Enhanced Bomb Effects for Obstacle Clearance

(Project Overview and Testing Task)

Donald E. Robeson
Coastal Systems Station, Dahlgren Division
Naval Surface Warfare Center
6703 West Highway 98
Panama City, FL 32407
phone: (850) 235-5536 fax: (850) 234-4141 e-mail: robesonde@ncsc.navy.mil
Award #: N0001498WX30031

John Allen
Coastal Systems Station, Dahlgren Division
phone: (850) 235-5688 e-mail: allenjb@ncsc.navy.mil

Timothy Hennessey
Indian Head Division, Naval Surface Warfare Center
phone: (301) 744-6783 fax: (301) 744-6719 e-mail: TimHennessey@uwdesign.ih.navy.mil

LONG-TERM GOALS

The Operational Requirements Document (ORD) for Shallow Water Mine Countermeasures (SWMCM) identifies the need for a system capable of simultaneously breaching obstacles and clearing mines, in-stride, from over the horizon, during an amphibious assault. Development of an improved capability and a quantification of available options for delivering explosives to the beach and surf zone to clear obstacles and mines are primary needs articulated in the Navy's MCM Campaign Plan.

A significant database of Mk 83 bombs tested against obstacles exists and was used as the starting point for this study. This database presently only includes single event detonations, and a clear need has been identified to develop cumulative damage rules for obstacles that are hit by multiple bombs at varying distances and configurations.

The goal of this project is to study, identify, and verify through analysis, testing, and simulation the damage mechanisms of obstacles (on land/in water) subjected to multiple bomb detonations. Multiple bomb detonations include sequential bomb detonations and simultaneous detonations of 1-D and 2-D arrays. This project will provide the acquisition community with the knowledge necessary to utilize the proper technology for development of and obstacle clearance system.

OBJECTIVES

Standard GP bombs represent an existing, rapidly deployable, building block for developing an effective system against obstacles. This project attempts to expand the existing knowledge base on the effectiveness of these weapons by meeting the following objectives:

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **1998**	2. REPORT TYPE	3. DATES COVERED **00-00-1998 to 00-00-1998**

4. TITLE AND SUBTITLE **Enhanced Bomb Effects for Obstacle Clearance (Project Overview and Testing Task)**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center,Coastal Systems Station Dahlgren Division,6703 W. Highway 98,Panama City,FL,32407**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM002252.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

- Demonstrate through testing, analysis and modeling the performance of sequentially and simultaneously detonating GP bombs against threat obstacles.
- Identify and quantify the kill mechanisms of GP bombs against the threat for both land and water, to allow a baseline for comparison of system concepts.
- Provide data so that the fidelity of empirical models can be enhanced, and more accurately represent explosive performance against obstacles in the near shore surf zone environment.
- Determine the validity or limitations of the pressure-impulse criteria for the obstacles, damage mechanisms, and environment.
- Determine effect of bomb verticality on obstacle destruction, primarily against land obstacles.
- Determine sensitivity of simultaneity, i.e., what are the time limits between successive bomb detonations necessary to treat the event as a distributed simultaneous event as opposed to a sequential event, and how does the performance change within the time limits.

APPROACH

This project is designed as a multi-year effort consisting of analysis and testing of bombs against obstacles on the beach and in the surf zone. The effort in FY98 focused primarily on bombs targeted against beach zone obstacles.

Analytical hydrocode models have been assembled to predict shock-loading levels for sequential and simultaneous detonations in air. These models are being compared to earlier testing done with the Mk 83 bombs. The predictions from these models will be used to plan tests using Mk 82 bombs later this summer. This work is being performed at NSWC-IHD. Details of this work are being reported in a separate task description (PI: Timothy Hennessey).

A test series using Mk 82's was performed on land. The tests are designed to validate specific questions and uncertainties arising from the analysis efforts, determine the potential impact of simultaneous detonations for decreasing ordnance requirements, and assessing clearance distances for sequential detonations on the beach and in water. Tests are being conducted at Eglin AFB with testing support provided by Eglin, Naval Surface warfare Center (NSWC)/Coastal Systems Station (CSS), and NSWC/Indian Head Division (IHD) personnel.

WORK COMPLETED

Simultaneous Detonation Test

This test consisted of a line of five Mk 82 munitions with a 32-foot separation between munitions. Identical obstacle arrays were placed around munitions A, B, C (see Figure 1). The arrays consisted of log posts, steel hedgehogs, steel tetrahedrons, and concrete cubes on concentric circles with radii of 8 feet (hedgehogs only), 13 feet, 18 feet, 23 feet, 28 feet, 33 feet (posts only), 38 feet (posts only), and 43 feet (posts only). This distance was the measurement to the center of the hedgehogs and log posts, and to the front of the cubes and tetrahedrons.

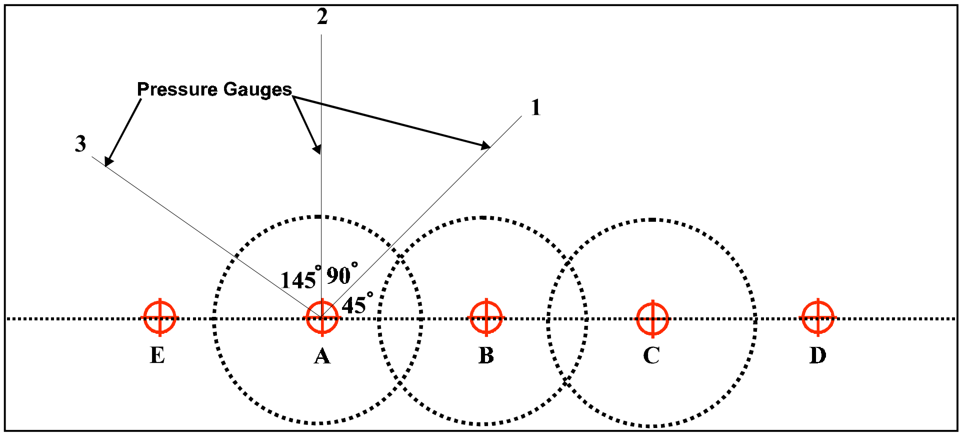

Figure 1. Simultaneous Detonation Test Layout

The Mk 82s were detonated simultaneously. Pressure time histories were recorded with pressure gauges at ground level (flush with ground) and at an elevation of four feet. The ground level gauges were placed along the lines 1, 2, and 3 that are shown in Figure 1. The in-air gauges were placed along line 2. After the detonation, overhead and ground level pictures were taken, the locations of surviving obstacles were surveyed, and the heights of the surviving obstacles recorded.

Single Mk 82 Tests

A series of six tests using individually detonated Mk 82s was conducted. Each test consisted of a single bomb placed in the center of an array of obstacles. The obstacles used were concrete cubes, steel tetrahedrons, and steel hedgehogs. Some of the obstacles used in the tests were damaged from previous Mk 82 tests. The damaged obstacles were used in the tests to collect data on cumulative damage effects for obstacles. Most of the preexisting damage to the obstacles was superficial, but a few of the damaged concrete cubes had significant fractures. After each detonation, ground level pictures were taken, the locations of surviving obstacles were surveyed, and the heights of the surviving obstacles recorded.

The test objectives were to obtain Mk 82 lethality data against the obstacles, develop an understanding of the failure mechanisms for the obstacles, and to assess the effects of cumulative damage for the obstacles. The data and knowledge acquired from the tests are to be used for model development and verification.

RESULTS

Simultaneous Detonation Test

The results of the simultaneous detonation were compared to the baseline case, which was conducted in FY97. The baseline case is an identical test setup with the exception that the Mk 82 bombs were detonated sequentially instead of simultaneously. After the bombs were detonated, the obstacles were subjectively scored for the baseline and simultaneous test as to their condition – minimal, moderate or severe damage. Minimal damage was defined as the obstacle having received superficial damage only, with little or no degradation to structural integrity. Moderate damage was defined as the obstacle having received structural damage and significant cosmetic damage. Severe damage was defined as the obstacle having received extensive structural damage that had significantly affected its structural integrity.

The comparison of the simultaneous detonation to the baseline case resulted in the conclusion that for the bomb separation used in the arrays, the overall results are identical. However, the condition of some of the individual obstacles did vary from their baseline counterparts. The preliminary analysis to date has identified some potential effects that occurred to the concrete cubes that were offset from the midpoint between the bombs E/A, A/B, and B/C. The cubes at these points exhibited slightly more damage than their counterparts in the baseline case. The phenomenon is of interest because the hydrocode model results show a slight increase in pressure along the midpoint. The results of the analysis are still inconclusive, but show some promise of agreement between tests and the models.

Single Mk 82 Tests

The Mk 82 neutralization radii are determined for the hedgehog, tetrahedron, and concrete cube. The radii determined from the tests are 30 to 60% below what is predicted through extrapolation from Mk 83 tests results against the obstacles. The hedgehog is particularly resistant to the blast effects due the plasticity of the steel legs when under a structural load. However, the hedgehogs were displaced a considerable distance (200 to 600 feet) from their original position, leading to the possibility of utilizing displacement as a method for removing the hedgehogs from a beach lane.

Valuable information was obtained on the failure mechanisms for the obstacles. Observations were made of the obstacles' final state, and the failure mechanism theorized. Modeling of the obstacle vulnerabilities will support or dismiss the hypotheses formed from the observations.

The hedgehogs are subject to bent and twisted legs with the number of perforations from fragment impacts increasing with a decrease of distance from the bomb. However, it is the plastic response of the legs to the structural loading that usually neutralizes the hedgehog by reducing the size of the hedgehog. This level of deformation though, requires close proximity to the Mk 82. Fragment damage to the hedgehog consisted of perforations and the occasional sheared off leg.

The concrete cube is susceptible to blast damage. Fragments do not have the energy required to impart significant damage to the cube. However, the fragments may assist the blast pressure/impulse in breaking up the cube. The cube and tetrahedron with preexisting damage showed an increased vulnerability to subsequent detonations. This infers that any fractures that the tetrahedron (welds) or concrete cube (structure) sustain from detonations, affects the structural integrity of the obstacle and increases the distance from the bomb at which it may be neutralized.

The tetrahedron is susceptible to the structural loading of the legs from the blast pressure/impulse. The structural loading caused failures at the welded joints. Fragment damage is similar to that seen on the hedgehogs, and may contribute slightly to the structural failure of the tetrahedron. The final condition of the tetrahedron welds were examined thoroughly to provide data in support of hydrocode modeling efforts of structural loading on tetrahedron legs. Figure 2 below shows the typical damage experienced by the tetrahedron obstacles.

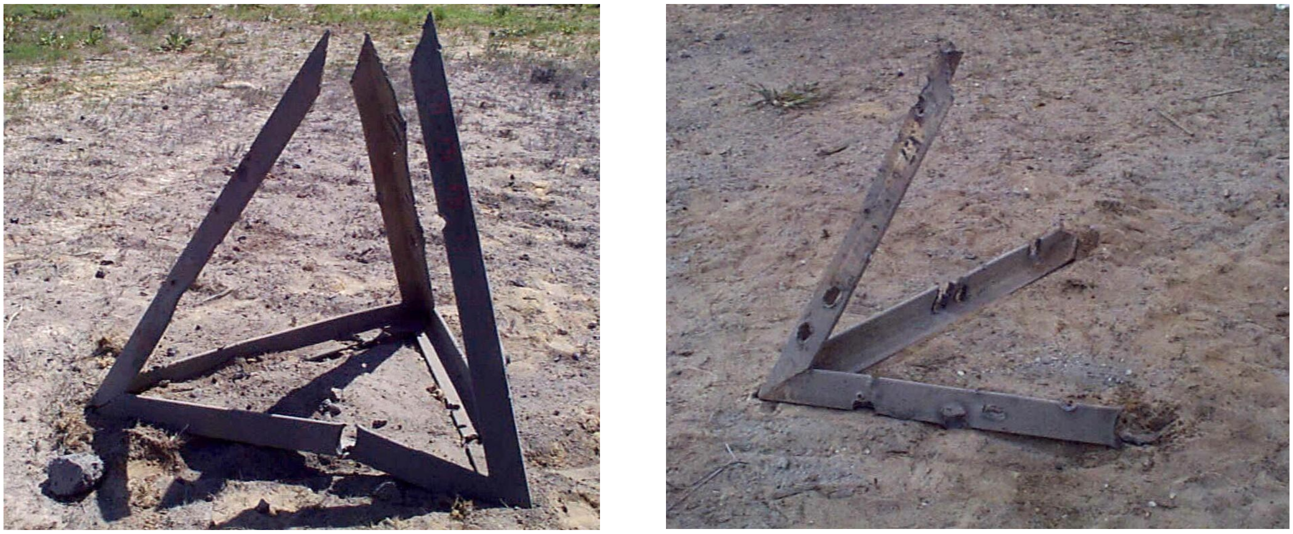

Figure 2. Tetrahedron: Typical Air-Blast and Fragment Damage

IMPACT/APPLICATIONS

This project will provide valuable insights into sequential and simultaneous bomb detonation effectiveness against obstacles through full scale point charge, 1-D, and 2-D array testing not previously conducted. Insights will be derived from the combined use of theoretical exploration, empirical testing and model simulations. Data obtained by this program will allow multiple detonation effects to be modeled as successive interdependent events.

TRANSITIONS

None this fiscal year. Program managers at PMO-407 and N852 support this effort and recognize that the output of this task can provide valuable input to the 6.4 program when it is restarted.

RELATED PROJECTS

This project exploits and builds on test data obtained from ongoing 6.4 and 6.5 mine and obstacle breaching programs; specifically Mk 83 tests from Obstacle Breaching Program, APOBS testing and SABRE testing.

Ongoing Mine Vulnerability and Sand Modeling efforts to understand the near shore regime and target vulnerability effects are related to this project. We are utilizing the insights that have been gained in these efforts, and use many of the tools and techniques developed by these efforts. The Standoff Delivery effort is helping define the limits of bomb verticality that are achievable and this will impact some of the planned testing and modeling efforts.