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United States General Accounting Office
Washington, DC 20548

July 24, 2002

The Honorable Tom Harkin
The Honorable Charles E. Grassley
The Honorable Peter G. Fitzgerald
The Honorable Richard Durbin
United States Senate

The Honorable Lane Evans
The Honorable James A. Leach
The Honorable Jim Nussle
House of Representatives

Subject: *2002 Update of the 155 mm Lightweight Howitzer*

In July 2000 and April 2001, we issued reports to you and several other members of Congress describing the schedule, cost, and technical status of the 155 mm Lightweight Howitzer program.¹ The 155 mm Lightweight Howitzer is expected to replace the M-198 towed howitzer. The Army-Marine Corps Lightweight Howitzer Joint Program Office is directing this program's development, with BAE SYSTEMS (BAE), a British company, as the prime contractor.

This report responds to your request of February 27, 2002, that we continue to monitor and report on this program due to your continued concerns about its schedule, cost, and technical difficulties and the program's readiness for low-rate initial production.

Results in Brief

Since our April 2001 report, all key milestones have slipped in large part because a 2-year low-rate initial production phase has been added to the program to provide production representative howitzers for operational testing. Correspondingly, the full-rate production decision has slipped from September 2002 to October 2004. The initial fielding of the howitzer by the Marine Corps has slipped to March 2005 or 8 months. The initial fielding of the howitzer by the Army has slipped to August 2006, or 17 months.

¹ See U.S. General Accounting Office, *Status Update of the New 155 mm Lightweight Howitzer*, GAO-01-603R (Washington, D.C.: Apr. 10, 2001) and *Defense Acquisitions: Howitzer Program Experiencing Cost Increases and Schedule Delays*, [GAO/NSIAD-00-182](#) (Washington, D.C.: July 28, 2000).

Report Documentation Page

Report Date 00AUG2002	Report Type N/A	Dates Covered (from... to) -
Title and Subtitle 2002 Update of the 155 mm Lightweight Howitzer	Contract Number	
	Grant Number	
	Program Element Number	
Author(s)	Project Number	
	Task Number	
	Work Unit Number	
Performing Organization Name(s) and Address(es) U.S. General Accounting Office 441 G Street NW, Room LM Washington, D.C. 20548	Performing Organization Report Number GAO-02-898r	
	Sponsoring/Monitoring Agency Name(s) and Address(es)	
		Sponsor/Monitor's Acronym(s)
		Sponsor/Monitor's Report Number(s)
Distribution/Availability Statement Approved for public release, distribution unlimited		
Supplementary Notes		
Abstract see report		
Subject Terms		
Report Classification unclassified	Classification of this page unclassified	
Classification of Abstract unclassified	Limitation of Abstract SAR	
Number of Pages 12		

Since our April 2001 report, total program cost estimates have increased from \$1,209.0 million to \$1,365.2 million, an increase of \$156.2 million. This increase is principally the result of the large number of design modifications resulting from developmental testing and restructuring the program to add a low-rate initial production phase. In addition, the costs for the towed artillery digitization (TAD) increased by about \$51 million because (1) the complexity of developing the software and integrating TAD with the howitzer was underestimated, (2) the amount of planned testing has been increased, and (3) the TAD development contract was placed under BAE.

Technical problems—such as the durability of the optical fire control, bore sight retention, and accuracy—cited in our April 2001 report and more recently raised by the services' testing organizations have been addressed through design changes. However, some of these changes have not yet been tested, and the Marine Corps Operational Test and Evaluation Activity (MCOTEA) has yet to review test data that the program office believes shows the howitzer has met accuracy requirements.

Additional information is being collected for the upcoming decision on whether the program should enter low-rate initial production. Such information includes (1) the final results from the operational assessment; (2) the results from the program office's planned testing of the strength and accuracy of the first pilot production howitzer; and (3) an assessment from independent contractors on production readiness and the cost to complete production of the howitzer.

The Department of Defense provided written comments that were technical in nature to a draft of this report. We incorporated those comments as appropriate.

Background

The 155 mm Lightweight Howitzer is intended to be a lighter, more transportable, and mobile weapon for strategic and tactical movements. Weapon performance requirements include a maximum weight of 10,500 pounds (about 5,500 pounds less than the M-198 towed howitzer it is to replace) and reduced time to place the weapon in a firing position compared with current weapons.

The Army-Marine Corps Lightweight Howitzer Joint Program Office directs the Lightweight Howitzer development program. The Army will assume program management responsibilities for the Lightweight Howitzer program upon completion of deliveries to the Marine Corps. The Army plans to buy 273 guns and the Marines plan to buy 377, which is less than their earlier plan to buy 413, due to the deletion of a requirement to store howitzers in caves in Norway and other fielding changes.

BAE is the Lightweight Howitzer prime contractor. Cannon barrels are being produced at the U.S. Army's Watervliet Arsenal under a separate contract and are to be provided as government-furnished equipment. The howitzer will eventually incorporate TAD, an onboard, precision, self-locating, and electronic aiming system. Until May 2002, General Dynamics was developing TAD under a separate contract for

the Army. As part of the most recent program restructuring General Dynamics is now producing TAD under a subcontract for BAE.

BAE has subcontracted about 70 percent of the howitzer’s production to the U.S. contractors listed in table 1.

Table 1: Major U.S. Subcontractors for the 155 mm Lightweight Howitzer

Subcontractor/location	Subcontracted component/activity
Rotek Inc., Florence, Kentucky	Traverse rack
Wegmann, Lynchburg, Virginia	Elevation assembly
Pacific Castparts Corp., Portland, Oregon	Titanium castings
Pacific Cast Technologies, Albany, Oregon	Titanium castings
Howmet Castings, Whitehall, Michigan	Titanium castings
Hydro-Mill, Inc., Chatsworth, California	Body assembly
Major Tool and Machine, Inc., Indianapolis, Indiana	Stabilizers, spades
Rock Island Arsenal, Rock Island, Illinois	Breach operating load tray system ^a
RTI International Metals, Inc., Niles, Ohio	Titanium
Seiler Instruments and Mfg., St. Louis, Missouri	Optical Fire Control

^a BAE plans to offer this work to the Rock Island Arsenal for pilot production gun 2 and low-rate initial production but only if the Army can reduce the Arsenal’s overhead rate enough to bring them into the competitive price range. For pilot production gun 1, BAE and Mitchell Aerospace of Canada are producing this assembly.

Source: Lightweight 155 mm Howitzer Joint Program Office.

Program Schedule Continues to Slip

Since we last reported on this program in April 2001, the program schedule for all key milestones dates has slipped for the howitzer because of inclusion of a low-rate initial production phase.²

In June 2001, the MCOTEA³ briefed the joint program office and advised them that the developmental guns were inappropriate for operational test and evaluation because they did not consider the developmental howitzers to be production representative. While the program office believed that the last four developmental guns would be production representative and had planned to use them for operational test and evaluation, MCOTEA told the program office that a production representative howitzer must:

² According to DOD Directive 5000.2, Operation of the Defense Acquisition System, low-rate initial production is intended to result in completion of manufacturing development in order to ensure adequate and efficient manufacturing capability and to produce the minimum quantity necessary to provide production configured or representative articles for initial operational test and evaluation, establish an initial production base for the system; and permit an orderly increase in the production rate for the system, sufficient to lead to full-rate production upon successful completion of operational (and live-fire, where applicable) testing. Directive 5000.2, para. 4.7.3.3.4.1.

³ Both MCOTEA and the Army Test and Evaluation Command are participating in the independent testing of the 155 mm gun; however, MOCTEA has been designated as the lead tester and in this role represents the views of both test activities when presenting briefings and other information regarding the testing of the 155 mm gun.

- be produced and assembled by contractors and subcontractors using components, manufacturing processes, and materials specified for the fielded system, and
- incorporate all engineering change proposals, system improvements and modifications resulting from analysis of developmental testing and operational assessment data to correct deficiencies in order to meet the requirements in the joint operational requirements document.

MCOTEA did not believe that the developmental howitzers met these criteria because they were produced in Great Britain exclusively by BAE and not built on the U.S. production line by U.S. subcontractors, and do not include all of the engineering changes resulting from developmental testing, including incorporation of castings. U.S. subcontractors are currently producing two pilot production howitzers to reduce production readiness risks related to establishing a U.S. production line. These guns also will be the first to include all of the design changes resulting from developmental and operational assessment testing and the first to be built with castings. Although these guns will be produced on U.S. production lines, MCOTEA does not believe these howitzers will be production representative because they will be given special handling and attention atypical of usual production line processes. Therefore, MCOTEA does not consider them suitable for operational testing. However, the Joint Program Office plans to test the first pilot production howitzer, which is scheduled for completion in July 2002. The Army Test and Evaluation Command will independently observe and assess the testing of the pilot production gun and provide the results of their assessment to MCOTEA, which will brief the results to the milestone decision authority, who will consider the results in making the low-rate initial production decision in October 2002.

In October 2001, in response to MCOTEA's concerns, the Joint Program Office restructured the program to provide production representative weapons for operational test and evaluation. The restructuring added low-rate initial production in place of full-rate production (Milestone C) and slipped the schedule for full-rate production by just over 2 years, as shown in table 2. In addition, the testing of the first production article was delayed by 4 months, and the initial fielding of this system by the Marine Corps and the Army was delayed an additional 8 months and 17 months, respectively.

Table 2: Comparison of Key Program Milestones

Key milestones	December 1998 schedule	December 2000 schedule	April 2002	Months delayed, December 1998 – December 2000 schedule	Months delayed, December 2000 – April 2002 schedule
Production Decision: Low Rate (Milestone C)	Not scheduled	Not scheduled	Oct. 2002 ^a	N/A	N/A
Production Decision: Full Rate	Sept. 2001 ^b	Sept. 2002	Oct. 2004	12	25
Production Contract Award: Low Rate	Not scheduled	Not scheduled	Nov. 2002	N/A	N/A
Production Contract Award: Full Rate	Oct. 2001	Oct. 2002	Nov. 2004	12	25
First Production Article Qualification Testing	Jan. 2003	Dec. 2003	Apr. 2004	11	4
Marine Corps Initial Fielding ^c	Nov. 2003	July 2004	Mar. 2005	8	8
Army Initial Fielding ^d	Mar. 2005	Mar. 2005	Aug. 2006	0	7

^a This is to be a decision on low-rate initial production; the full rate production decision is scheduled for October 2004.

^b In July 2000, the program office had slipped this date to March 2002.

^c Marine Corps initial fielding is defined to be about 38 guns for a battalion from both I & II Marine Expeditionary Force.

^d Army initial fielding is defined to be about six guns to support a troop battery in a light-division. Source: Lightweight 155mm Howitzer Joint Program Office.

Program Cost Estimates Continue to Increase

The most recent program office cost estimates, as of April 2002, show the total costs for the development and production of the howitzer and TAD program to be \$1,365.2 million—an increase of \$156.2 million from the program office’s February 2001 estimate of \$1,209.0 million.⁴ Details of these cost increases are shown in table 3.

⁴ We reported in April 2001 that the program office’s total cost estimate, as of February 2001, was \$1,250.2 million. This estimate included \$492.1 million for the estimated production of the Army’s howitzers and TAD. However, the program office told us recently that they had overstated this cost by \$41.2 million, thus the cost they should have provided to us for inclusion in our April 2001 report was \$450.9 million. Therefore, we are using \$450.9 million as the baseline for this report and are adjusting the total cost estimate accordingly.

Table 3: Increases in Estimated Development and Production Costs of the Howitzer and Towed Artillery Digitization

Then-year dollars in millions

Program	February 2001	April 2002	Cost increase from February 2001 to April 2002
US Marine Corps Lightweight Howitzer RDT&E	\$162.8	\$178.5	\$15.7
US Marine Corps Lightweight Howitzer and Towed Artillery Digitization Upgrade Production	543.0	621.0	78.0
Army Towed Artillery Digitization Upgrade RDT&E	52.3	103.6	51.3
Army Lightweight Howitzer and Towed Artillery Digitization Upgrade Production	450.9	462.1	11.2
Total	\$1,209.0	\$1,365.2	\$156.2

Source: Lightweight 155mm Howitzer Joint Program Office.

The cost of the howitzer developmental program funded by the Marines increased from \$162.8 million to \$178.5 million or an increase of \$15.7 million. This increase includes \$6 million for extending the program by 2 years, \$4.5 million for testing of the pilot production guns, \$2 million for operational testing, \$1.5 million for program management, and \$1 million for in-house systems engineering.

The cost of the howitzer and the TAD production program funded by the Marines increased from \$543 million to \$621 million, an increase of \$78 million. More than half of this increase, about \$43 million, was for about 1,000 design modifications that have been made to the howitzer during development. The cost increase also includes about \$28 million in other program costs including inflation due to program extension as well as \$7 million for increases in the costs of cannon barrels produced by the Watervliet Arsenal.

The cost of the TAD developmental program funded by the Army increased from \$52.3 million to \$103.6 million, an increase of \$51.3 million. According to a program official, TAD development costs increased because (1) the complexity of developing the software and integrating TAD with the howitzer was underestimated, (2) the amount of planned testing has been increased, (3) the gun was hardened, and (4) the TAD development contract was placed under BAE. Thus, the costs associated with these activities are higher than originally planned. The acquisition of TAD has been restructured. First, to centralize the development and integration of the howitzer and TAD, the Army's development contract with General Dynamics for TAD has been moved under BAE, the prime contractor for the howitzer. Second, TAD is being funded and developed in two blocks. The current program includes the funding for the development and production of the block 1. The block 1 digital fire control is to be capable of automatically determining gun location, accurately aiming and pointing the gun, providing navigation instructions, digital communications, and providing directions for gun emplacements. About 10 percent of the software required to complete TAD will be needed for block 1 while the remaining 90 percent will support block 2. When funded and developed, Block 2 of TAD is to provide the gun with

greater digital communication connectivity and allow onboard technical computation of firing data that will ultimately increase accuracy through integration of individual propellant temperatures and individual gun muzzle velocity measurement systems.

The cost of the TAD and howitzer production program funded by the Army increased from \$450.9 million to \$462.1, or by \$11.2 million. This increase is primarily the result of the numerous design modifications made to the howitzer during development and increases in the cost of the cannon barrels produced by the Watervliet Arsenal.

Technical Problems Being Addressed, but Testing Is Still Ongoing

The program office believes that all technical problems that MCOTEA and we identified have been addressed. In our April 2001 report, we identified a number of technical problems impacting the performance of the 155 mm gun, all of which the program office had resolved or was attempting to resolve through design changes. More recently, MCOTEA identified a number of technical issues that it believed would jeopardize the successful completion of the operational test and evaluation of the 155 mm gun if not resolved. According to MCOTEA, the program office has addressed all but one of the issues identified by MCOTEA, primarily through design changes, some of which have been tested while others have yet to be tested. The one issue still outstanding relates to the accuracy of the gun.

In our April 2001 report, we focused on seven technical problems: (1) insufficient spade size, (2) flexure of the saddle assembly causing accuracy and bore sight retention problems, (3) faulty titanium welding processes, (4) spade cracking, (5) faulty spade latch, (6) spade damper that did not operate well in all soil types, and (7) durability of the optical fire control. According to the program office, design changes had been incorporated to correct these problems although not all had been field-tested when we issued our report.

During our current review, we focused on the nine issues that MCOTEA believed would jeopardize the successful completion of operational test and evaluation on the 155 howitzers. These issues were (1) bore sight retention, (2) accuracy, (3) durability of the optical fire control, (4) spades, (5) design stability, (6) production representative howitzers, (7) compressed test schedule, (8) weapon balance, and (9) logistics demonstration schedule and products.

MCOTEA told us that the program office has resolved all of their concerns except accuracy through design changes, additional or planned testing, and the addition of a low-rate initial production phase to provide production representative howitzers for operational testing and evaluation.

According to the program office, the objective accuracy requirement for the 155 mm howitzer is 1 mil using the TAD Block I inertial measurement system to do the

electronic aiming and pointing; that is, the gun's barrel and optical sight must always be pointed within 1 mil of the same direction.⁵ The accuracy requirement for the gun without TAD is 3 mils. However, the initial developmental guns were so flexible that after the guns were elevated or moved from side to side, the guns lost bore sight retention, with the barrels and optical sights in some cases differing by 12 to 13 mils of pointing in the same direction. In addition, thermal effects caused the optical sights to move relative to the barrel, causing the gun to lose bore sight.

The program office has made a series of design changes to the howitzer that has improved its accuracy. For example, the parts of the gun holding the cannon barrel have been stiffened, which has reduced the flexure allowed by the lightweight titanium and insulation has been added to mitigate the thermal effects. These and other changes have increased the accuracy level to within 3 mils. During December 2001, February 2002, and April 2002, Yuma Proving Grounds conducted three separate accuracy tests with a developmental gun. A contractor for the Army Test and Evaluation Command observed and determined the results of the three tests. The gun failed to meet the 3-mil accuracy requirement for the first test because a reconditioned fire control unit was used. However, a new fire control unit was installed on the gun prior to the second test and the gun met the 3-mil accuracy requirement for last two tests. The program office has made other design changes that are to be incorporated into the pilot production guns and that they believe will further improve the gun's accuracy. For example, a titanium balancer post (mounting point for the optical sight) is to be substituted for the existing aluminum post on pilot production gun 2 to further reduce flexure.

MCOTEA told us that their concerns related to accuracy will not be resolved until after they have assessed (1) the developmental test data that the program office believes confirms the accuracy of the developmental guns at 3 mils and (2) the Army Test and Evaluation Command's report on its observations and assessment of the Joint Program Office's testing of the first pilot production gun for accuracy and strength of design. These tests on the first pilot production gun are scheduled to occur starting in August 2002.

Additional Information Being Collected for Low-Rate Initial Production Decision

While progress has been made in addressing technical problems identified as part of developmental testing, additional information is being collected for the upcoming decision on whether the program should enter low-rate initial production. The milestone decision authority--the Assistant Secretary of the Navy for Research, Development, and Acquisition--intends to factor in the final results from the operational assessment, the planned testing of the pilot production gun, and the independent contractor assessments of production readiness and costs.

⁵ A mil is short for "milliradian", which is an angular measurement that is 1/1000th of a radian. A radian is 57.3 degrees of the arc of a circle; 17.7 mils equal 1 degree.

To determine the readiness of the program to enter low-rate initial production in October 2002, the Assistant Secretary of the Navy for Research, Development, and Acquisition—the milestone decision authority—established the following criteria:

- Complete an independent production readiness assessment and present the results to the Acquisition Coordination Team.
- Submit an independently validated research, development, testing, and evaluation, and production cost estimate 30 days prior to the Milestone C decision meeting.
- Provide the milestone decision authority with test results confirming the strength of design of the Pilot Production gun per the International Test Operating Procedure for Artillery.

To demonstrate the first criterion, the program office told us that it has contracted with the Best Manufacturing Practices Center to complete an independent readiness assessment. According to the program office, BAE and its subcontractors are currently producing two pilot production guns (the first gun is to be completed by July 2002); the intent of this production is to demonstrate production readiness. The Center will assess the adequacy of production facilities and equipment put in place by BAE and each subcontractor to produce the pilot production guns. The Center will also assess the skill levels of production personnel and the processes and controls being used to ensure production takes place in accordance with specifications and other requirements.

To meet the second criterion, the program office told us that it has contracted with the Science Applications International Corporation (SAIC) to independently compile a research, development, test, and evaluation and production cost estimate for completing the program. According to the program office, SAIC plans to develop the cost estimate by loading program office cost data into its own cost models. The Army and Navy cost analysis centers are to verify SAIC's cost estimate.

To address the third criterion, the program office will test the first pilot production gun for accuracy and strength of design. This testing is to be independently observed and assessed by the Army Test and Evaluation Command and reported to MCOTEA, which is to brief the results to the Assistant Secretary of the Navy. In addition, the Assistant Secretary is to consider the results of the operational assessment in determining whether the program is ready for low-rate initial production.

Agency Comments and Our Evaluation

The Department of Defense provided written comments that were generally technical in nature on a draft of this report. We incorporated those comments as appropriate.

Scope and Methodology

To determine progress in meeting program schedule and cost estimates, we interviewed officials of the program office, Picatinny Arsenal, Picatinny, New Jersey, and obtained, reviewed, and analyzed data. These data include key acquisition milestones dates, acquisition schedules, and budget requirements program funding documents. We compared these data to information previously provided by program office officials. We also met with officials from the Assistant Secretary of the Army for Acquisitions, Logistics, and Technology; the Assistant Secretary of the Navy for Research, Development, and Technology; the Marine Corps Combat Development Command, Quantico, Virginia; and the Marine Corps Operational Test and Evaluation Activity, Quantico, Virginia.

In examining technical difficulties affecting the program, in addition to meeting with and obtaining information, including test reports, from program office officials listed above, we held discussions with MCOTEA and ATEC representatives performing the testing, and observed a test firing session of the howitzer at 29 Palms, California.

To determine readiness for entry in to low-rate initial production, we reviewed the Department's low-rate initial production criteria, discussed this issue with program office and testing officials, and reviewed the program office's entrance criteria.

We conducted our work from March through June 2002 in accordance with generally accepted government auditing standards and generally relied upon agency-provided data.

Unless you publicly announce the contents of this report earlier, we plan no further distribution of this letter until 30 days after the date of this letter. At that time, we will send copies of this letter to the Secretary of Defense; Secretary of the Navy; Commandant of the Marine Corps; Secretary of the Army; Director, Office of Management and Budget; and interested congressional committees. We will also make copies available to other interested parties upon request. In addition, the report will be available at no charge on the GAO's Web site at <http://www.gao.gov>.

If you have any questions, or need additional information, please call me at (202) 512-4841. Major contributors to this letter are Jim Solomon, Ted Baird, Joe Dewechter, and Gary Middleton.

A handwritten signature in black ink that reads "R E Levin". The letters "R" and "E" are in all caps and are spaced apart from "Levin", which is in title case.

R. E. Levin
Director
Acquisition and Sourcing Management



ACQUISITION,
TECHNOLOGY
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22 JUL 2002

Mr. Robert E. Levin
Director, Acquisition and Sourcing Management
U.S. General Accounting Office
441 G Street
Washington, D.C. 20548

Dear Mr. Levin:

This is the Department of Defense (DoD) response to the GAO Draft Report, "2002 Update of the 155mm Lightweight Howitzer," dated June 27, 2002 (GAO Code 120146/GAO-02-898R). While the draft report does not make any recommendations, the DoD desires to provide general and specific comments which, if accepted, would improve the technical accuracy of the draft report. These comments are provided in the enclosure.

The DoD appreciates the opportunity to comment on the draft report.

Glenn F. Lamartin
Director
Strategic and Tactical Systems

Enclosure
as stated

