

Small Diameter Bomb (SDB) II

Executive Summary

- The Small Diameter Bomb (SDB) II developmental testing is complete. Operational and live fire testing is ongoing. The Air Force completed Government Confidence Testing (GCT) in May 2018. The Air Force awarded the Low-Rate Initial Production Lot 4 contract for 660 weapons (570 Air Force, 90 Navy) in January 2018.
- The SDB II has demonstrated the Normal Attack (NA) mode, the primary employment method for the SDB II, against moving targets, but has had difficulty hitting static targets. Software changes have shown improvements against static targets, but are not fully validated. The Air Force successfully demonstrated Coordinate Attack (CA) and Laser Illuminated Attack (LIA) in 2017, and verified CA and LIA enhancements and corrections during GCT in 2018.
- The program implemented corrective actions and fixes for all failure modes discovered in developmental test and GCT. The program discovered six anomalies in GCT, identified and implemented a fix for five, and awaits the opportunity to test new software to address the sixth during operational test.
- The Air Force began IOT&E in June 2018 with an adequately resourced test program.

System

- The SDB II is a 250-pound, air-launched, precision-glide weapon that uses deployable wings to achieve standoff range. F-15E aircraft employ SDB IIs from the BRU-61/A four weapon carriage assembly.
- The Air Force directed design of the SDB II to provide the capabilities deferred from SDB I. It includes a weapon datalink allowing for post-launch tracking and control of the weapon, as well as a multi-mode seeker to provide the ability to strike mobile targets in adverse weather.
- The SDB II combines Millimeter-Wave radar, imaging infrared, and laser-guidance sensors in a terminal seeker, in addition to a GPS and an Inertial Navigation System, to achieve precise guidance accuracy in adverse weather.
- It incorporates a multi-function warhead (blast, fragmentation, and shaped charge jet) designed to defeat armored and



- non-armored targets. The weapon can be set to initiate on impact, at a preset height above the intended target, or in a delayed mode.
- There are three principal attack modes: NA, LIA, and CA. The SDB II is used against moving or stationary targets using its NA (radar/infrared sensors) or LIA modes, and stationary targets with its CA mode.
- The SDB II is designed to provide increased weapons load per aircraft and reduce collateral damage while achieving kills across a broad range of target sets by precise accuracy, small warhead design, and focused warhead effects.
- An SDB II-equipped unit or Joint Terminal Attack Controller (JTAC) will engage targets in dynamic situations and use a weapon datalink network to provide in-flight target updates, in-flight retargeting, weapon in-flight tracking, and, if required, weapon abort.

Mission

Combatant Commanders will use units equipped with the SDB II to attack stationary and moving ground and littoral targets in adverse weather conditions at standoff ranges.

Major Contractor

Raytheon Missile Systems – Tucson, Arizona

Activity

- As of May 2018, the Air Force completed 19 NA, 3 CA, 4 LIA Guided Test Vehicles (GTV) (including 4 repeats) and 9 NA, 3 CA, and 2 LIA Live Fire (LF) tests (including 4 repeats) against moving and stationary targets as part of contractor-led developmental testing. Of those events, the Air Force conducted 7 GTV and 6 LF tests with ultrahigh frequency (UHF) weapon data link (WDL) updates, and 12 GTV and 7 LF test shots were conducted with Link 16 WDL updates. NA is the primary employment method for the SDB II.
- The Air Force completed a government-managed 28-shot NA mode GCT program in May 2018, which tested the weapon in more operationally realistic environments with more operationally representative hardware and software. During GCT, the Air Force dropped all 31 available weapons

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- (28 planned plus 3 spare weapons); 29 were NA, and 1 each were CA and LIA. Results were 25 successes and 6 failures.
- The GCT events incorporated more operationally realistic employment challenges, to include:
 - GPS degradation and denial
 - JTAC controlled weapons
 - Various on- and off-board airborne targeting systems
 - Simple denial and deception measures
 - In-flight retargeting
 - Maneuvering and stop/start motion by targets
 - Higher clutter environments, including more decoy or confuser targets to stress the classification feature
 - During GCT, the Air Force accomplished one successful employment against a maritime target and two successful ripple releases (dropping two bombs in rapid succession against different targets).
 - The Program Office completed 20 rounds of seeker Captive Flight Tests (CFTs), resulting in over 2,260 target runs in a wide variety of terrain and environmental conditions. These tests logged over 483 hours of seeker operation without a single failure.
 - The program has augmented and refined the Integrated Flight System (IFS) model by incorporating the results of the 2,260 CFT runs as well as weapon flight tests. Raytheon released its IFS model verification and validation report in July 2017, and the Air Force Operational Test and Evaluation Center expects to give initial accreditation prior to completion of operational testing.
 - The Program Office completed over 2,000 hours of ground reliability testing and over 2,320 hours of in-flight captive carry reliability testing (CCRT). The CCRT program is complete; however, captive hours will continue to be collected during the Production Reliability Incentive Program (PRIDE) beginning with Lot 2 production-representative assets.
 - The program redesigned the Air Turbine Alternator (ATA), which provides power to the SDB II fuse, to address a deficiency identified during a captive flight test failure. Regression testing is nearing completion. At least 10 weapons incorporating the new ATA will be available and employed during IOT&E.
 - The Air Force commenced operational test flights on June 4, 2018. It has released 31 weapons to date including 21 NA, 3 CA, and 7 LIA missions. Six NA missions and one CA mission were unsuccessful in hitting the intended target as planned. All other NA and CA missions resulted in direct hits on their targets and the LIA missions all resulted in weapons hitting the weapon controller's laser spot. The causes of the six NA and one CA unsuccessful missions were:
 - A mission planning error preventing the weapon from receiving inflight target updates
 - Incorrect WDL keys preventing the weapon from receiving IFTUs and having the target in the seeker field of view
 - An electrical transient resulting in uncontrolled flight of the weapon
 - Corrupted IFTUs resulting in the target being outside of the seeker field of view
 - On the CA mission, the Height of Burst (HOB) sensor did not function because the seeker dome cover is believed to have contacted the dome after jettison causing damage and preventing the seeker from functioning properly
 - Two NA missions remain under review
 - The Air Force awarded the Low-Rate Initial Production Lot 4 contract in January 2018 for 660 weapons (570 Air Force, 90 Navy).
 - The Air Force conducted all testing in accordance with the DOT&E-approved Milestone C Test and Evaluation Master Plan.
- ### Assessment
- In the NA mode, the SDB II successfully engaged both moving and stationary targets, including proper classification of target type (wheeled versus tracked) on 19 of 22 GTV flight tests (including GCT); 3 events had failures. The program has implemented corrective actions and fixes for all failure modes discovered in test.
 - In the CA and LIA modes, the program adequately addressed the two failure types found in the CA mode, as demonstrated in test. During GCT, the program conducted two successful LIA tests against moving targets with new weapon software and successfully tested new capability in a CA test and a LIA test using a ground-based laser against a fixed target.
 - Early phases of operational testing have been largely successful, with one mission failure prompted by a mission planning error and two possible reliability failures, which are under technical review. The challenges with mission planning appeared during developmental test and became manageable with time and experience, but with one attributable failure already in operational test, mission planning will remain an emphasis item.
 - The Air Force has employed a total of 101 SDB IIs during testing to date. Seventy-one weapons have been successful in terms of Free Flight Reliability, with 19 failures and one no test. Ten weapons have not yet been formally adjudicated. The resulting reliability level of 0.79 is slightly below the 0.80 level required by the end of IOT&E, and is moderately below the 0.85 level required by the end of Lot 2 in September 2018. Delays in entering IOT&E are due to the steady rate of discovering new failure modes in GCT, which resulted in the lower than required reliability rates and implies the weapon was not yet fully mature.
 - The program has thoroughly implemented corrective actions and fixes for all failure modes discovered in developmental test. A fix implemented after a failure in October 2014 may have failed to correct the root cause because a recent operational test failure appears to have the same failure mode. Otherwise, there have been no failures to date of components or software for which a fix has already been implemented. Reliability improved modestly from developmental test which produced a figure of 0.74 (28/38) compared to GCT which demonstrated 0.81 (26/32). Initial operational test results show 17 free flight reliability successes in 20 attempts (0.85), providing an acceptable point estimate for reliability, but

this current figure is insufficient to state with confidence that reliability will meet final requirements.

- The Air Force discovered six anomalies during GCT. These include: a software coding error that has been fixed and tested; a maritime target problem; three anomalies related to employment against static targets, which were successfully addressed in a final weapon software version tested prior to IOT&E; and a cracked seeker dome that prevented the seeker from operating properly. The seeker dome cover appears to have contacted the seeker dome after jettison, resulting in damage to the dome.
- The SDB II continues to perform well against moving targets in the NA mode. Difficulties against static targets in some conditions have been addressed with a combination of software improvements and modified employment procedures first implemented at the end of GCT. Initial results are promising but require further testing in operational test to confirm.
- Continued comparisons of the IFS model pre- and post-flight predictions indicate the model is adequate for the kinematics

flown in flight test to date. Raytheon Missile Systems continues to develop and update the IFS model, which will be essential to the assessment of the results of live fire and operational testing. IFS, in combination with lethality and free flight reliability data, will produce single shot kill probability values needed to assess end-to-end weapon effectiveness against a range of operationally relevant targets.

Recommendations

The Air Force should:

1. Re-fly the two failed GCT maritime missions during the operational test period to better characterize weapon performance against the maritime target category.
2. Examine opportunities during operational testing to eliminate possible redundancy with tests successfully completed in GCT.
3. Maximize the number of GCT and operational test shots used to validate the IFS in order to improve its overall performance.

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