

# Overhead Liquid Dispersion System (OLDS) Non-Lethal Demonstration Program DAAE30-99-C-1072

# Final Report (CDRLs A003 and A006)

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#### 1.0 Introduction

United States military forces are increasingly finding themselves in peacekeeping and police operations where the use of lethal force must be avoided if possible. Currently, if US military forces find themselves facing an unarmed, but angry crowd, they have very few methods other than lethal forces to disperse the crowd at a sufficient distances to prevent potential to hazard to themselves from rocks, bottles, etc. The Overhead Liquid Dispersion System (OLDS) was conceived as a method to rapidly distribute non-lethal, crowd control liquids over crowds/groups of people. In operation, if an unruly crowd formed and it was determined that the crowd had to be dispersed, an OLDS system could be used to remotely disperse appropriate non-lethal, crowd control liquids over the crowd from distances greater than 350 feet. In other words, unruly crowds can be broken up at ranges where US military personal are not exposed to harm by the crowd. The dispersed liquid could be any one of a range of materials including malodorants, tear gas agents, marking agents, pepper sprays, etc. The choice of liquid to be dispersed over the crowd would depend upon a number of factors including military policy (i.e., allowable chemicals), desire to mark trouble makers for later action, crowd dispersal, etc.

The OLDS proof-of-concept program successfully demonstrated the safe dispersion of a liquid over an area sufficient to disable a large group of people. The OLDS demonstrated rapidly dispersing nearly 90 in<sup>3</sup> of liquid payload over a 40 foot diameter area (1300 ft<sup>2</sup>) at distances of more than 350 feet from where it was launched, while minimizing any hazards associated with debris size and shape. The technology developed during the OLDS program is easily scalable to provide dispersion at greater distances, smaller or larger liquid coverage diameters, or dispersion of materials with different physical properties (density, viscosity, surface tension, etc.). For the purpose of establishing a baseline design, a water-based non-lethal liquid was chosen. The OLDS technology can, however, be used to disperse any variety of non-lethal, powders, rubber pellets, encapsulated liquids or other non-lethal substances depending on the requirements of the specific application.



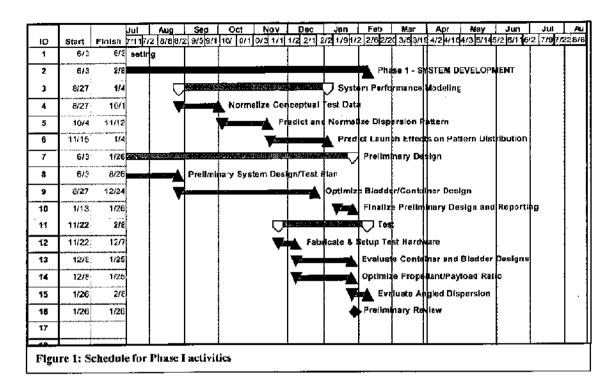
The OLDS consists of a launch system, adjustable time delay fuze, and dispersion system. The launch system provides the impetus to expel the dispersion system from the launch platform. The dispersion system disperses the non-lethal liquid over the target area and consists of a liquid container with an integral gas generator to disperse the liquid. The fuze controls the initiation of the launch and dispersion systems, and includes an electronic safe and arm and a time delay.

For the demonstration program, an existing tube-launcher platform (the M87 Volcano Tube Launcher) was used as a launch platform for the OLDS. An existing launch platform was used to reduce system development and demonstration costs. For a production system, OLDS variants could use a variety of launch platforms such as a 120 mm mortar or a grenade launcher. Using existing launch platforms significantly reduces the cost to the military to implement OLDS by reducing logistics footprints, and providing common tactics, training, and procedures with existing lethal weapons.

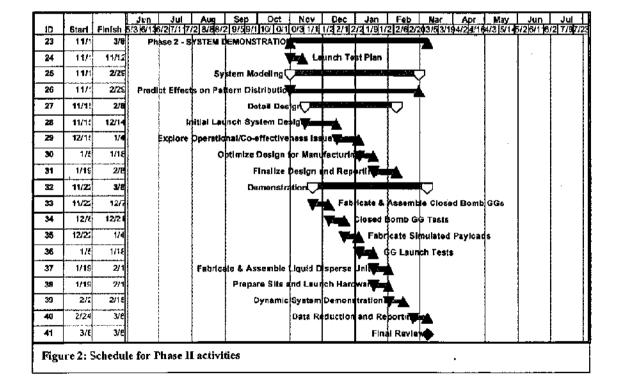
This final report summarizes the activities completed by PRIMEX Aerospace Company for the OLDS proof-of-concept program during the period between June 3, 1999 and March 31, 2000. The program was divided into two phases: Phase I — Dispersion System Development and Phase II — Launch System Development and System Demonstration. The objective of Phase I was to develop a dispersion system with the capability to safely disperse a liquid over a wide area. The objectives of Phase II were to develop the launch system and to evaluate the OLDS effectiveness in end-to-end tests at PAC's outdoor test range in Moses Lake, Washington.

In each phase of the OLDS program, development activities were initiated with preliminary analysis of the system. Initial designs of the launch and dispersion systems were based on this analysis and these designs were refined during development testing. The schedule for Phase I and Phase II activities are shown in Figures 1 and 2, respectively. The relationship between design, analysis and testing is described further in Sections 2 and 3 below and is expressed graphically with the flow charts in Section 3.











#### 2.0 Design Development

#### 2.1 Overview

The OLDS consists of three subsystems: the dispersion system, fuze and launch system. Design iterations were made to each of these subsystems in development tests at the subsystem and system level. The design objectives for this program phase were:

- Dispersion of a non-lethal liquid at short, medium and long ranges (up to 500 feet)
- Maximum dispersion pattern area with the optimal liquid droplet size
- Minimal debris size and mass

Dispersion system design and fuze procurement were completed during Phase I of the OLDS program, while the launch system design was completed during Phase II.

#### 2.2 Dispersion System

The dispersion system disperses the non-lethal liquid over the target area. It consists of a container (Figure 3) that houses the non-lethal liquid and the dispersion gas generator. The liquid container (payload canister) is optimized to fragment uniformly to ensure an even dispersion. Fragment size is minimized to reduce the hazard to the target. The dispersion gas generator pressurizes the liquid, causing the payload canister to burst and disperse the liquid. The pressurization rate is optimized to disperse the liquid over a large area in sufficiently sized droplets.

PAC demonstrated in system tests the capability to disperse liquid across a range of droplet sizes, from <sup>1</sup>/<sub>2</sub> inch diameter down to vapor (droplet size was determined by measuring the diameter of a dyed liquid droplet after it contacted witness paper). With the capability to create droplets of different sizes, PAC can adjust the liquid dispersion characteristics (droplet size, throw distance, etc.) for liquids of different properties (viscosity, density, etc.) for different applications.

Figure 3: Payload canister



The demonstration test payload canister developed and demonstrated during this phase of the program is shown in Figure 3. The design drawings are shown in Appendix 1. The payload canister is 4.9 inches in diameter and 6.0 inches long with an internal volume of nearly 90 in<sup>3</sup>. The exterior of the canister is scored with longitudinal and circumferential lines. The purpose of the score lines is to control the size and shape of any canister fragments produced during liquid dispersion. Controlling the canister fragment size and shape is necessary to prevent the canister fragments from becoming hazardous.

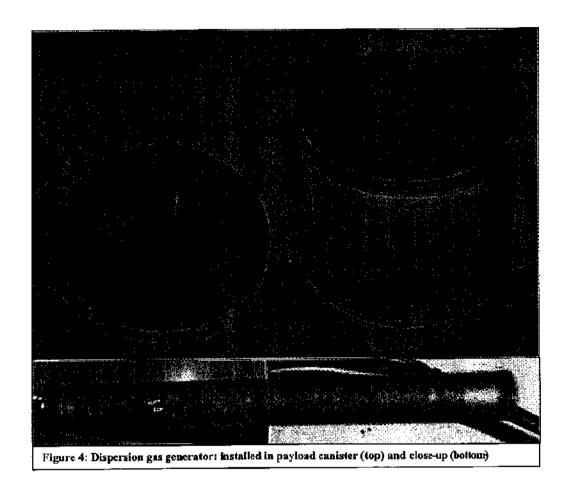
Material selection was critical for the design of the payload canister. Several materials were tested in initial development tests with unsatisfactory results. Polyethylene, Ultem 1000 (polyetherimide), polycarbonate and polysulfone all proved to be too notch insensitive - tough and ductile - for use in the payload canister. During system testing, payload canisters made from these materials did not fragment into small pieces. Polyvinyl chloride (PVC) proved to be a better choice due to its relatively higher notch impact sensitivity.

To promote uniform fracture and minimize debris size, the exterior of the canister was scored as shown in Figures 3 and 4. Uniform fracture is critical to ensure an even dispersion pattern. The scoring was optimized during development testing to determine the depth and number of scoring lines required for good fragmentation. The scoring depth differs between the hoop (circumferential) and longitudinal directions to account for the differences in stress in each direction.

Structural analysis revealed that fragmentation of the curved ends of the canister could be improved by scoring the interior of the canister at this location; this feature will be incorporated into future designs.

The dispersion gas generator is located in the center of the payload canister and is supported at both ends to withstand transportation and launch forces. It is supported by threaded interface with the payload canister at one end and a slip ring at the other end. The gas generator is composed of a housing made from Ultern 1000 (polyetherimide). The gas generator propellant





load and configuration was optimized based upon computer modeling and development testing. The final design is shown in Figure 4 and in Appendix A.

The final dispersion gas generator configuration consists of:

- Housing and end plugs constructed from Ultern 1000 (polyetherimide)
- 5.0 g WC818 smokeless powder propellant
- (4) Ø 0.25 in BKNO<sub>3</sub> tablets to improve ignition transfer
- 5.0 inches, 7.5 grain/ft, Rapid Deflagrating Cord (RDC) for ignition transfer



#### 2.3 Fuze

The fuze receives the "Fire" command from the user and initiates the launch system and the dispersion system. The time delay between the launch system initiation and the dispersion system initiation will be user selectable to adjust for targets at different ranges.

A commercial, off-the-shelf, electronic safe and ann with a built-in time delay and two fire signal outputs was procured for use as the fuze in the OLDS; the MagicFire Igniter is shown in

Figure 5. After receiving the "Fire" command, the MagicFire Igniter sends fire signals to the electric matches used to initiate the launch and dispersion system gas generators. The electronic circuitry of the MagicFire Igniter provides a time delay between the two fire signals that initiate the gas generators. Since this time delay controls the time between the initiation of the launch gas generator and the dispersion gas generator, it also controls the distance from the launch site to the location at which the dispersion occurs (distance-to-dispersion). For purposes of OLDS demonstration tests, the duration of the fuze time delay was pre-set for each test during assembly. This type of

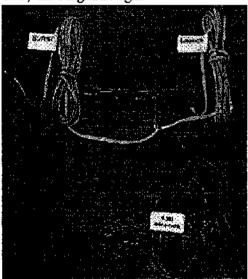


Figure 5: MagicFire Igniter used as a fuze in development tests

fuze is field adjustable. The final product will be user-selectable or adjustable so that the user can "dial-in" the time (which corresponds to a specific distance) that dispersion occurs.

#### 2,4 Launch System

The launch system expels the dispersion system from the launch platform. It consists of the launch platform and the launch system gas generator. For this effort, the M87 Volcano Tube Launcher was utilized as a launch platform. The launch gas generator provides the impetus to propel the payload canister from the tube launcher. The gas generator is optimized to minimize the peak acceleration of the payload canister and ensure structural integrity, while still achieving



adequate launch velocity. To ensure the integrity of the payload it was decided that the peak accelerations should be less than 250 G's.

The use of the M87 Volcano Tube I anneher as a launch platform meant that the payload canister would have a 19.50 inch stroke and that the pressure inside the launcher should be less than 100 psi. PAC chose to fix the elevation of the Volcano tube launcher at 45° to simplify operation for the user. Initial predictions showed that with an elevation of 45°, a launch velocity of 125 ft/s was needed to achieve a range of 500 feet.

In this phase of the program, a discarding payload shuttle was used to seal the Volcano tube launcher and prevent blow-by of gases past the payload canister during launch. In the next phase, this seal will be integrated into the payload canister, reducing part count and minimizing debris hazard.

The launch system gas generator was adapted to the existing firing chamber in the Volcano Tube Launcher. Gas generator-analysis software developed by PAC was used to make preliminary determinations of propellant type, shape and weight and onifice sizing given the internal dimensions of the firing chamber. During development testing further refinements were made to the propellant load and orifice sizing.

The final launch system gas generator configuration consists of:

- Orifice Plug with ten Ø 0.040 orifices
- Closure with O-ring seal and fuze initiator pass-thru
- 15 grains HPC-91 double-base propellant perforated grain size of Ø.25 X .25 in provides progressive, controlled burn for consistent performance
- 0.1 g WC231 smokeless powder to improve ignition transfer
- (2) Ø 0.25 in BKNO<sub>3</sub> tablets to improve ignition transfer



#### 3.0 Development Testing

#### 3.1 Overview

The OLDS design was developed through testing at the subsystem and system levels. The OLDS design was developed, iterated and demonstrated in four test series:

- · Dispersion gas generator testing
- Dispersion system testing
- Launch system testing
- OLDS demonstration and evaluation testing

Dispersion gas generator testing and dispersion system testing were performed during Phase I of the OLDS program, while launch system testing and the OLDS demonstration were performed during Phase II.

Testing provided essential data needed to understand system performance and make design changes. Data gathered during testing included:

Liquid droplet size

- Payload canister fragment shape and size
- Dispersion pattern size and shape
- Payload canister acceleration and velocity

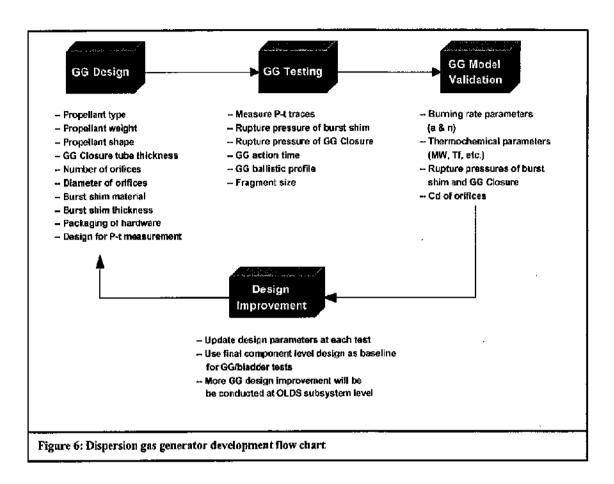
Volcano tube pressure

System performance models were correlated to actual test data, resulting in a better understanding of the interactions between critical system parameters. With this information, deliberate design changes were made. The relationship between design, analysis and testing is expressed graphically in the flow charts for each test series shown below.

#### 3.2 Dispersion Gas Generator Testing

The objective of the dispersion gas generator development tests was to optimize the performance (pressure-time output) of the dispersion gas generator. The flow chart for dispersion gas generator development is shown in Figure 6.





The dispersion gas generator was developed using a variant of closed-bomb testing. In traditional closed-bomb testing a gas generator is fired into a fixed-volume test tank. Pressure-time measurements of tank pressure and internal gas generator pressure are made and critical parameters (propellant type and weight, orifice diameter and number, etc.) are adjusted until the desired performance is obtained.

In testing of the OLDS dispersion gas generator, burst disks were added to the test tank and the tank was filled with water. The burst disks were sized to break at the predicted burst pressure of the payload canister. Thus, when the gas generator fires, the water inside the tank is pressurized until the burst pressure of the disks is reached; at which point the water is expelled from the tank. In this manner, the bursting of the payload canister can be simulated without the extra cost and complexity of using a real payload canister. Figure 7 shows the closed-bomb test tank.



Nine closed-bomb tests were performed during development of the dispersion gas generator.

The initial design used a polyethylene housing surrounding 1.2 grams of WC818 smokeless

powder. Due to localized and non-uniform bursting of the polyethylene housing, the propellant was not completely burned during the event. The gas generator housing was bursting before sufficient pressure could be maintained to ensure complete propellant burn. For some testing, a latex rubber bladder was added to surround the polyethylene housing to reduce the effect of the localized bursting of the housing. Results from



Figure 7: Closed-bomb test tank

this configuration were not successful, as the latex rubber also burst non-uniformly. The housing material was changed to Ultern 1000 (polyetherimide) and the latex rubber bladder was eliminated, with much-improved results. Ultern 1000's brittleness eliminated the localized bursting problem and its higher burst pressure resulted in a more complete propellant burn.

#### 3.3 Dispersion System Testing

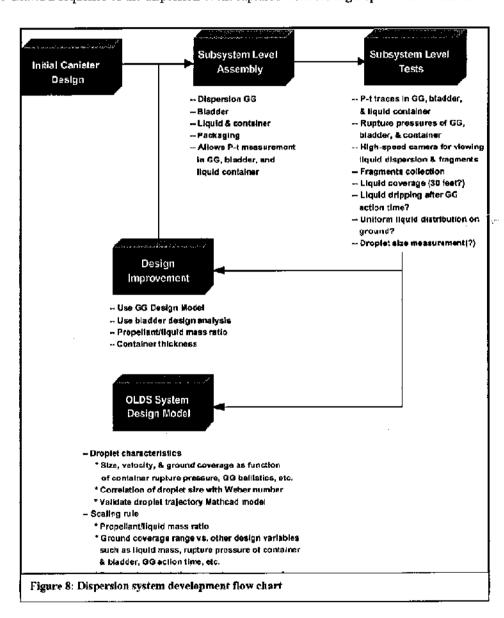
The objective of dispersion system testing was to optimize the performance of the payload canister to safely disperse liquid, while refining the dispersion gas generator for use at a system level. Critical parameters for optimization included dispersion pattern size and shape, droplet size and fragment size and shape. These parameters are closely and complexly interrelated by:

- Payload canister burst pressure
- Payload canister fracture homogeneity
- Internal pressurization rate

The flow chart for the dispersion system development is shown in Figure 8.

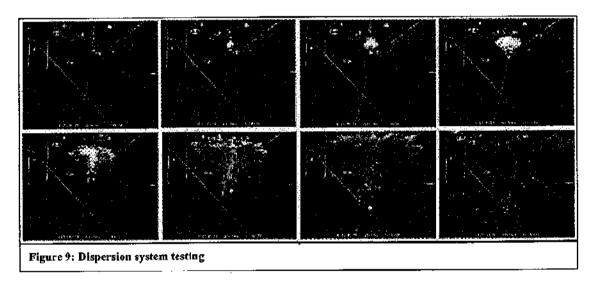


Nine dispersion system tests were performed in PAC's indoor test arena. The indoor test arena is located at PAC's Redmond, Washington facility. It consists of a 70' by 70' space with lighting, camera and instrumentation capability to support a variety of dispensing and dispersing tests. The dispersion system was hung approximately fifteen feet above the floor. The payload canister was instrumented to measure internal (liquid) pressure and a high-speed video camera with 1,000 pictures/second capability was used to capture the dynamics of the liquid dispersion. Figure 9 shows a sequence of the dispersion event captured from the high-speed video camera.





The first test was performed using a three-piece payload canister fabricated from polyethylene. In this test, the joints between the canister and the end caps failed, resulting in the liquid being dispersed from the top and bottom of the canister. A revised end cap design was created, but Polyethylene was abandoned as the canister material due to difficulties in manufacturing and non-optimal structural characteristics. Polycarbonate, polysulfone and Ultem 1000 (polyetherimide) were each tried for use in the payload canister. Payloads fabricated from each of these materials performed significantly better than polyethylene; the canisters fractured and liquid was dispersed. However, the fragment size was too large and the fragments did not fracture uniformly nor along the intended lines of fracture.



The design of the payload canister was revised to employ polyvinyl chloride (PVC). To enhance break-up at the ends of the container, the end caps were curved and the joint between the end caps and tube was moved; Appendix A shows a cross-section of the payload canister detailing the joint location and end cap curvature. Testing showed that the break-up of the canister was improved – fragments were reasonably sized and uniform – and liquid was dispersed evenly.

The resulting liquid dispersion pattern is circular in shape with a diameter of about 40 feet. The size of the liquid droplets range from  $^{1}/_{3}$  to  $^{1}/_{2}$  inch in diameter (droplet size is determined by measuring diameter of droplet after it contacts witness paper). The largest fragments were from



the ends of the canister, whose fragmentation can be optimized, as discussed earlier. Typical fragments were  $1-2 \text{ in}^2$  and smaller.

During dispersion system testing PAC was able to demonstrate the capability to produce liquid droplets ranging in size from  $^{1}/_{2}$  inch diameter to vapor. With the capability to create droplets of different sizes, PAC can adjust the dispersion for liquids of different properties (viscosity, density, etc.) or different applications. Pepper spray, tear gas, malodorants, or visible, ultraviolet or infrared tracers are all viable payloads depending on the mission. The actual payload is to be determined and political/treaty considerations will affect the range of possible options.

#### 3.4 Launch System Testing

The objective of launch system testing was to develop a launch system capable of launching the dispersion system from the M87 Volcano Tube Launcher at a velocity of 125 ft/s. Preliminary analysis showed that a velocity of 125 ft/s is required to meet the flight distance goal of 500 feet given a launch elevation of 45°.

Testing was performed in PAC's indoor test arena. The Volcano Tube Launcher was mounted

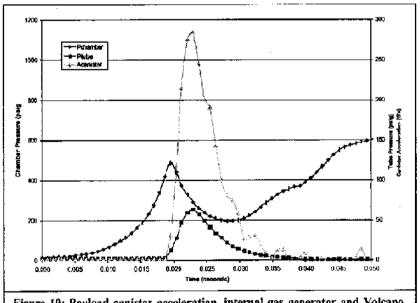


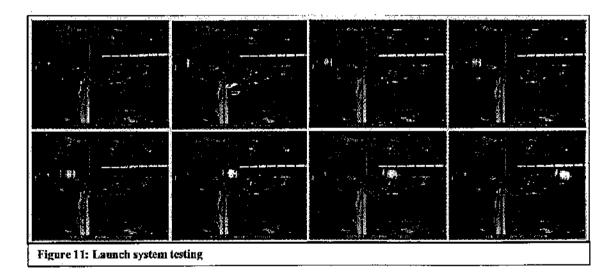
Figure 10: Payload canister acceleration, internal gas generator and Volcano tube pressure-time histories from launch system development testing



horizontally to a wall at a height of about 13 feet above the floor of the test arena. A catch net and large catch pillows were placed at the other end of the arena (about 60 feet) to capture the liquid-filled durnmy payload canister at the end of its flight. A high-speed video camera shooting at 1,000 pictures/second was used to determine payload velocity at muzzle exit. Payload accelerations were measured and volcano tube and internal gas generator pressure was recorded. A sample of this data is shown in Figure 10.

Six tests were performed to optimize the launch system. Refinements were made to the gas generator with changes in propellant type and weight, as well as the exhaust orifice diameter.

Later system level testing revealed that the launch system repeatedly expelled the payload at a velocity of 126 ft/s. A photo sequence of payload launch is shown in Figure 11.



#### 3.5 OLDS Demonstration and Evaluation

The objective of the OLDS demonstration and evaluation was to show the end-to-end function of the launch and dispersion systems at PAC's outdoor test range at short, medium and long distances. Additional objectives included documenting the OLDS with video coverage and evaluating dispersion patterns at each distance.

Testing was performed at the PRIMEX facility in Moses Lake, Washington. The payload



canisters were painted bright orange on the exterior and filled with green dye for better visibility. Payload canister velocity at muzzle exit was measured using a high-speed VHS video camera with 400 pictures/second capability. Launch and dispersion dynamics were captured with the following camera coverage:

- (2) VHS video cameras
- (1) Digital video camera
- (1) SLR camera
- (1) High-speed digital video camera (1,000 pictures/second)
- (1) High-speed VHS video camera (400 pictures/second)

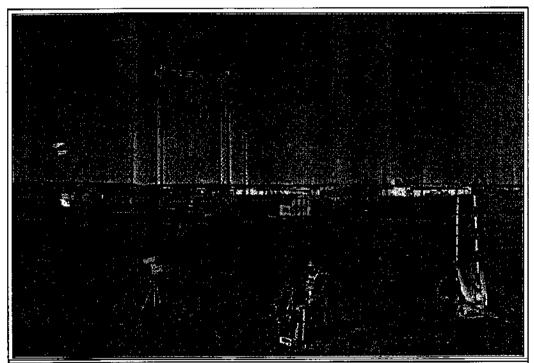


Figure 12: OLDS Demonstration and Evaluation Test set-up at PAC Test Facility in Moses Lake, Washington

The launch velocity was held fixed at 125 ft/s and the Volcano Tube Launcher was maintained at a fixed elevation of 45°, so the payload canister followed a fixed trajectory. The distance-to-dispersion was adjusted for the short, medium and long distances by varying the time delay between the initiation of the launch and dispersion systems. Since the payload canister trajectory



was fixed, the burst height varied with dispersion distance. A picture of the test set-up and test facility is shown in Figure 12.

Table 1: Test results from OLDS demonstration and evaluation											
		Delay	Payload	Muzzle	Dispersion	Dispersion Pattern					
	Range	Time	Weight	Velocity	Elevation	Center	Length	Width			
#	(ft)	(sec)	(lb)	(ft/s)	(ft)	(ft)	(ft)	(ft)			
26	250	3.1	3.97	126	~100	217	45	~40			
2C	250	3.1	3.96	126	~100	266	51	43			
ЗА	200	2.6	3.96	126	~110	175	~40	<b>~4</b> 0			
4A	350	4.9	3.95	126	~30	349	41	19			
4B)	350	4.9	3.99	126	~30	355	29	27			

Five tests were performed with nominal, downrange dispersion distances of 200 feet (one test), 250 feet (two tests) and 350 feet (two tests). Data acquired during testing is tabulated in Table 1. A photo sequence showing the function of the dispersion system at 350 feet (test 4B) is shown in

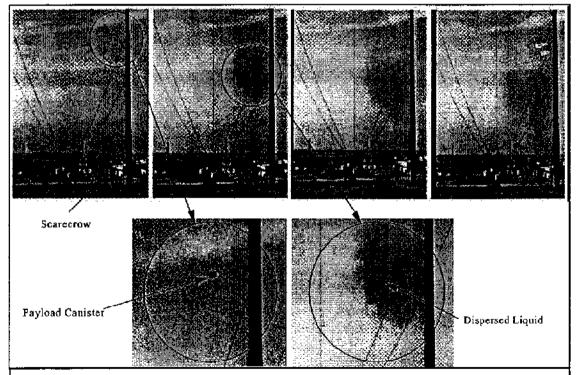


Figure 13: Photo sequence of dispersion system functioning in test 4B (350 ft downrange, 30 ft dispersion elevation). Orange payload canister can be seen in flight in left photo and close-up. Remaining photos show dispersion of liquid payload (green-dyed water). Note: The large poles in the photos are not part of this test.



Figure 13. In test 4B, the dispersion system functioned at a height of 20 - 30 feet and heavily coated an area about 30 feet in diameter with liquid.

The flight of the payload canister mimics that of a punted football; the canister tumbles endover-end while rotating about its long axis. Because of this tumbling action the payload experienced greater than expected drag and as a result flight distances were shorter than expected. A simple change to the launch system to increase the muzzle velocity to 150 ft/s would increase the flight distance to 500 feet.

The dispersion pattern size and shape varied according to burst height and correspondingly, the distance-to-dispersion. At the shorter dispersion distances, the payload canister is much higher when dispersion occurs and consequently liquid is dispersed over a wider area with less density than at longer dispersion distances. Fragments of the payload canister were similar in size and

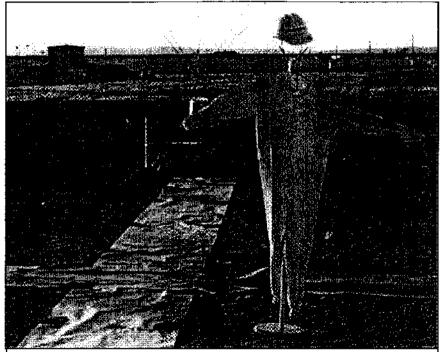


Figure 14: "Scarecrow" used in Test 4B. Green-dyed water heavily coats the scarecrows' hat, shoulders and arms, indicating effective liquid coverage at the target.



shape to those observed in dispersion system testing. These fragments were spread over a wider area than the droplets.

A "scarecrow" consisting of a hard hat and white overalls was set up at a distance of 350 feet from the launch site for the second test at the 350-foot range. The intent of using the scarecrow was to provide an added indication of liquid dispersion over a "real" target. A post-test photograph of the scarecrow is shown in Figures 14 and 15. The scarecrow was heavily coated with green-dyed water over its hat, shoulders and arms indicating very effective liquid coverage in the zone of the target. Figure 15 shows a close up of the hard hat and overalls.

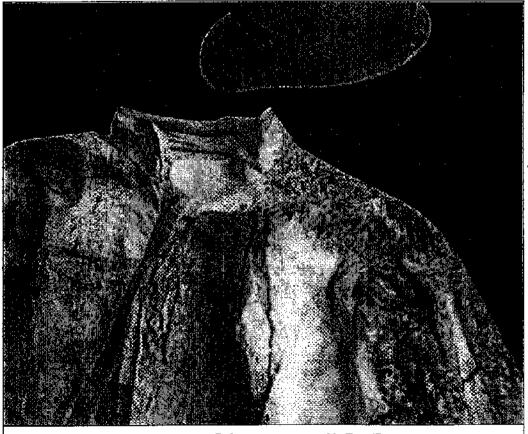


Figure 15: Close-up of hardhat and overalls from scarecrow used in Test 4B.



#### 3.6 Conclusions

During development testing the OLDS launch and dispersion systems were developed, demonstrated and evaluated. It was shown that the OLDS is capable of dispersing nearly 90 in<sup>3</sup> of liquid over a 40 foot diameter area, while minimizing debris size and mass. Further, PAC has developed the capability to create droplets of different sizes, allowing adjustments to the system to account for dispersion of liquids of different properties (viscosity, density, etc.) or different applications. The launch system was demonstrated to have consistent and reliable launch velocities. System testing demonstrated the end-to-end function of the OLDS and its capability to safely disperse liquid at short (200 feet), medium (250 feet) and long (350 feet) ranges.



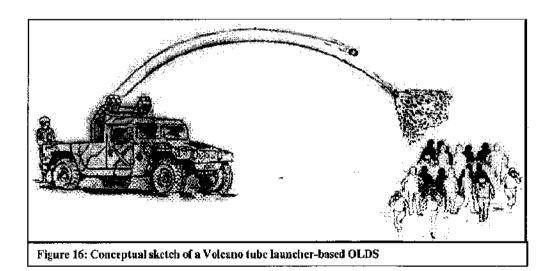
#### 4.0 Alternative Applications

While the M87 Volcano Tube Launcher was selected as the launch platform for the initial phase of the OLDS program, the technology developed during this program is applicable to a wide range of other deployment platforms and methods. Applications for OLDS typically fall into two categories:

- Crowd Control scatter or incapacitate a crowd from a distance without causing permanent injury to crowd members
- Area Denial prevent an intruder from entering a secure area without permanent injury to the intruder

#### 4.1 Crowd Control

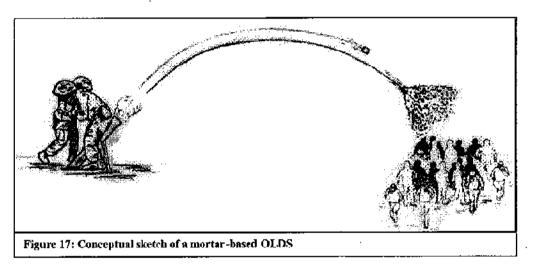
The OLDS developed during this contract was designed for use in crowd control. The utilization of the existing Volcano Tube Launcher platform means that OLDS can be deployed from either a helicopter or ground-based equipment. Placing OLDS on a vehicle (Figure 16) keeps the operator protected and a safe distance away from the crowd while keeping him highly mobile and providing the capability to step-up to the next level of force.



As an alternative, the current OLDS technology could be introduced into such platforms as the 120mm mortar (Figure 17) or a grenade launcher such as the M203A. These platforms have the



benefit of man-portability and wide use and availability. The greater mobility of a man-portable device allows the operator to maneuver into a position where a vehicle-based could not, such as through a street strewn with debris. A mortar or grenade launcher-based OLDS would have a reusable launch platform, reducing system cost. The OLDS could be self-contained (launch system, dispersion system and fuze built together into a single unit), permitting a "drop and fire" launch like a conventional mortar. The operator would set the distance-to-dispersion via a rheostat-type control, drop the OLDS into the launcher and the launch system would initiate when the device hits the bottom of the tube.



During this contract, PAC performed eleven launch system development tests in support of a mortar-based launcher concept. The intent of this effort was to develop a launch system gas generator that could be integrated into the payload canister, making the OLDS a single, self-contained unit. The launch system gas generator used a housing fabricated from PVC tubing to reduce the size and mass of fragments (the gas generator was designed to fragment following function). This side-effort was stopped once launch velocities reached 100 ft/s and it was demonstrated that a single, self-contained device for use in a mortar-based OLDS is feasible. The self-contained OLDS concept could also be applied to the Volcano Tube Launcher approach as well, making the Volcano tube a reusable launcher and reducing the overall system costs.



#### 4.2 Non-Lethal Area Denial

OLDS could be used in a mine-based application as a means of safely preventing intruders from entering a secure area. A hand-emplaced mine could be developed based on the existing payload canister. The launch system would be refined to offer dispersion at an optimal altitude for maximum area coverage for a non-lethal payload. Development testing of the current OLDS concept has demonstrated that at a dispersion height of only fifteen feet, a water-based liquid dispersion pattern of 40 feet in diameter is possible. Active or passive trip devices could be employed to actuate the OLDS-mine. Figure 18 shows an area denial, mine-based OLDS system.

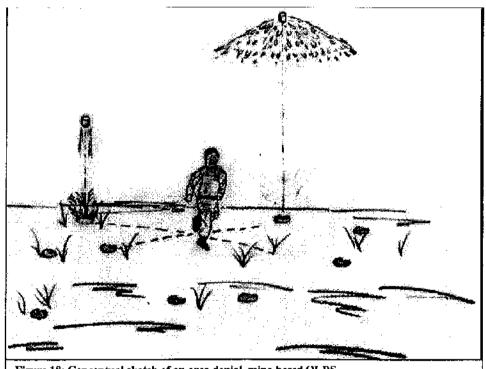
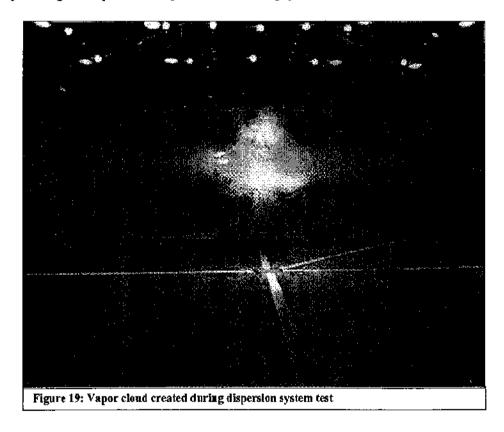


Figure 18: Conceptual sketch of an area denial, mine-based OLDS



#### 5.0 Non-Lethal Payload Considerations

The OLDS was developed with the intent of carrying pepper spray (Oleoresin Capsicum or OC) as the non-lethal agent. Pepper spray is capable of quickly incapacitating an aggressor by causing severe irritation and discomfort in the eyes and throat. Severe pain causes shortness of breath and involuntary closing of the eyelids. These effects can last from 20 to 40 minutes. It is currently in wide use by the FBI, police agencies and swat teams. With pepper spray as the non-lethal liquid, OLDS would be very effective at disabling a large group of people. However, current US military policy restricts the use of pepper spray to one-on-one engagements. PAC is actively seeking user input on other possible non-lethal payloads.



The technology developed by PAC during this phase of OLDS can be used to disperse any variety of non-lethal liquids, powders, rubber pellets, encapsulated liquids or other non-lethal substances. PAC has demonstrated the capability of producing liquid droplets ranging in size from 1/2 inch diameter to vapor. Figure 19 shows a dispersion system development test



performed at PAC where a vapor cloud was created. This vapor cloud lingered in the air until the atomized liquid evaporated. A vapor cloud might be useful for dispersing some non-lethal agents (tear gas, for example). Or, this type of dispersion might be useful in a less-than-lethal application using a fuel-air explosive mixture.

With the capability to create droplets of different sizes, PAC can adjust the dispersion for liquids of different properties (viscosity, density, etc.) or different applications. Tear gas, malodorants, or visible, ultraviolet or infrared tracers are all viable payloads depending on the mission. An integral flash-bang could be incorporated as an additional distraction.



#### 6.0 Recommendations

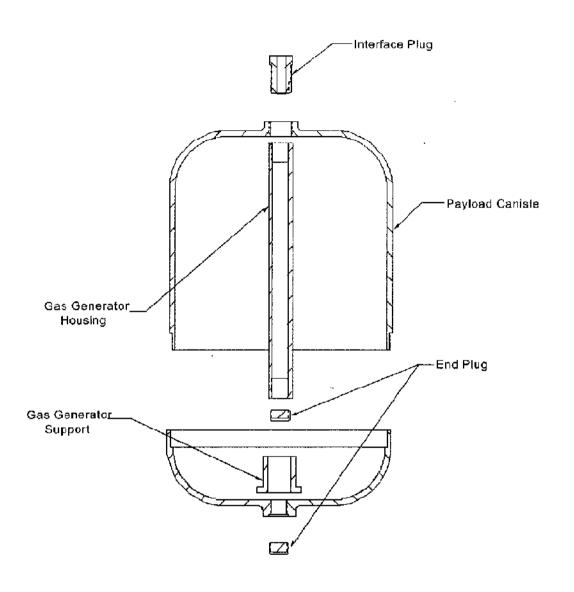
PRIMEX Aerospace Company recommends that the next phase of the OLDS program pursue the following activities:

- <u>Development of a self-contained OLDS</u> Integration of the launch and dispersion systems into a single, self-contained unit will reduce part count and overall system complexity, thereby reducing system cost. Further, a self-contained OLDS can utilize a wide variety of launch platforms.
- <u>Development of a operator-selectable firze</u> A firze with the capability for the operator to select the time delay between the initiation of the launch and dispersion systems (which determines the distance-to-dispersion) will provide greater system capability. It is proposed that the fuze be calibrated in distance so that the operator can set the distance-to-dispersion and fire the OLDS without having to reference a look-up table.
- Payload canister optimization The ends of the payload canister can be optimized for fragmentation by scoring the interior of the canister. Further refinement of the payload canister design for fragmentation will result in reduced fragment size and mass while providing better liquid dispersion. In addition, the payload canister should incorporate an o-ring or other feature to seal the launch tube from gas blow-by during launch. Non-fragmenting canister materials such as cardboard could be included as possible canister materials.
- Range requirements Determining the requirement for maximum distance-to-dispersion
  is necessary for launch system optimization. The launch technology developed during
  the proof-of-concept program can be scaled to longer distances-to-dispersion, if needed.
- Non-lethal substance selection Determining the non-lethal substance or substances to
  pursue for use in the OLDS is critical for dispersion system optimization. The dispersion
  technology developed during this phase of the OLDS program can be scaled to liquids
  with different properties or substances such as powders, rubber pellets or encapsulated
  liquids.



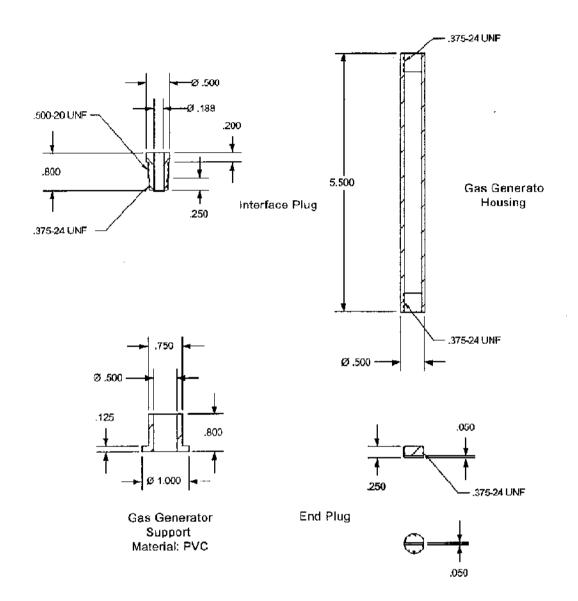
Appendix A: OLDS Conceptual Design Drawings





Overhead Liquid Dispersion System (OLDS) Dispersion System Assembly

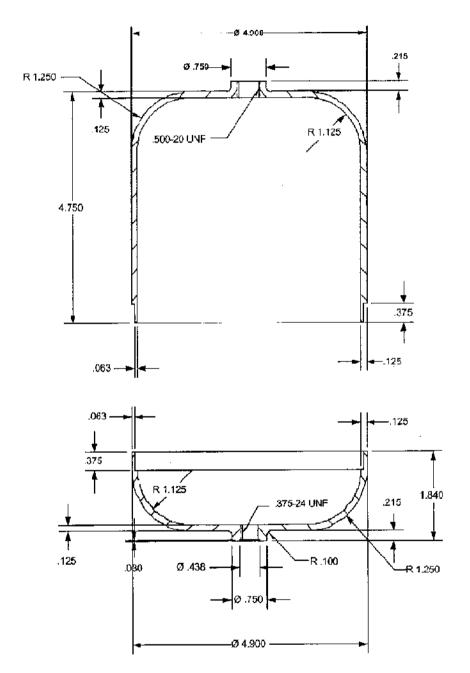




Overhead Liquid Dispersion System (OLDS)
Dispersion Gas Generator

Material: Ultern 1000





Overhead Liquid Dispersion System (OLDS) Payload Canister Material: PVC

Grooving:

Circumferential -0.50 in spacing, .070 in deep Longitudinal - 12° spacing, .015 in deep Do Not Groove thru Joints