

# ARCHIVED REPORT

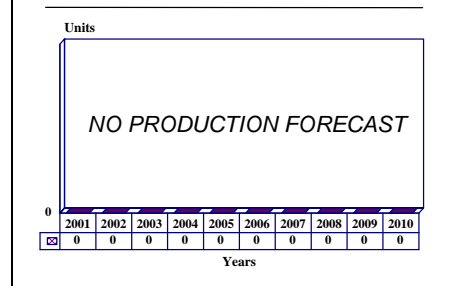
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## M898 Sense and Destroy Armor Projectile – Archived 10/2002

### Outlook

- Funding for program terminated by Congress, but some caveats are in order
- Product improvements still under development by contractor
- Technical shortcomings of munition should preclude any restart of program
- While still being promoted on the export market, no sales are forecast

10 Year Unit Production Forecast  
 2001 - 2010



### Orientation

**Description.** A carrier projectile dispensing anti-tank submunitions.

**Sponsor.** The development of the Sense and Destroy Armor submunition has been sponsored by the United States Department of Defense through the Defense Advanced Research Projects Agency and the United States Army Armament, Munitions and Chemical Command, Picatinny Arsenal, Dover, New Jersey.

**Contractors.** The Sense and Destroy Armor submunition was being competitively developed by Aerojet ElectroSystems Incorporated, Azusa, California, and Alliant Techsystems, Edina, Minnesota, United States. In May 1991, the Aerojet design was selected for the full-scale development program.

**Licensee.** None at this time.

**Status.** Prior to its effective termination by Congress, the restructured generic Sense and Destroy Armor program was in full-scale engineering development with a product improvement program under way. The first service deliveries under the low-rate initial production program were made in January 1997; the last units were delivered in 2000. Despite the termination of funding, the contractor is continuing the development of the munition, refining the design.

**Total Produced.** As of January 1, 2001, a total of 1,227 M898 Sense and Destroy Armor projectiles and the associated submunitions had been manufactured. An additional undetermined number of the submunitions had been manufactured for component tests, function tests and integration fits.

**Application.** An artillery projectile which dispenses an intelligent submunition for use against massed armored formations. The Sense and Destroy Armor submunition was also designed to be dispensed from other 155 millimeter artillery carrier projectiles (it was planned for the XM982 Excaliber), the M269 227 millimeter rocket used in the M270 Multiple Launch Rocket System, and possibly missile-type dispensers.

**Price Range.** Based on the revised procurement objective, the unit price of the XM898 Sense and Destroy Armor projectile loaded with two Sense and Destroy Armor submunitions was \$64,023 in Fiscal 1993 United States dollars; this was based on the procurement of 1,213 loaded projectiles. The Fiscal 1998-1999 P1 document listed the unit price of the loaded M898 at \$71,520 based on the procurement of 1,085 projectiles, while the unit price as listed in the Fiscal 1999 documents is \$102,727 based on the procurement of 550 projectiles. The latest projected

price for serially produced weapons before the funding was terminated was put at \$138,260 in Fiscal 2000 dollars.

## Technical Data

**Launch/carrier vehicle.** As initially developed and manufactured under the low-rate initial production program, the Sense and Destroy Armor submunition is integrated with a modified version of the 155 millimeter M483A1 carrier projectile designated M898. The M898 projectile can be fired by any NATO standard 155 millimeter artillery system or piece. Before it was terminated, plans called for the integration of the Sense and Destroy Armor submunition with the new XM982 Excaliber extended-range (combined base bleed and

rocket assisted) projectile. Like the M898, two Sense and Destroy Armor submunitions were also carried in the XM982 projectile. The Sense and Destroy Armor submunition is also planned for integration with the M269 rocket of the M270 227 millimeter Multiple Launch Rocket System and the MGM-140 Army Tactical Missile System. The Sense and Destroy Armor submunition was also planned for integration with the AGM/BGM/UGM-109 Tomahawk cruise missile.

**Dimensions.** The following data are for the latest prototype of the generic Sense and Destroy Armor submunition.

|                   | <u>SI units</u>   | <u>US units</u> |
|-------------------|-------------------|-----------------|
| Munition diameter | 14.73 centimeters | 5.8 inches      |
| Munition length   | 17.52 centimeters | 6.9 inches      |
| Munition weight   | 13.6 kilograms    | 29.9 pounds     |

**Performance.** The following range data were planned for the M898 Sense and Destroy Armor projectile fired at the Zone 8 charge. The armor perforation figure was derived from our standardized formula for High

Explosive Anti-Tank warheads. As this was to be a top attack weapon, it would have been capable of destroying any tank in existence or foreseen.

|                   | <u>SI units</u>   | <u>US units</u> |
|-------------------|-------------------|-----------------|
| Maximum range     | 22,500 meters     | 24,606 yards    |
| Armor perforation | 92.79 centimeters | 36.53 inches    |

## Variants/Upgrades

**Variants.** Not applicable to this submunition at this time. As noted above, before its termination, the Sense and Destroy Armor submunition was planned for integration with other carrier/dispensing vehicles. The first of these would have been the XM982 carrier projectile, with a version of the M269 rocket as used in the M270 Multiple Launch Rocket System expected to follow shortly thereafter.

**Modernization and Retrofit Overview.** In 1995, even before the low-rate serial production program got under way, the United States Army Armament Research, Development and Engineering Center (Picatinny Arsenal) issued a Request for Proposals for a four-year product improvement program for the M898 Sense and Destroy Armor submunition. Desired were a greater range, an improved lethal mechanism, and a 300 percent increase in the size of the footprint. As of mid-2000, ongoing improvements had resulted in an increase of the sensor footprint by a factor of three, and integration with the longer ranged XM982 projectile was ongoing.

The US Army claimed that the weapon's effectiveness would be greatly enhanced by the Sense and Destroy Armor Product Improvement program which was first funded in Fiscal 1997. The product-improved Sense and Destroy Armor submunition was to have an enlarged footprint which would enable each submunition to cover approximately three times the area of the baseline submunition; an improved infrared sensor to detect targets at higher altitudes; and a combined effects (multi-fragmentation) warhead enabling it to kill more targets. As a result, the product-improved Sense and Destroy Armor submunition was to be more effective not only against its primary target, self-propelled howitzers, but also against light and heavy missile launchers, surface-to-air missile sites, air defense units, surface-to-surface missiles and towed howitzers. However, the termination of funding by Congress killed this effort.

## Program Review

**Background.** Due to the former Warsaw Pact's numerical superiority in armored vehicles (particularly tanks), the United States Army, Air Force and Defense Advanced Projects Research Agency commenced a number of investigative programs in the late 1960s to develop a means for the stand-off destruction of multiple tank targets, whether stationary or moving.

The Sense and Destroy Armor concept, first developed in 1968, is one result of these investigations. However, the technology of that time was not advanced enough for development of such a weapon. Originally, the M509 203 millimeter carrier projectile was thought to be ideal for integration with the Sense and Destroy Armor concept due to its ample interior capacity. Following the development of the 203 millimeter version, it was believed that the Sense and Destroy Armor technology should instead be integrated with a 155 millimeter carrier projectile, as few nations use 203 millimeter artillery, while 155 millimeter artillery is ubiquitous.

In 1977, the United States Army's Research and Development Center solicited industry interest for the development of a smart submunition for demonstration purposes. The Center issued 31 requests for quotations to contractors and six responded: Alliant Techsystems (then Honeywell), Aerojet, Lockheed Martin (then Martin Marietta), Cutler-Hammer, Hughes, and Singer. On May 10, 1978, the Army awarded a contract to Aerojet for \$820,000. Alliant Techsystems submitted an unsolicited proposal on February 16, 1979, in which it proposed to demonstrate its submunition for \$100,000. The Army then negotiated this proposal and issued an additional contract.

Aerojet and Alliant Techsystems became competitors for the development of the Sense and Destroy Armor technology. After technology demonstration test firings in 1979, both companies were awarded three-year contracts for the preliminary phase of the full-scale development of the Sense and Destroy Armor submunition in September 1980.

The program was initially faced with the dilemma of incorporating design components and subassemblies that were sensitive enough to detect stationary and moving ground targets, but strong enough to withstand the high g forces of an artillery projectile. In the first proof of principal tests which began in 1979, the Sense and Destroy Armor submunitions were dropped from a suspended cable stretched across a canyon. These submunitions detected the target with a radiometer, rather than with the dual-mode millimeter wave

radar/infrared sensor system of the definitive submunition.

In April 1985, the program achieved its first real success with the destruction of a pair of stationary M48 tanks with a preprototype Sense and Destroy Armor submunition. The test firings of the Aerojet prototype Sense and Destroy Armor submunition were said to be less successful than those of Honeywell, which achieved mobility kills against targets on a 300 meter x 400 meter field. The slant range of the projectile to the target when the submunitions were dispensed was in the region of 90-120 meters; the test projectile was ground launched from an M109 self-propelled howitzer about 11,265 meters (12,319 yards) away. The combined active millimeter wave, passive millimeter wave and linear infrared sensor system employed on these test submunitions would enable the weapon to work in areas where the enemy may use electronic countermeasures and where visibility is hampered by dust, smoke or severe weather.

While the United States Army had canceled the 203 millimeter XM836 Sense and Destroy Armor program in 1984 in order to redirect the funds to the 155 millimeter XM898 Sense and Destroy Armor program and similar programs, Congress and the Secretary of Defense objected and later reinstated the XM836 program. The advanced phase of development was due for completion in mid-1985 but was later suspended in favor of the XM898 155 millimeter version and the "generic" version described below. After a prime contractor was selected, the initial (the 227 millimeter Multiple Launch Rocket System) version of the Sense and Destroy Armor weapon was expected to become operational in 1994.

Some Army officials claim that the Sense and Destroy Armor development program has been "gut-wrenching" because it represents a different way of doing battle, stressing a lower volume of more expensive rounds "and not just high volumes of dumb iron." An Aerojet official said that weapon had the potential to be the Army equivalent of the Combined Effects Munition (CBU-87/B) which Aerojet makes for the Air Force.

The 227 millimeter Multiple Launch Rocket System/Sense and Destroy Armor Program. In the late 1980s, the Army began a program to integrate the Sense and Destroy Armor submunition with the M269 rocket of the highly successful M270 227 millimeter Multiple Launch Rocket System, for which Lockheed Martin is the prime contractor. This version of the submunition

would retain 90 percent of the submunition components, but design changes have been required to make the submunitions operate under the differing launch environment of this multiple rocket system. Due to the rocket's larger size, it is capable of carrying six Sense and Destroy Armor submunitions. Such a deployment would have complemented the capabilities of the 155 millimeter cannon-launched XM898 projectile with its smaller payload of two submunitions.

Because of the larger size of the rocket and increase in available capacity, Alliant Techsystems had proposed a millimeter wave radar and two-color infrared sensors – a system that, according to company officials, had an inherently lower cost. The proposed submunition had a diameter of 14.73 centimeters (5.8 inches), and 93 percent of the parts were identical to those of the standard 17.53 centimeter (6.9 inch) submunition for the 227 millimeter Multiple Launch Rocket System rocket. Both versions of the submunition were 20.31 centimeters (8.0 inches) long. The smaller one weighed about 12.5 kilograms and the larger, 13.6 kilograms. However, as a result developmental problems related to the XM898 155 millimeter version of the Sense and Destroy Armor program, the full-scale effort to integrate the submunition with the M269 rocket of the M270 227 millimeter Multiple Launch Rocket System was put on hold in 1994.

155 millimeter Version. In the late 1980s, 203 millimeter artillery was being earmarked for retirement from the United States' active inventory by the early 1990s. Also, since 203 millimeter artillery was in service with only a few other nations, it soon became evident that a 155 millimeter version of the Sense and Destroy Armor weapon would be desirable. The 155 millimeter caliber is essentially the world standard for artillery systems.

The Sense and Destroy Armor M483 carrier projectile was modified to the XM898 Sense and Destroy Armor artillery projectile by thinning of the walls of the projectile. This 155 millimeter version of the Sense and Destroy Armor program had a payload of two submunitions. Contracts for the competitive development of the system were awarded in January 1984. The (then) Avco Systems Division won the initial development contract, but later opted out of the competition. Nevertheless, most of the technologies used in the Sense and Destroy Armor program were at least partially developed by Avco Systems Division, now Textron Defense Systems.

Avco's flat cone-shaped charge (often erroneously called self-forging fragment) warhead, called Skeet, was originally designated the Enhanced Sensing Munition. This munition is also the principal component of the Improved Remote Area Anti-armor Mine. Three of

these munitions were the payload of the M483A1 carrier projectile to which was added the M577 fuze assembly.

In 1986, the 155 millimeter Sense and Destroy Armor program was in low-key development, being impacted by funding constraints. The United States Army Armament, Munitions and Chemical Command then issued a request for what was termed a "generic" Sense and Destroy Armor munition.

Further Development - Generic Sense and Destroy Armor. The "generic" Sense and Destroy Armor program reflected a slight redirection of the program to develop a common component munition for broader application. The initial deployment priority was slated for the 227 millimeter Multiple Launch Rocket System and 155 millimeter howitzers. All Sense and Destroy Armor submunitions developed under this program were expected to be hardened for potential application to other cannon artillery systems. This development responded to the primary deficiency identified by the Fire Support Mission Area Analysis – insufficient lethality.

By the end of Fiscal 1986, submunition component designs had been completed and subsystem designs had been initiated. In addition, the Rocket dispenser subsystem and XM898 155 millimeter projectile carrier had been designed and the M269 227 millimeter Multiple Launch Rocket System rocket integration effort initiated. Parallel design efforts were conducted for the 17.53 centimeter (6.9 inch) submunition for the 227 millimeter Multiple Launch Rocket System rocket and the 14.99 centimeter (5.9 inch) submunition for the XM898 155 millimeter projectile in order to ensure meeting goals of 70 percent commonality in parts and over 85 percent commonality in cost. The XM898 155 millimeter effort then followed the 227 millimeter Multiple Launch Rocket System portion of the Sense and Destroy Armor development by about one year.

The initial program objectives were the completion of the submunition warhead design and the test firing of the XM898 version. To meet these goals, components and subsystems were tested (incorporating results of Air Force tests), with an all-up configured submunition tested prior to transition to full M269 227 millimeter Multiple Launch Rocket System and XM898 155 millimeter development.

In September 1987, Aerojet and Honeywell were awarded cost plus incentive fee contracts worth \$87.209 million and \$95.371 million, respectively, for the full-scale development of the Sense and Destroy Armor concept. The contracts were originally expected to run some 57 months, to June 1991. Under the originally anticipated leader-follower program, one firm was to be

selected for production prime after 30 months, with the other firm also receiving a portion of each production contract. Production was expected to begin prior to the termination of the full-scale engineering development contract. However, under the restructuring of the generic Sense and Destroy Armor program, the Aerojet design was selected in May 1991, and the firm was designated the sole source.

Sequence of Operation. First tested in component form in 1979, the Sense and Destroy Armor technology was developed so it could be used in the same manner as any other tube or rocket artillery round. No guidance/control system was needed, as the tube or multiple-launch rocket artillery fired at target coordinates received from the Joint Surveillance/Target Attack Radar System, Joint Tactical Information Distribution System, Stand-Off Target Acquisition System or other intelligence resources.

Upon reaching the target area, two submunitions would be ejected from the base of the canister in the carrier projectile. After the submunitions were ejected, a vortex ring parachute would automatically be deployed, enabling each of the submunition's three sensors (active millimeter wave, passive millimeter wave and linear infrared) to search the area at an angle of 30° off vertical. After a target was acquired, an armor-piercing warhead employing a flat cone-shaped charge (often erroneously called a self-forging or explosive formed fragment) would be fired toward the top of the vehicle, where the armor is thinnest. The warhead product would strike the target at about 2,438 meters per second (8,000 feet per second) versus a nominal 1,650 meters per second (5,413 feet per second) for a 120 millimeter tank round. The sequence of operation is depicted in the illustrations at the end of this report.

Other Carriers. Aside from the XM982 155 millimeter carrier projectile, other carriers of the Sense and Destroy Armor submunition could have included the MGM-140 Army Tactical Missile System, the GBU-15/AGM-130, the 120 millimeter mortar, fire and forget missiles and various other dispensers, including one or more that will replace the defunct joint United States-Europe Modular Stand-Off Weapon. The most recent efforts to integrate the Sense and Destroy Armor submunition with other carriers were made under the "Tomahawk Stops the Attacking Regiments" program of the US Navy. This effort investigates the integration of several different submunitions with the AGM/BGM/UGM-109 Tomahawk cruise missile. Other submunitions considered under this program were the Brilliant Anti-Tank weapon and the BLU-108/B Sensor Fuzed Weapon.

Technical Troubles. As the Defense Acquisition Board review scheduled for September 1993 approached, the Sense and Destroy Armor test program ran into technical problems. The submunitions has never been able to hit a moving target; however, this was not an operational requirement. In addition, its overall effectiveness as expressed by percentage of hits was unsatisfactory. Therefore, in mid-1993 the program's engineering development phase was extended by two years.

In additional tests conducted in late 1993, the submunition again performed poorly. By late 1993, most military observers considered the program dead. In its work on the Fiscal 1995 defense budget, the House of Representatives Armed Services Committee zeroed the procurement request and recommended a \$10 million authorization to terminate the program. However, proponents of the program hoped that results of a final series of tests scheduled for early 1994 would reverse the decision.

The Sense and Destroy Armor program was given an extended lease on life by the successful results of the 1994 test program. But opponents of the program claimed that some strange mathematics were used to arrive at the data that were released following the tests. A total of 26 XM898 155 millimeter projectiles, each dispensing two Sense and Destroy Armor submunitions, were fired in the tests. Of these, 11 were counted as hits (42 percent), eight were counted as a "near miss," two were termed "far misses," and five were termed self-destruct. Based on these data, the program supporters claimed a 73 percent reliability factor for the submunition.

Later tests of the submunition were said to have different results. Once criticism of the munition was that it apparently never fired at Zone 8, the maximum charge that gives the 22.5 kilometer desired range. While there were reports of a "non-tactical firing" at Zone 8, research indicated that this was a computer simulation and not an actual firing. In July 1995, another series of firing tests was reportedly conducted. While the problem of the submunitions hitting each other was said to have been eliminated, other concerns were apparent.

Full-Scale Operational Testing. In July 1998, the US Army began a month-long series of initial operational tests of the M898 Sense and Destroy Armor weapon. The tests, conducted at the US Army's Cold Regions Test Center in Fort Greely, Alaska, evaluated the weapon's effectiveness in battlefield conditions. The test program consisted of four successive firings – once each week for a month – from an eight-piece M198 howitzer battery. Active-duty personnel from the 18<sup>th</sup>

Airborne Corps, Fort Bragg, North Carolina, fired 24 projectiles each week for a total of 96 rounds (192 submunitions). They were fired at “real countermeasure targets” located approximately 19 kilometers (11.8 miles) downrange – the maximum range of the M198 howitzer.

While detailed test results have never been released, sources indicated they were far less than satisfactory. Apparently, the submunition had a low hit rate.

One source indicated that the poor test results were at least partially due to the fact that the munition was fired in very windy conditions that affected the parachute-stabilized submunitions as they descended. Critics remarked that the US Army was procuring a “fair weather” weapon, pointing out, of course, that the weather does not always cooperate in time of battle.

Another source indicated that the targets were heavily camouflaged. The critics this time charged that if the United States taxpayer is buying a munition that cannot function in the presence of technology that has been in use for thousands of years, something is wrong.

In commenting on the tests, another source noted that human error may have contributed to the low success rate, in effect saying that the troopers pointed the guns in the wrong direction. The critics, including some in Congress, had a field day with this statement, and questioned whether the US Army was training its artillery troops so poorly that they could not hit a stationary target only 17.74 (or even 22) kilometers away. Subsequently, this statement was regarded as just another excuse for the poor technical performance of the submunition.

The poor results of the Fort Greely tests, plus congressional actions related to the funding of the Sense and Destroy Armor program, prompted the Office of the Secretary of Defense to order that the US Army develop contingency plans for the program. The Army responded that testing of the German SMART 155, a similar weapon, would be conducted.

Another series of reliability tests were scheduled for 1999. These tests, conducted at the Yuma Proving Ground in September and October, resulted in what the US Army considered a successful performance of the munition, as it neared the mandated 80 percent reliability figure. Further testing in early 2000 did not demonstrate the necessary 80 percent reliability figure. This, among other concerns, prompted Congress to zero the Fiscal 2001 funding request for the weapon. Meanwhile, the US Army, which was then committed to the product-improved version of the weapon, did not include any version of the Sense and Destroy Armor weapon in its through-2004 budget plans.

Questions. In the 1994 tests, nine of the projectiles were fired with charge Zone 7R, while four were at charge Zone 7W. The maximum range in the tests of 15.5 kilometers (16,950.8 yards) was achieved with Zone 7R. Opponents of the program were quick to point out that the maximum range capability of the new M109A6, the 155 millimeter self-propelled howitzer that is to be the mainstay of the US Army for the coming decade, is 30 kilometers (32,808 yards) with the M203 charge. Thus, two questions were raised by the opponents of the munition: first, why were the early 1994 tests firings not conducted using the M284 cannon on the M109A6; and second, why was the Zone 8 charge not used in the tests that included the M185 cannon?

Based on an analysis of the data released, it is apparent that the Sense and Destroy Armor submunition works best when fired at shorter ranges at lower g loadings. The best performance of the submunition was when it was fired at Zone 7W, which imposes a 6,800 g loading. Zone 7R imposes a 8,200 g loading. The design range for the Sense and Destroy Armor projectile is 22.5 kilometers (24,606 yards).

In a reprogramming request made in mid-1994, the Army stated that additional tests were needed to correct the technical problems and to test the M898 projectile and Sense and Destroy Armor submunitions when fired at Zone 8. However, our research indicates that the July 1995 tests were not fired at Zone 8, but at a lower charge. Subsequent tests conducted through 1996 and into 2000 were apparently conducted in a similar manner, though detailed information has not been released. It is also not known what Zone charges were used in the July-August 1998 tests, although if the submunitions were fired at the maximum range of the M198 as they were stated to be, Zone 8 would have to had been used.

More Questions. The test program run in late 1999 only generated more questions by the critics of the program. More than a few observers pointed out that the Army used some “innovative statistics” when publishing the results of the tests, specifically the designation of several “near misses” as successes. Be that as it may, in the additional tests that were conducted, the weapon failed to achieve the criteria set out for the program.

Explosive Reactive Armor. The Sense and Destroy Armor technology that was being fielded was not affected by the widespread deployment of explosive reactive armor by the Russian Federation and several other nations in portions of their combat vehicle inventories. The armor is mostly used on the tops of tanks in order to defeat top-attack technology such as that used by the Sense and Destroy Armor submunition.

However, this application of the armor poses a corresponding weight penalty that reduces both the speed and mobility of the tank. Even if the explosive reactive armor plates are placed on top of the tank, the combined effects of an attack by the Sense and Destroy Armor munition and the ensuing explosion of the armor's own flyplate(s) would more than likely damage some of the tank's fire control sensors.

Production. In January 1995, as a result of the perceived success in the most recent round of tests, the Army Systems Acquisition Review Council recommended that the low-rate production of the M898 Sense and Destroy Armor projectile and munitions be approved. In March 1995, the Pentagon's full Defense Acquisition Board gave its approval to the initial low-rate production of the M898 version of the Sense and Destroy Armor program. Under this effort, a total of 1,106 Sense and Destroy Armor projectiles were manufactured. On August 11, 1995, Aerojet received the first contract for the low-rate initial production of the Sense and Destroy Armor weapon.

Operational Analysis. The Sense and Destroy Armor program had a number of problems, both technical and doctrine-related. As of September 2001, most of the technical problems had not been fully corrected. Our research indicates that these technical problems *were not* related to the contractor. It is the US Army's doctrine in relation to the development and use of the weapon that has led to most of the criticism.

Apparently, most of the 1994 and later tests were designed to give the Sense and Destroy Armor submunitions the best chance of functioning in the proper manner. It remains questionable whether the tests were conducted against the military requirement – and if they were, was the requirement altered to suit the tests? Also, given the constraints of national security, how were the July-August 1998, September-October 1999, and early 2000 tests conducted? Were these tests tailored to let the weapon perform at its best or were they conducted in a realistic manner?

Probably the most salient points – points that have been totally ignored by the military journals – are that the Sense and Destroy Armor submunition has never been tested against a moving target, has never hit a moving target, and will almost certainly never be able to do so. The evidence now indicates that the weapon was, from the outset, never intended to be able to hit a moving target. This may have been acceptable in the days when massed formations of Warsaw Pact armor were expected to be encountered, but is it realistic to expect the same target scenario in the new century? Even though it now appears that *none* of the new artillery-delivered sensor-fuzed munitions entering

service (including BONUS and SMART 155) can hit a moving target, some question whether the United States should be funding the procurement of a weapon that lacks this capability.

Even against a stationary target, the performance of the M898 Sense and Destroy Armor weapon when fired at the maximum zone charges is questionable. Of course, the results of the July-August 1998 tests (supposedly conducted using Zone 8) have yet to be released and indeed may never be. And it should again be noted that the Zone 8 charge is needed in order to achieve the design 22.5 kilometer range. While some of the September and October 1999 tests were indeed fired at Zone 8S, the range was apparently not the full design range.

A major defense publication used the term “non-tactical firing” in relation to the 1997 and earlier tests at this zone charge. Yet, the Sense and Destroy Armor weapon was widely promoted as a counterbattery weapon for the Army's Force 21. The promoters of the Sense and Destroy Armor weapon may wish to note that much of the perceived-threat tube and multiple-launch rocket artillery systems have a greater range than the 30 kilometer standard of US tube and rocket artillery, and that the (unproven) maximum range of the M898 Sense and Destroy Armor projectile is 22.5 kilometers. The object of self-propelled artillery in any form is to “shoot and scoot”; modern fire control makes this an easy task. And again, the Sense and Destroy Armor submunition cannot hit a moving target.

The Sense and Destroy Armor munition was being touted as an ideal munition for the Navy's Tomahawk cruise missile. This would involve a major change in warfighting doctrine for the seagoing service. Since the flat cone-shaped charge (explosively formed projectile) warhead technology used in the Sense and Destroy Armor munition had no real applicability against unarmored targets (read ships), we can only surmise that the Navy is getting into the business of destroying tanks!

The Sense and Destroy Armor program was attacked on several fronts as follows:

- Technically - This avenue of attack is supported by the above data. Proponents counterattacked with a mass of (questionable) data from tests that were apparently conducted in such a manner as to yield the best results for the weapon.
- Financially - Opponents questioned if the protracted development period (including the initial low-rate production phase) was worth the nearly one billion dollars being spent on it. They also asked if the operational weapon that would result would be

worth the money, and whether there were some other weapon that could address the same mission area in a more cost-effective manner.

- Operationally - Given the facts noted above, plus the stated objective of the Army to attack targets

100 kilometers distant, it is fairly clear that the M898 Sense and Destroy Armor weapon does not really fit into the Army's warfighting plans. And again, *it cannot hit a moving target.*

## Funding

Much of the program feed-in technology for the Sense and Destroy Armor program has been sensitive.

| <u>US FUNDING</u>  |             |             |             |             |             |             |             |             |  |
|--|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--|
|  | <u>FY90</u> |             | <u>FY91</u> |             | <u>FY92</u> |             | <u>FY93</u> |             |  |
|  | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> |  |
| <u>Research and Development</u>                                |             |             |             |             |             |             |             |             |  |
| United States Army <sup>(a)</sup>                              |             |             |             |             |             |             |             |             |  |
| Sense and Destroy Armor Engineering Development <sup>(b)</sup> |             |             |             |             |             |             |             |             |  |
| PE#0604814A  |             |             |             |             |             |             |             |             |  |
| Project D644 <sup>(c)</sup>                                    | -           | 134.9       | -           | 103.9       | -           | 148.2       | -           | 92.7        |  |
| <br>   |             |             |             |             |             |             |             |             |  |
|  | <u>FY94</u> |             | <u>FY95</u> |             | <u>FY96</u> |             | <u>FY97</u> |             |  |
|  | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> |  |
| <u>Research and Development</u>                                |             |             |             |             |             |             |             |             |  |
| United States Army <sup>(a)</sup>                              |             |             |             |             |             |             |             |             |  |
| Sense and Destroy Armor Engineering Development <sup>(b)</sup> |             |             |             |             |             |             |             |             |  |
| PE#0604814A  |             |             |             |             |             |             |             |             |  |
| Project D644 <sup>(c)</sup>                                    | -           | 41.0        | -           | 40.5        | -           | 16.2        | -           | 9.4         |  |
| Project D2ST <sup>(d)</sup>                                    | -           | 5.0         | -           | 0.0         | -           | 0.0         | -           | 0.0         |  |
| <br>   |             |             |             |             |             |             |             |             |  |
|  | <u>FY98</u> |             | <u>FY99</u> |             | <u>FY00</u> |             | <u>FY01</u> |             |  |
|  | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> |  |
| <u>Research and Development</u>                                |             |             |             |             |             |             |             |             |  |
| United States Army <sup>(a)</sup>                              |             |             |             |             |             |             |             |             |  |
| Sense and Destroy Armor Engineering Development <sup>(b)</sup> |             |             |             |             |             |             |             |             |  |
| PE#0604814A  |             |             |             |             |             |             |             |             |  |
| Project D644 <sup>(c)</sup>                                    | -           | 5.6         | -           | 31.6        | -           | 19.4        | -           | 9.8         |  |
| Project D2ST <sup>(d)</sup>                                    | -           | 4.2         | -           | 0.0         | -           | 0.0         | -           | 0.0         |  |

All dollar amounts are in millions.

<sup>(a)</sup>Two former research and development efforts were concerned with the initial development of Sense and Destroy Armor technology.

<sup>(b)</sup>Sense and Destroy Armor Engineering Development.

<sup>(c)</sup>Project D276 - Sense and Destroy Armor - supported the advanced development of the Sense and Destroy Armor munitions and transitioned to program element number 64631, project D369, in the second quarter of Fiscal 1984. Project D369 was later changed to Project D644, Generic Sense and Destroy Armor. This project funded the full-scale engineering development and testing of the XM898 Sense and Destroy Armor projectile and integrated the two Sense and Destroy Armor submunitions with the respective carrier platforms.

<sup>(d)</sup>Project D2ST financed the direct costs of operational test and evaluation of the Sense and Destroy Armor munitions. The Sense and Destroy Armor was an Acquisition Category IC system. Initial Operational Test and Evaluation was conducted in Fiscal 1998. Operational testing was conducted under conditions similar to those encountered in actual combat. Operational



testing provided the Army with an independent test and evaluation of the effectiveness and suitability of the system. Project D2ST was restructured from SSN E66300, Projectile, Artillery, 155 millimeter SADARM, M898, Procurement Ammunition, Army.

**US FUNDING**

|                              | <u>FY95</u> |             | <u>FY96</u> |             | <u>FY97</u> |             | <u>FY98</u> |             |
|------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                              | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> |
| <u>Procurement</u>           |             |             |             |             |             |             |             |             |
| United States Army           |             |             |             |             |             |             |             |             |
| M898 Sense and Destroy Armor | 110         | 29.8        | 150         | 41.1        | 600         | 93.6        | 300         | 65.3        |
|                              |             |             |             |             |             |             |             |             |
|                              | <u>FY99</u> |             | <u>FY00</u> |             | <u>FY01</u> |             | <u>FY02</u> |             |
|                              | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> | <u>QTY</u>  | <u>COST</u> |
| <u>Procurement</u>           |             |             |             |             |             |             |             |             |
| United States Army           |             |             |             |             |             |             |             |             |
| M898 Sense and Destroy Armor | 30          | 31.3        | NL          | 14.9        | NL          | 14.9        | TBD         | TBD         |

TBD = To be determined

NL = Not listed

The procurement funding listed above was for the low-rate initial production of the M898 Sense and Destroy Armor projectile. For fiscal 1995, under the low-rate initial production program, \$24.8 million was originally allocated for the procurement of 80 projectiles. The original request for FY96 included \$24.3 million for 77 projectiles; for FY97, \$62.4 million for 336 projectiles; and for FY99, \$77.6 million for 1,085 projectiles.

**Recent Contracts**

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Prior to August 1995, the contracts related to this system were solely for the continued development of the munition. In April 1992, Aerojet was awarded a \$321,609,577 cost-plus-incentive-fee contract for this development. Work under this contract (DAAA21-86-C-0309), was completed by August 31, 1994. On August 11, 1995, Aerojet was awarded a \$14,475,032 increment of a \$28,975,032 cost-plus-incentive contract for the low-rate initial production of 110 XM898 Sense and Destroy Armor projectiles. The sole-source contract, number DAAE30-95C-0080, was initiated on January 10, 1995, by the Tank-Automotive and Armaments Command. On October 18, 1995, Aerojet awarded Alliant Techsystems a \$10.9 million contract for subcontracting work. In June 1996, a \$9.6 million option on the DAAE30-95C-0080 contract for 120 additional Sense and Destroy Armor projectiles was taken. On February 11, 1997, the second low-rate initial production contract for 600 M898 projectiles was awarded at a value of \$82 million. On September 17, 1999, Aerojet was awarded a \$14.3 million contract (an option) for the low-rate initial production of the submunition.

## Timetable

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The following timetable is for the Sense and Destroy Armor program only.

| <u>Month</u> | <u>Year</u> | <u>Major Development</u>  |
|--------------|-------------|---|
| Mid          | 1970s       | Concept definition  |
| Early        | 1978        | Initial contract awards   |
| June         | 1979        | Test firings  |
| September    | 1980        | Competitive contracts awarded for 203 millimeter Sense and Destroy Armor development program  |
| January      | 1984        | Competitive contracts awarded for 155 millimeter Sense and Destroy Armor development program  |
| Mid          | 1984        | Avco wins 155 millimeter Sense and Destroy Armor competition evaluation   |
| January      | 1985        | Request for generic Sense and Destroy Armor munition issued   |
| October      | 1989        | Major developmental/operational test program begun  |
| May          | 1991        | Downselection in favor of Aerojet design made   |
| July         | 1993        | Technical problems extend the engineering development phase by two years  |
| Late         | 1993        | Series of follow-on tests conducted   |
| March-April  | 1994        | Second series of follow-on tests conducted  |
| July         | 1995        | Additional follow-on tests conducted  |
| August       | 1995        | Initial low-rate production contract awarded  |
| November     | 1996        | First low-rate production service deliveries  |
| July-August  | 1998        | Operational testing   |
| September    | 1999        | Further reliability testing   |
| Early        | 2000        | Further reliability testing, Congress zeroes Fiscal 2001 funding  |
| Late         | 2001        | Low-rate initial production of M898 155 millimeter version of Sense and Destroy Armor submunition complete; contractor continues to test original version, as well as low-scale development of product-improved version |

## Worldwide Distribution

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**Export Potential.** It was long believed by most observers that if the Sense and Destroy Armor munition were ever placed in full-scale serial production, extensive export of the munition would be unlikely. This is due to the sensitive technology involved as well as the difficulty that has been encountered in selling other anti-armor weapons systems such as M712 Copperhead. Aside from NATO, several of the Arab nations, in particular the Gulf States, were expected to be customers (next to Israel) for the Sense and Destroy Armor munitions, but due to the power of the Israeli lobby within the United States, sales prospects were doubtful. Also, there are several competing systems (SMART 155 and BONUS) now in development in Europe.

The initial export push for the M898 Sense and Destroy Armor weapon was in relation to the United Kingdom's Staff Requirement 1238 for a stand-off air-to-surface weapon. For this requirement, the Sense and Destroy Armor submunition was to be integrated with an airborne dispenser. Hunting Engineering teamed with Aerojet to compete for this requirement. Several other nations, including the Netherlands and Switzerland, had expressed an interest in procuring the Sense and Destroy Armor or similar weapon.

**Countries.** Developmental and low-rate production munitions for operational testing and service deliveries were manufactured in the **United States**.

## Forecast Rationale

It now appears that the long-troubled Sense and Destroy Armor program is dead. The death knell was sounded when Congress zeroed Fiscal 2001 funding for the program and the US Army failed to include the weapon in its through-2004 procurement plan. While there is an ongoing effort by supporters to revive the program (a variety of dispensing platforms are being proposed for the submunition), the weapon has never passed an operational test without some sort of manipulation of

the data. Therefore, the data gathered for this latest report on the Sense and Destroy Armor program cannot support a restart of this program.

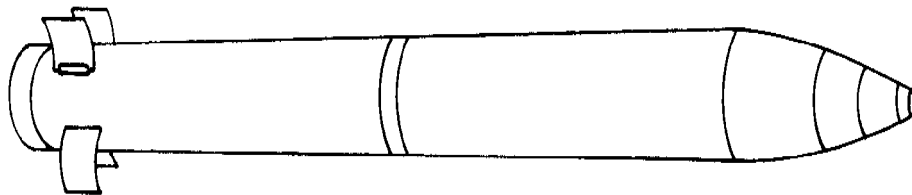
However, this program has a history of almost magically returning to life. Indeed, the contractor is continuing the development of the product-improved version of the submunition. So, while we are forecasting that the program will remain dead, we will continue to monitor it for new developments.

## Ten-Year Outlook

### ESTIMATED CALENDAR YEAR PRODUCTION

| Munition               | through 00 | High Confidence Level |    |    | Good Confidence Level |    |    | Speculative |    |    | Total 01-10 |    |
|------------------------|------------|-----------------------|----|----|-----------------------|----|----|-------------|----|----|-------------|----|
|                        |            | 01                    | 02 | 03 | 04                    | 05 | 06 | 07          | 08 | 09 |             | 10 |
| AEROJET ELECTROSYSTEMS |            |                       |    |    |                       |    |    |             |    |    |             |    |
| M898 SADARM (a)        | 1227       | 0                     | 0  | 0  | 0                     | 0  | 0  | 0           | 0  | 0  | 0           | 0  |
| Total Production       | 1227       | 0                     | 0  | 0  | 0                     | 0  | 0  | 0           | 0  | 0  | 0           | 0  |

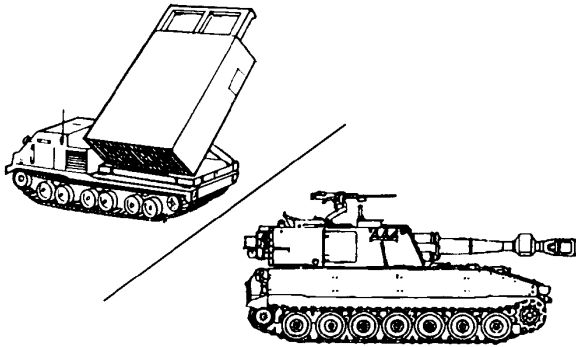
(a) The production figures shown are only for the winning design from Aerojet. All production is for developmental test and engineering projectiles, operational test projectiles, and low rate initial production (1,106 projectiles) for the XM898/M898 155 millimeter version. The year 2000 production includes the last 120 projectiles procured under the low rate initial production program. Each M898 projectile contains two Sense and Destroy Armor submunitions. This forecast chart DOES NOT include any Sense and Destroy Armor submunitions for the XM982 Excaliber projectile or any other dispenser application.



SADARM/M269 MLRS rocket

Source: Government Accounting Office

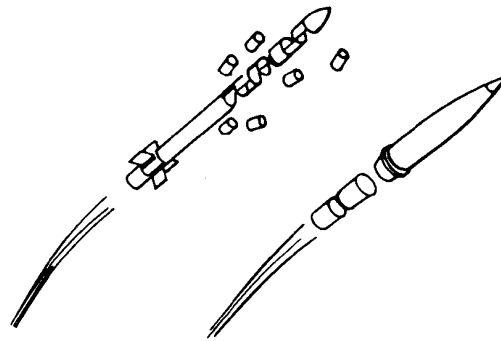
**Sense and Destroy Armor Operational Concept**



M270 MLRS and M109 155 mm Howitzer

**1. DELIVERY SYSTEM**

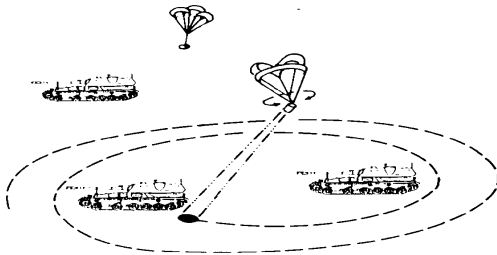
Source: Government Accounting Office



M269 MLRS Rocket and M898 155 mm Projectile

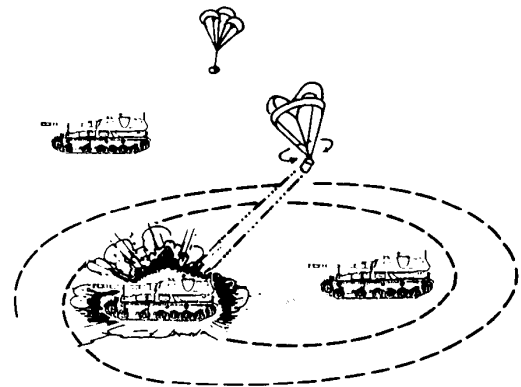
**2. EJECTION OF SUBMUNITIONS**

Source: Government Accounting Office



**3. SEARCH FOR TARGET**

Source: Government Accounting Office



**4. DESTRUCTION OF TARGET**

Source: Government Accounting Office