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**Environmentally Adaptive  
Sonar Technology (EAST) Project  
Report for Participation in the Littoral  
Warfare Advanced Development (LWAD)  
99-3 Experiment**

by

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The objective of the Environmentally Adaptive Sonar Technology (EAST) project is to develop approaches to improve shallow water target detection for Navy active sonar systems. The current investigation involves using a time reversed acoustic pulse (TRAP) as a method of real time correction of propagation dispersion of the energy in an active sonar transmit waveform. The approach of the EAST project is predominantly experimentally based in the Naval Postgraduate Schools Advanced Acoustic Research Laboratory (AARL) shallow water tank facility. Computer modeling is also used to extend the experimental results to more realistic environments.

The at sea experimental objectives of the EAST project in LWAD 99-3 were two fold:

- 1) Conduct a feasibility systems engineering test of a TRAP sonar system.
- 2) At sea demonstration of about a 3dB improvement in SNR using a basic TRAP sonar approach over standard match filter active sonar signal processing for a single element sonar system.

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## **1 Introduction**

The objective of the Environmentally Adaptive Sonar Technology (EAST) project is to develop approaches to improve shallow water target detection for Navy active sonar systems. The current investigations involves using a time reversed acoustic pulse (TRAP) as a method of real time correction of propagation dispersion of the energy in an active sonar transmit waveform. The approach of the EAST project is predominantly experimentally based in the Naval Postgraduate Schools Advanced Acoustic Research Laboratory (AARL) shallow water tank facility. Computer modeling is also used to extend the experimental results to more realistic environments.

The TRAP sonar approach is to use time reversal acoustic (TRA) methods to remove the environmental distortion of the target echo in shallow water environments. This is done in real time by construction of a time reversed acoustic pulse (TRAP) from the acoustic reception of a standard active pulse. The TRAP is then transmitted and produces an improved coherence and signal level of the target echo back at the receiver. The CONOPS for this LWAD sea test was a direct comparison of the TRAP echo detection to the standard active pulse detection.

## **2 Experimental Objectives**

The participation of the EAST project in LWAD 99-3 was an opportunity to conduct some early risk reduction at sea testing by leveraging experimental assets already in place for the test. The at sea experimental objectives of the EAST project were two fold:

- 1) Conduct a feasibility systems engineering test of a TRAP sonar system.
- 2) At sea demonstration of about a 3dB improvement in SNR using a basic TRAP sonar approach over standard match filter active sonar signal processing for a single element sonar system.

## **3 Experimental Approach**

The EAST project extensively leveraged equipment of the LWAD program and other participating projects to conduct the experiment. All wet end equipment was provided by several projects. The Forward Scatter Echo Detection (ForSED) and LWAD Backscatter Measurement System provided the source and the receiver. The source was a single low frequency XF-4 operated near the hydrophones resonance of about 400 hz. The 3 dB down bandwidth of the XF-4 was 400 hz. The single element receiver was one element of a multi-element, 37.5 foot vertical line array of model E100a Dual Sensitivity Hydrophones. The receive array was suspended directly below the XF-4 source element. This configuration resulted in a quasi bi-static omni directional source/receiver sonar system. The Multistatic ASW Capability Enhancement (MACE) project provided the source amplifier van capable of driving the XF-4 source at a maximum power of better than 200 dB at the thirty second ping rate required by the EAST project.

The experimental target geometry is shown in figure(1). The objective of the geometry was to provide beam aspect, low doppler target returns to the source/receive array. Starting at

minimum range the target then proceeded to open range following the ladder track on subsequent legs of the geometry. On subsequent runs of the geometry the range of the entire five leg sequence could be moved out as detection allowed. The initial CPA range was one nautical mile.

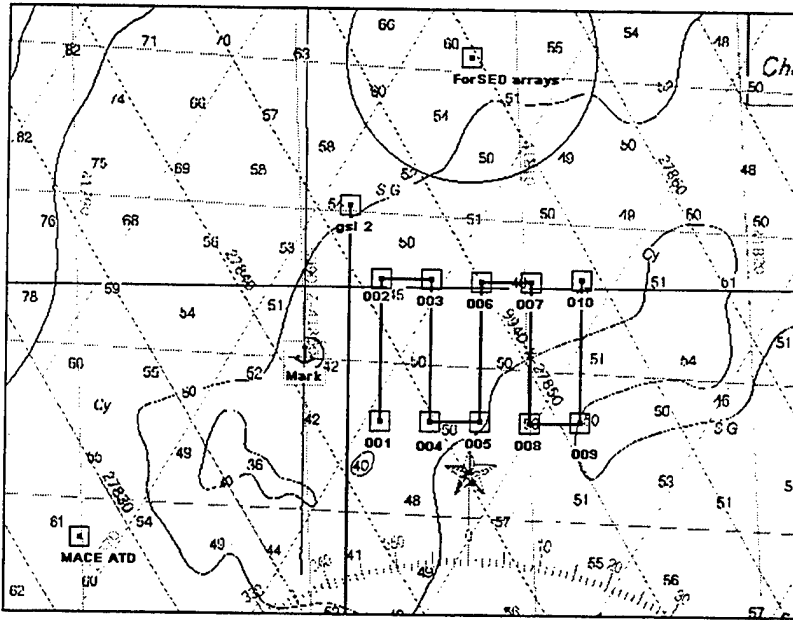


Figure (1): Experimental Geometry. Five leg ladder pattern in increasing range from the source/receive ship (designated by Mark)

The dry end for signal generation, processing and data storage was provided by the EAST project. The equipment consisted of a set of high data rate (5Mhz) digital to analogue / analogue to digital cards housed in a standard 233 Mhz Pentium II computer chassis. The interfacing software was all written in Matlab and provided the real time control and analysis capability for the TRAP sonar system.

#### 4 Test Results

The EAST project was originally scheduled to get a single five hour target data collection event. As the test evolved, two additional collection opportunities were made available to the EAST project. On each of these three events, numbered event 32, 33 and 33a, the target geometry in figure (1) was run. Sufficient time existed between the events to conduct a quick look analysis of the data and reconfigure the system before the next event. The availability of this extra time between events proved to be beneficial as early results indicated a severe platform noise problem existed. The time between events was well used in making sure all possible avenues to overcome the noise problem were explored.

Table (1) presents the ping log for the three events. Between the three events over 400 ping sets were transmitted. A ping set consisted of an initial ping and a second time reversed ping

constructed in real time from the reception from the initial ping. The system was able to sustain a ping set transmit rate of one ping set per minute.

As can be seen in table, different combinations of transmit frequency, pulse width, filter settings, and the like were tried. These variations were the result of attempting to overcome the noise problem initially encountered in the first event. While these variations were a good engineering test of the real time flexibility of the system, they were unsuccessful in overcoming the high ambient noise problem.

## **5 Summary**

The EAST projects first objective of a systems engineering test was fully met. With over 400 ping sets transmitted between the three events, with substantial variation of the system settings between and during events, the real time implementation of a time reversed based sonar system was demonstrated. The second objective of validating the laboratory tank tests results between a basic TRAP sonar approach and standard match filter active sonar signal processing was not met due to the high platform noise levels encountered. As with any sea test experience, however, many issues were brought to light that will have impact on the success of future tests of the system. As a highly equipment leveraged, risk reduction experiment, the EAST projects participation in LWAD 99-3 was highly successful.

## **6 Acknowledgements**

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## EAST TRAP Ping Log

	Number of Ping Sets	Transmit frequency (hz)	Pulse Width (ms)	Hanning Windowed (y/n)	Band Pass Filter (hz)	Number of Filter taps	Sample Depth	Recorded on Channel 1	Recorded on Channel 2
<b>Event 32</b>	13	400	12.5y		500-700	1500	150K	phone 16	tx1
	23	400	12.5y		500-700	1500	150K	phone 16	tx1
	2	400	12.5y		300-700	1500	150K	phone 16	tx1
	26	400	12.5y		300-700	1500	150K	phone 16	Unfiltered phone 15
	37	400	12.5y		300-700	1500	150K	phone 16	Unfiltered phone 15
	36	400	12.5y		300-700	1500	150K	phone 16	Unfiltered phone 15
	2	400	12.5n		300-700	1500	150K	phone 16	Unfiltered phone 15
	3	400	12.5n		300-700	1500	150K	phone 16	Unfiltered phone 15
	2	400	12.5n		300-700	1500	150K	phone 16	Unfiltered phone 15
	2	400	12.5y		300-700	1500	150K	phone 16	Unfiltered phone 15
	4	400	12.5y		300-700	1500	150K	phone 16	Unfiltered phone 15
	12	400	50y		300-700	1500	150K	phone 16	Unfiltered phone 15
5	400	50y		300-700	1500	150K	phone 16	Unfiltered phone 15	
<b>Event Total</b>	<b>167</b>								
<b>Event 33</b>	25	495	10.1y		350-750	1500	70K	phone 16	Unfiltered phone 14
	4	495	10.1y		490-500	1500	70K	phone 16	Unfiltered phone 14
	1	495	10.1y		445-545	1500	70K	phone 16	Unfiltered phone 14
	4	495	10.1y		445-545	1500	100K	phone 16	Unfiltered phone 14
	2	495	50.5y		445-545	1500	100K	phone 16	Unfiltered phone 14
	7	495	50.5y		445-545	1500	100K	phone 16	Unfiltered phone 14
	3	495	50.5y		445-545	1500	100K	phone 12	Unfiltered phone 13
	5	495	101.0y		490-500	500	110K	phone 12	Unfiltered phone 11
	28	495	10.1y		445-545	500	150K	phone 12	tx1
	14	495	10.1y		445-545	500	150K	phone 12	tx1
<b>Event Total</b>	<b>93</b>								
<b>Event 34</b>	61	495	10.1n		300-800	100	100K	phone 12	Unfiltered phone 11
	50	390	12.8n		200-800	100	100K	phone 12	Unfiltered phone 11
	46	390	12.8n		200-800	100	100K	phone 12	Unfiltered phone 11
<b>Event Total</b>	<b>157</b>								
<b>Total Ping Sets</b>	<b>417</b>								

Note: All data sampled at 10Khz

Table 1: Ping log of LWAD 99-3 EAST Events

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