major catalyst for Brainlike product commercialization.