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United States General Accounting Office
Washington, DC 20548

April 10, 2001

The Honorable Lane Evans
House of Representatives

Subject: Status Update of the New 155 mm Lightweight Howitzer

Dear Mr. Evans:

In July 2000, we issued a report to you and several other members of Congress describing problems with the new 155 mm Lightweight Howitzer program.¹ The new 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 correspondence responds to your request of December 2000 that we continue to monitor and report on this program due to your continued concerns about its schedule, cost, and technical difficulties.

RESULTS IN BRIEF

Since our July 2000 report, all key milestones except one have continued to slip. For example, acceptance of the first developmental howitzer slipped an additional 5 months from June to November 2000, and delivery of the remaining 7 developmental howitzers was delayed an additional 5 to 10 months. The production decision has slipped from March 2002 to September 2002 and the initial fielding of the new howitzer by the Marine Corps has slipped another 8 months to July 2004 or 28 months from the date set at the original contract award. The initial fielding of the howitzer to the Army remains unchanged at March 2005.

Since July 2000, total program cost estimates have increased from \$1,129.9 million to \$1,250.2 million, an increase of \$120.3 million.² This increase is principally the result of restructuring the developmental contract which added \$20.2 million and an approximately \$100 million increase for an electronic aiming system.

¹ See *Defense Acquisitions: Howitzer Program Experiencing Cost Increases and Schedule Delays* (GAO/NSIAD-00-182, July 28, 2000).

² All fiscal year 2002 cost estimates are predecisional, as the President's fiscal year 2002 budget has not yet been submitted to the Congress.

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Abstract Since our July 2000 report, all key milestones except one have continued to slip. For example, acceptance of the first developmental howitzer slipped an additional 5 months from June to November 2000, and delivery of the remaining 7 developmental howitzers was delayed an additional 5 to 10 months. The production decision has slipped from March 2002 to September 2002 and the initial fielding of the new howitzer by the Marine Corps has slipped another 8 months to July 2004 or 28 months from the date set at the original contract award. The initial fielding of the howitzer to the Army remains unchanged at March 2005. Since July 2000, total program cost estimates have increased from \$1,129.9 million to \$1,250.2 million, an increase of \$120.3 million. 2 This increase is principally the result of restructuring the developmental contract which added \$20.2 million and an approximately \$100 million increase for an electronic aiming system.		Monitoring Agency Acronym
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In our July report, we focused on three technical problems—insufficient spade size (devices that anchor the howitzer in the ground to stabilize the gun during firing), instability of the saddle (the part of the howitzer in which the cannon barrel rests), and faulty titanium welds. The Program Office reports that the contractor has enlarged the spade and tests at Yuma on the first developmental gun have verified it is now properly sized; the new saddle design was recently successfully field tested in the United Kingdom; and one weld was repaired on site and a second faulty crack continues to be monitored. We also focused on four additional technical problems during our current review. The first is a problem with the cracking of the spades. The second is a problem with loose spade latches that create difficulties in removing the spades from the ground. The third is with a device—the spade damper—intended to help the spade dig into the soil to stabilize the gun, but which does not work properly in all soil types. The fourth problem involves the durability of the optical sight being developed for the gun. According to Program Office officials, design solutions have been identified for each of these new problems. These design changes have not been fully incorporated and field tested to date.

Program officials provided oral comments that were generally technical in nature to a draft of this correspondence.

BACKGROUND

The new 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 9,000 pounds (7,000 pounds less than M-198 towed howitzer it is to replace), reduced time to place the weapon in a firing position, and an increased rate of fire compared with current weapons.

The Army-Marine Corps Lightweight Howitzer Joint Program Office directs and funds 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 413.

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 the towed artillery digitization upgrade, a precise location and targeting system being developed by General Dynamics for the Army under a separate contract as government-furnished equipment.

BAE is currently planning to subcontract 70 percent of the howitzer's production to subcontractors in the United States listed in table 1.

Table 1: Major United States Subcontractors for the New 155 mm Lightweight Howitzer

Subcontractor/location	Subcontracted component/activity
United Defense LP, Pascagoula, Mississippi	Final Assembly, Test, and Delivery
HydroMill, Inc., Chatsworth, California	Body Assembly
Major Tool and Machining, Inc., Indianapolis, Indiana	Stabilizers, Spades, Trails
Rock Island Arsenal, Rock Island, Illinois	Breach Operating Load Tray System
RTI International Metals, Inc., Niles, Ohio	Titanium

Source: Lightweight 155 mm Howitzer Joint Program Office

PROGRAM SCHEDULE CONTINUES TO SLIP

Since the program inception and since we last reported on this program in July 2000, the program schedule for all key milestones dates have slipped for the howitzer, except one. The schedule for the towed artillery digitization upgrade will also slip.

In December 2000, the Joint Program Office restructured the development program consistent with the new contract with BAE.³ The restructuring slipped the schedule even further beyond the already delayed schedule estimates from December 1998, as reflected in table 2. For example, acceptance of the first developmental howitzer was delayed by an additional six months, the production decision (Milestone III) and contract award were delayed by an additional 12 months, and initial fielding of this system by the Marine Corps was delayed an additional 8 months. Initial fielding of the howitzer by the Army remained unchanged at March 2005.

³ The restructuring was retroactive to June 2000.

Table 2: Comparison of Key Program Milestones Since the Original Schedule

Key Milestones	Original February 1996 schedule	December 1998 schedule	December 2000 schedule	Months delayed since original 1996 schedule	Months delayed since December 1998 schedule
First Test Article Acceptance (first developmental howitzer)	June 1998	May 2000	November 2000	24	6
Production Decision (Milestone III)	December 1999	September 2001 ⁴	September 2002	33	12
Production Contract Award	December 1999	October 2001	October 2002	34	12
First Production Article Qualification Testing	March 2001	January 2003	December 2003	33	11
Marine Corps Initial Fielding ⁵	March 2002	November 2003	July 2004	28	8
Army Initial Fielding ⁶	March 2005	March 2005	March 2005	No change ⁷	No change ⁷

Source: Lightweight 155mm Howitzer Joint Program Office

Delivery of all developmental howitzers has also slipped since our last report in July 2000. Table 3 below shows that all eight developmental howitzers were to be delivered by February 2001 but only one of the eight developmental howitzers has been delivered. In addition, delivery of the remaining seven has been delayed from an additional 5 to 10 months. Program Officials told us that it was a conscious decision to delay delivery of the last four howitzers for operational testing in order to implement changes resulting from developmental testing.

⁴ In July 2000, the program office had slipped this date to March 2002.

⁵ Marine Corps initial fielding is defined to be about 38 guns for a battalion from both I & II Marine Expeditionary Force.

⁶ Army initial fielding is defined to be about 6 guns to support a troop battery in a light-division.

⁷ While the overall program has been significantly delayed, program officials believe the original Army initial fielding date of March 2005 is achievable, in part, due to the likelihood that a small number of guns can be delivered to support a troop battery.

Table 3: Comparison of Original and Revised Delivery Dates for Developmental Howitzers

Developmental Howitzer (unit number)	Original delivery date	Revised delivery date (as of May 2000)	Current delivery date	Months delayed from original delivery date	Months delayed since May 2000
1	May 2000	June 2000	Acceptance November 2000 ^s	6	5
2	May 2000	October 2000	April 2001	11	6
3	June 2000	November 2000	June 2001	12	7
4	June 2000	January 2001	June 2001	12	5
5 – 8	October 2000	February 2001	December 2001	14	10

Source: Lightweight 155mm Howitzer Joint Program Office

The schedule delays have been caused by the need for engineering changes and corrective action to address problems found during manufacturing and initial contractor and government testing at Yuma Proving Grounds on the first developmental gun. These problems included difficulties with the design of the spades, which dig into the ground to stabilize the weapon during firing; the stiffness of the saddle assembly which holds and supports the cannon barrel; and difficulties with the titanium welding process.

The initially designed spades were too small to firmly anchor the howitzer into the ground, causing excessive movement during firing. The original saddle assembly design created pointing accuracy problems when the howitzer was fired from sloping ground. As for the titanium welding problems, the first developmental gun experienced two instances of faulty welds, one of which required repair. Details on BAE’s efforts to address these problems will be discussed in a later section.

According to Program Office officials, the Army’s towed artillery digitization upgrade, a precise location and targeting system, is also experiencing significant schedule delays primarily due to software development. According to these officials, the winning contractor for the digitization program assumed in its bid that about 90 percent of the software written for another cannon program could be re-used for the digitization program. The contractor just recently performed a detailed analysis of the software for the other program and determined that only 70 percent to 80 percent of this software could be re-used for the digitization program. According to Program Office officials, more new code will have to be written than originally estimated resulting in the need to restructure the digitization program. The Program Office is currently developing alternative courses of action for consideration by the users and the program executive officer. Because no course of action has yet been adopted, cost and schedule projections have not been made. However, a Program Office official stated that since the howitzer is designed to initially operate with an optical

^s The first developmental howitzer was delivered in June 2000. However, according to Program Office officials the gun required additional testing and modifications by the contractor before it was accepted in November 2000.

sighting system, rather than a digitized system, any schedule slippage in the towed artillery digitization upgrade will not affect the howitzer's schedule.

PROGRAM COST ESTIMATES CONTINUE TO INCREASE

The most recent Program Office cost estimates, as of February 2001, show the total costs for the development and production of the howitzer and the digitization program to be \$1,250.2 million—an increase of \$120.3 million from the Program Office's July 2000 estimates. All fiscal year 2002 cost estimates are predecisional—that is they are not yet final nor approved—because the President has not submitted his fiscal year 2002 budget request to the Congress. Details of these cost increases are shown in table 4.

Table 4: Increases in Estimated Development and Production Costs of the New Howitzer and Towed Artillery Digitization

Then-year dollars in millions

Program	July 2000	February 2001	Total program cost increase from July 2000 to February 2001
US Marine Corps Lightweight Howitzer RDT&E	\$142.6	\$162.8	\$20.2
US Marine Corps Lightweight Howitzer and Towed Artillery Digitization Upgrade Production	492.6	543.0	50.4
Army Towed Artillery Digitization Upgrade RDT&E	43.8	52.3	8.5
Army Lightweight Howitzer and Towed Artillery Digitization Upgrade Production	450.9	492.1	41.2
Total Budget	\$1,129.9	\$1,250.2	\$120.3

Source: Lightweight 155mm Howitzer Joint Program Office

The howitzer developmental program funded by the Marine Corps increased by \$20.2 million. This increase primarily represents the restructuring of the BAE development contract for the howitzer. The estimated contract cost increased \$22.4 million, from \$43.4 million to \$65.8 million, when the contract was restructured from a cost-plus-incentive fee contract into a cost-sharing contract.⁹ According to Program Office officials, the increase of \$22.4 million includes \$5.0 million required for the addition of two pilot production guns; \$8.5 million for risk reduction efforts; integration of the cannon barrels and towed artillery digitization upgrade (government-furnished equipment) and long-lead costs; and \$8.9 million for extending the program by one year.

⁹ The cost increase of \$22.4 million includes \$2.2 million contributed by Italy for the development of the howitzer. Therefore, the total increase in U.S. cost of the howitzer development program is \$20.2 million.

According to Program Office officials, while the Marine Corps has always had the same requirements for its towed artillery digitization upgrade production program, it had not included all funding necessary to meet its full requirements in previous cost estimates. By including all necessary funding for full requirements for the first time in its February 2001 estimates, an additional \$50.4 million for the Marines' towed artillery digitization program is reflected in estimated program costs. The \$8.5 million increase in the Army's digitization development program resulted from the additional costs that will be required to refurbish, after their use for operational testing, four of the developmental guns needed by the digitization program for testing purposes.

Program Office officials also reported that the Army increased its cost estimate by \$41.2 million for the production of the howitzer and digitization program. During our discussions with Program Office officials, they said that they did not know why this increase occurred.

According to Program Office officials, the estimated cost of the cannon barrel is included in the howitzer production costs. These officials said that the cost of cannon barrels has fluctuated from \$106,000 to \$334,000, depending on the workload at Watervliet Arsenal. The most recent estimate for the cannon barrels is between \$200,000 and \$224,000.

TECHNICAL PROBLEMS CONTINUE TO BE IDENTIFIED

In our July 2000 report, we focused on three major problems: (1) insufficient spade size, (2) flexure of the saddle assembly, and (3) faulty titanium welding processes. BAE has made efforts to address these problems. We have identified four additional technical problems during our current review that had not been identified in July 2000—spade cracking, spade latch, spade damper, and optical sighting difficulties.

Initial Technical Problems

Based on the results of tests made on the prototypes of the lightweight howitzer prior to July 2000, BAE determined that the spades were not large enough to securely anchor the weapon into the ground during firing in all soil conditions. The spades are critical to the operation of the howitzer because they are designed to dig about six inches into the ground to stabilize the gun during firing. To solve the spade size problem, BAE enlarged the spades and installed them on the first developmental weapon. A Program Office official told us that live-fire testing of the first developmental weapon at Yuma has confirmed that the spades are now large enough to anchor the weapon as required.

BAE has stiffened the saddle assembly—now termed “fat boy”—and the cradle to address problems with the howitzer's accuracy and stability. The saddle assembly, along with the cradle, holds and supports the cannon barrel. Program Office officials told us before the saddle assembly and cradle were stiffened, the fire control system

(optical sights) would not remain aligned with the barrel of the howitzer (boresight retention) at high elevation or severe side-leaning conditions because the gun was too flexible. BAE also reports adding two shims that are intended to reduce offset errors and a new thermally insulated linkage rod to counter different thermal expansion effects between adjacent aluminum and titanium components. The stiffened saddle and cradle have been installed on the second developmental howitzer (scheduled for delivery in April 2001) and tested in the factory on level and sloping surfaces. Program Officials report that this redesigned howitzer met accuracy requirements during the recent preliminary field testing in the United Kingdom.

A February 2000 inspection of the first developmental howitzer being manufactured by BAE revealed quality problems with the welding process of some titanium parts. As a result, BAE revised its manufacturing processes related to titanium welding. Nonetheless, initial field testing of the first developmental howitzer resulted in two indications of titanium weld cracking. Program Officials report that one of the cracks was repaired on-site and that they are continuing to monitor the second crack.

BAE is considering casting, the process of building molds for parts and pouring molten metal into the molds to form the parts, from 30 to 40 of the gun parts that would have been fabricated by welding pieces of the metal together. The introduction of castings will cause welding requirements to decline; however, none of BAE's current United States subcontractors selected for production of the gun is capable of producing castings. BAE has identified at least five potential casting suppliers, who are currently developing quotes, cost estimates and delivery schedules based on casting concepts approved by BAE, for providing titanium castings. BAE is currently determining which castings will be incorporated into the production of the two planned pilot production guns. Program Office officials told us that BAE has been working with two casting producers under a technology assistance agreement and expects to finalize casting contracts within the next 30 days. The integrated program master schedule indicates that the first pilot production gun that is to include castings is scheduled to be live fire tested in March 2002.

New Technical Problems

While enlarging the spade has reportedly addressed the problem we identified in July 2000, three new problems with the spade have been identified. In August 2000, testing of the enlarged spade disclosed that the spade cracked in the lower portion of its blade when the howitzer was fired in very hard soil. To solve the cracking that was occurring in the spades, BAE made 14 design modifications that essentially strengthened and reshaped the spades but added no weight. This redesign is to be incorporated on the seven undelivered developmental guns still in production and the first developmental testing howitzer. The Program Office is confident that these changes will address the spade cracking problem, however these changes to the spade have not been field-tested to date.

Testing of the first developmental gun at Yuma Proving Grounds in December 2000 and January 2001 revealed that the latches used to release tension from the spade so

it can be removed from the ground were becoming loose during firing of the gun. This causes difficulty in removing the spades from the ground. This problem occurred several times and is classified in test incident reports as a major problem that still requires corrective action. Although Program Office officials told us that a corrective action has been developed and will be incorporated on howitzers to be delivered in the future, during our site visit to observe a field test of the howitzer in March 2001, a Program Office official identified this as a continuing problem. Current plans are to conduct tests on the spade latch improvements prior to safety testing in June 2001.

In addition, testing at Yuma identified another problem related to the operation of the spades involving the spade damper. The spade damper is a device that allows the trail arm¹⁰ to compress against the howitzer body during firing, orienting the spade for proper digging into the ground to stabilize the gun during subsequent firings. Firing tests revealed that the damper did not always allow the trail arm to properly compress against the howitzer body in all soil types. The howitzer is tested in soil types varying from sand to hardpan/rock. The damper was designed with only a single setting for all soil types. The Program Office is considering a new design that would provide two settings for the spade damper that howitzer operators could choose from depending upon soil type. Program Office officials report that modifications will be incorporated in the howitzers scheduled to be delivered on and after June 2001, and then retrofitted on earlier delivered howitzers.

Another new technical problem involves the optical sight that is being developed for the new howitzer. According to a Program Office official, the lightweight howitzer program is modifying the M-198 howitzer optical sight and plans to use it on the new howitzer until the Army's towed artillery digitization upgrade program reaches full development. It will be retained as a backup when the digital fire control becomes available. However, the greater stresses created by the new howitzer, which result from the lighter weight of the howitzer has proven damaging to the optical sight. A redesign of the optical sight was recently completed, which Program Office officials report has operated successfully in factory testing. The new optical sight will not be tested in live-fire conditions until after the second developmental gun is delivered in April 2001. A Program Office official told us that the accuracy of the gun could not be determined until all of the redesigns and the optical sight have been tested under live-fire conditions.

AGENCY COMMENTS

Representatives of the Program Office, as well as both the Departments of the Army and Navy provided oral comments that were generally technical in nature to a draft of this correspondence. We incorporated these technical changes as appropriate.

¹⁰ The trail arm is an extension that extends outward from the base of the howitzer to give it more stability.

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 for the delivery of the eight developmental howitzers, and preliminary fiscal year 2002 budget requirements program funding documents. We compared these data to information previously provided by Program Office officials. We also met with officials from the Office of the Under Secretary of Defense for Acquisitions, Technology, and Logistics, the Departments of the Army and Navy, Washington, D.C.; and the Marine Corps Systems Command, 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 representatives performing the testing, and observed a test firing session of the howitzer at Yuma Proving Grounds, Yuma, Arizona.

We conducted our work from February through March 2001 in accordance with generally accepted government auditing standards and generally relied upon agency-provided data.

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 Honorable Donald H. Rumsfeld, Secretary of Defense; the Honorable Robert B. Pirie, Acting Secretary of the Navy; General James L. Jones, Commandant of the Marine Corps; the Honorable Joseph W. Westphal, Acting Secretary of the Army; the Honorable Mitchell Daniels, Director, Office of Management and Budget; and interested congressional committees. The letter will also be available on GAO's home page 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 James Solomon, Ted Baird, Steve Martinez, and Lee Carroll.

Sincerely yours,



R. E. Levin
Director
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(120042)

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