# SENSE AND DESTROY ARMOR (SADARM)

| Army ACAT IC Program* | | Prime Contractor |
| --- | --- | --- |
| Total Number of Systems: | 47,331 | GENCORP Inc. (Aerojet) |
| Total Program Cost (TY$): | $3,075.8M | |
| Average Unit Cost (TY$): | $65,000 | |
| Full-rate production: | FY05 | |

* *Program plan before restructure*

## SYSTEM DESCRIPTION & CONTRIBUTION TO JOINT VISION 2020

The Sense and Destroy Armor (SADARM) is a "smart" artillery submunition designed for ***precision engagement*** of self-propelled howitzers as well as other lightly armored vehicles. By destroying the enemy's self-propelled counterfire capability, SADARM contributes to ***full-dimensional protection***. Denying the enemy's use of self-propelled howitzers better enables friendly forces to move at will and ***dominate maneuver***.

SADARM is designed to attack and kill lightly armored vehicles. Each 155 millimeter (mm) howitzer round delivers two submunitions. Once dispensed, the submunition deploys a parachute-like deceleration device. At a pre-determined distance from the ground, the submunition ejects the deceleration device and deploys another device to stabilize and rotate the submunition. As the submunition falls and rotates, it searches the ground with a millimeter wave sensor (both active and passive) and an infrared sensor array. Using the sensors and detection logic, the submunition is designed to detect countermeasured targets in a variety of climates. If the sensors detect a target, the submunition fires an Explosively Formed Penetrator (EFP) at the target. If no target is detected, the submunition is designed to self-destruct.

At the start of FY00, the Army had planned to keep Basic SADARM in low-rate production, and to develop a SADARM Product Improvement (PI) for eventual full-rate production. During FY00, the Army decided instead to pursue a modified product improvement called SADARM Basic+ that would improve submunition reliability and sensor performance as well as integrate the SADARM submunition into an extended range 155mm round (Excalibur). However, neither this program nor Basic SADARM is currently funded.

## BACKGROUND INFORMATION

SADARM entered low-rate production in March 1995. Testing prior to this decision showed poor reliability at the longest range. Technical testing from 1996-1998 showed improvement in submunition reliability at the longest range, but still below the 80 percent reliability requirement. By the beginning of 1998, reliability at 15 kilometers was approximately 70 percent. In addition, an incompatibility between the SADARM round and the electronic fuze was discovered. Although the Army decided to field basic SADARM with only the mechanical fuze, the Army continues to investigate this incompatibility. There were also a number of critical technical tests at Yuma Proving Ground, Arizona, and Ft. Greely, AK, to test SADARM's capabilities in a variety of countermeasures and environments. The weather varied from rain to sun to snow. All of the tactical rounds were fired at 15 kilometers, where submunition reliability was greatest. In general, SADARM performed well in these technical tests.

An IOT&E was conducted in August 1998 at Ft. Greely. The DIA-validated array was nearly identical to the defensive array used in the Ft. Greely technical tests. All of the targets were real threat vehicles. All five missions of 24 rounds each (120 total) were fired at 19.4 kilometers. The Army validated this as a likely range for the operational test scenario. Besides range, the other major difference between the operational and technical tests was firing procedures and thus accuracy. During the IOT, soldiers generated the inputs and calculated the ballistic solutions using equipment, software, and methods representative of what would be available when SADARM is fielded. The operational test results were well below requirements.

The major LFT&E activities were completed in FY98. To augment the lethality data from about 30 impacts on a variety of threat vehicles during end-to-end technical test firings, a seven-shot tower test against 2S3 SPHs and a T-72 tank was conducted at Aberdeen Proving Ground, MD. Also, the impacts on actual threat targets during IOT provided valid additional data for the live fire assessment.

## TEST & EVALUATION ACTIVITY

Technical testing in 1999 and 2000 focused on improving submunition reliability. After the contractor conducted numerous reliability tests (including high stress firings) in 1999, the Government fired tactical rounds at 17 and 19 kilometers at ambient desert temperature throughout 1999 and 2000. These technical tests were conducted at Yuma Proving Ground against a large non-operational target array.

A Limited User Test (LUT) was conducted in April and May 2000 at Yuma Proving Ground. This test was to support a fielding decision of a limited number of basic SADARM rounds. The DIA-approved target array and countermeasures were operationally representative of the Southwest Asia scenario. All four missions of 24 rounds each (96 total) were fired at 19 kilometers. Target location errors were drawn from operationally representative data of the AN/TPQ-37 Firefinder radar. The Army conceded one of the missions due to a large targeting error, so an additional targeting error was selected. The conceded mission was scored as zero kills. Missions were fired at 4:00 a.m., 6:00 a.m., 12:00 p.m., and 2:00 p.m.

The SADARM TEMP was revised and approved by OSD in mid-FY00. However, because the TEMP addresses the unfunded PI SADARM T&E program, it is no longer current.

## TEST & EVALUATION ASSESSMENT

In 1998, DOT&E assessed the system to be not operationally effective and not operationally suitable. Major factors in this assessment were variable submunition effectiveness, reliability, and delivery accuracy. Submunition effectiveness varied depending on factors including realistic target emplacement in foliage, countermeasure nets, heat sources such as fires, exhaust, or expended shell casings, and time of day. Winds affected submunition delivery accuracy and operational effectiveness during some missions fired. One mission was canceled to avoid high wind conditions. An additional mission was canceled due to the expectation of inaccurate delivery and a third mission was conceded due to a large targeting error. Low submunition reliability, estimated to be 44 percent versus 80 percent required, was a significant factor in the overall assessment. Even when test conditions appeared to be favorable, SADARM still did not meet its effectiveness requirement.

DOT&E's 1998 assessment included a Live Fire lethality evaluation of the basic SADARM warhead, which concluded that it is capable of damaging or destroying its expected primary threat targets, given that it strikes them. SADARM also has some capability against tank targets, but to a lesser degree.

Technical testing in 1999 and 2000 demonstrated that there has been some progress in submunition reliability since the 1998 IOT&E. A reliability of 74 percent (20/27) was scored for 15 rounds fired with lower powder charges at 17 kilometers in August 1999. During that same test period, seven rounds fired with the highest powder charge at 17 kilometers were scored as 86 percent (12/14) reliable. All other tests were conducted with the highest powder charge at a 19-kilometer range. Results under ambient desert conditions were 73 percent (11/15) in September 1999, 69 percent (11/16) in January 2000, and 67 percent (10/15) in March 2000. Each of these tests used slightly different submunition design and/or production techniques. There were additional tests of rounds conditioned hot (145º F) and cold (-26º F). Hot conditioned submunitions scored 100 percent (8/8) in January 2000 and 83 percent (20/24) in March 2000. Cold conditioned submunitions scored 63 percent (5/8) in January 2000 and 88 percent (7/8) in March 2000.

Since each of these reliability test events had a different configuration, it is inappropriate to combine the results. The reliability of ambient rounds at a 19-kilometer range appeared to decrease over time (September 1999 to March 2000) and the conditioned rounds appeared to have a higher reliability than the non-conditioned rounds. In addition, the reliability at 17 kilometers is similar to results observed in 1997 (73 percent (71/97)). DOT&E's best estimate is that current submunition reliability at the longest range is approximately 70 percent.

SADARM exceeded the Army's kill requirements in the LUT, despite not meeting the submunition reliability requirements. The results were 1.4 times the required kills for five missions. This includes a score of zero kills for the mission conceded because of large targeting error. Reliability of LUT submunitions was estimated to be 72 percent (43/60) versus 80 percent required. Because the tactical submunition is not instrumented, reliability scoring is very subjective. It is difficult to separate unreliable submunitions from reliable submunitions that did not detect targets. Accurate reliability scoring is even more difficult during operational tests, such as the LUT, where countermeasures reduce detection probabilities.

While SADARM met its operational effectiveness requirements in the desert LUT, it is not clear whether the currently designed round could pass a retest at Ft. Greely. While submunition reliability appears to have improved since the IOT&E, reliability was not the only issue in the 1998 IOT&E. Wind effects and submunition effectiveness in the Ft. Greely environment are still important factors that will affect operational effectiveness. An operational test at Ft. Greely is required to determine whether the current system would pass its requirements in a verdant summer environment.

Despite meeting the LUT requirement, it appears that the Army's doctrine of firing 24 rounds at each battery-sized target is inefficient. With one exception, the howitzers that were killed during the LUT were hit in the first 12 rounds. Even for that mission, however, the requirement was met in the first 12 rounds. For howitzers with multiple hits, it is difficult to determine which hit killed the target. As was observed during firings in prior technical testing and IOT, howitzers that are hit are generally killed. In addition, 60 percent (114/190) of the submunitions had no threat vehicle in their footprint. This may be improved by leveraging Firefinder's increased accuracy in locating individual howitzers (as opposed to the entire threat battery). A doctrine that targets individual howitzers, rather than the whole battery, may provide a more efficient use of SADARM rounds.

## CONCLUSIONS, RECOMMENDATIONS AND LESSONS LEARNED

The basic SADARM test program was highly successful at integrating a variety of actual threat vehicles into target arrays for the technical tests, IOT, and LUT. The result was a six-fold increase in the number of data points available to support the live fire evaluation over what would have been available from only the dedicated tower test. If a product improvement to SADARM is developed and tested, a similar approach should be followed.

Instrumentation of the tactical round is required. This instrumentation would help isolate specific reliability problems as well as provide reliability data. An instrumented round provides greater efficiencies in testing and fault tree assessments. An overall improved submunition reliability would result.

A change in firing techniques is strongly recommended. There is inefficiency in the current number of rounds employed against each target. In the LUT, 60 percent of the submunitions did not have a target in their footprint. A firing doctrine that maximizes the use of the Firefinder radar's accuracy in locating individual threat howitzers should be considered.

Operational test results indicate that SADARM may have significantly reduced effectiveness in environments in which the probability of detection of individual threat targets is known to be low. The Army should consider tactical changes (such as firing more rounds in these conditions) or a redesign of the submunition target detection algorithm.