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Unclassified Version of a November 1989 Report to the Chairman, Committee on Armed Services, House of Representatives

February 1990

ABRAMS TANK

Block II Modifications Not Ready to Enter Production

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The Honorable Les Aspin
Chairman, Committee on Armed Services
House of Representatives

Dear Mr. Chairman:

This report is the unclassified version of the classified report we provided you in November 1989 in response to your request that we review the Army's plans to modernize the Abrams tank. We have also provided your staff with several briefings on the program.

At the time of our review and initial reporting, the Army planned to make a production decision on the Block II modification program in August 1991. It had requested procurement funds in the fiscal year 1990 budget for long-lead and nonrecurring items. In our report, we made a recommendation to the Secretary of Defense that he withhold approval of the obligation of Block II procurement funds for the Block II program pending certain Army actions.

Although the Department of Defense agreed in principle with our recommendations, it believed that requirements already placed on the Army would provide adequate information to make an appropriate decision at the milestone III production review. Our concern at that time, however, was that procurement funds would be obligated before further review by the Secretary of Defense.

Since we issued our classified report, the Secretary of Defense has submitted his fiscal year 1991 budget. The budget reflects significant changes to the Block II program. The Secretary has requested funding for only 62 Block II-modified Abrams tanks; subsequently he plans to terminate Abrams production. This number falls far short of the 2,926 Block II-modified tanks that the Army originally planned to procure. The per-tank cost would also be much higher than the approximately $3 million per-tank cost estimated for the total program.

We have not revised this report to take these new actions into consideration. The information contained in the appendix reflects the program status as of August 1989. However, we believe that the issues we raise will contribute to congressional deliberations during the coming budget debates.

EXECUTIVE SUMMARY

PURPOSE

The Army requested $166 million in advanced procurement funding for fiscal year 1990 to produce a costly and significantly modified Abrams M1A1 tank, which is the most recently fielded tank of the M1 series. The Army believes that such a tank, which will be called the "M1A2," is needed as an interim response to future Soviet threats. The tank will be produced in limited quantities until fiscal year 1997, when the Army plans to begin production of a dramatically different tank, which may or may not be based on the Abrams design.

The House Committee on Armed Services asked GAO to examine the Army's justification for the M1A2 tank program to evaluate

-- whether the improved performance the Army expects of the proposed modification package can be realized;

-- whether the Army's acquisition strategy allows for adequate testing and evaluation to be performed before production decisions must be made; and

-- what impact, if any, the program will have on future tank modernization.

BACKGROUND

The Army's current tank upgrade package, called the "Block II program," represents the third in a series of block modifications to the Abrams tank. Full-scale development of an integrated system began in December 1988, although individual components have entered full-scale development at different times. The program will go directly from development into full-rate production as the M1A2 tank in fiscal year 1991. The five new components the Army has approved for production in the M1A2 tank include a commander's independent thermal viewer, additional armor, an improved commander's weapons station, a carbon dioxide laser range finder, and a position/navigation system. The Army believes that these modifications will improve the commander's ability to acquire targets, better protect the crew, increase precision gunnery, and help tank crews navigate on the battlefield. New software will be required to connect the Block II digital components together and to the existing analog components.

The Army also plans to incorporate other changes into the M1A2 tank. One significant change, to the fire control system, will allow the incorporation of munitions from the Army's Armament Enhancement Initiative program.

results until after the M1A2 enters production. These problems may prevent the Army from reaching its performance goals, and solving them may lead to program delays.

Block II Program Raises Affordability Concerns

The Army's program has raised affordability concerns because proposed costs of the Army's preferred program are higher than the ceiling established by the Office of the Secretary of Defense. In addition, the Army has recently requested an additional $95 million to complete development, which adds to these concerns.

The estimated costs of the Block II modifications add about 20 percent to the price of the current tank. These estimates appear accurate. However, Block II program production costs exceed the currently approved production cost ceiling of $3.037 million per tank set by the Office of the Secretary of Defense in August 1989. That amount is enough to produce the commander's independent thermal viewer and the improved commander's weapons station in a core configuration, but not the other three components. Unless costs can be reduced, additional funding will be required if the Army is to meet annual procurement objectives mandated by the Office of the Secretary of Defense. Further, a tank with fewer modifications than planned calls into question the magnitude of the M1A2's effectiveness gains as demonstrated in the Army's cost and operational effectiveness analysis.

The Army believes that it can reduce the cost of the currently produced tank by the time the Block II modifications enter production in 1992 and apply these reductions to production of the Block II tank. However, GAO questions the validity of these cost reductions.

Compressed Acquisition Schedule Is Risky

The Block II program is predicated on the Army's ability to field a tank in advance of the future Soviet tank threat projected for the mid-1990s. This requires an acquisition strategy that calls for committing advanced production funds before test information is available. Although component-level testing of individual modifications will have taken place when the Army makes a production decision, the critical unknown factor is how these components will operate as a system. Testing of the fully developed system will not be completed when the Army makes advanced procurement decisions. In addition, the overall development schedule, which allows very little time to identify and correct problems, may deny the Army needed performance data at the time of the critical production decision. The absence of a period of low-rate initial production will further increase the Department of

-- the Army is able to demonstrate the cost-effectiveness of the system, using a current assessment of armor protection and threat capabilities and realistic tactical and tank crew-fighting assumptions in a new cost and operational effectiveness analysis, and

-- the Army modifies its acquisition strategy to allow time to complete and evaluate live-fire and operational testing and to take corrective actions before beginning production of the Block II modifications.

AGENCY COMMENTS AND GAO'S EVALUATION

The Department of Defense provided official oral comments on a draft of this report. It agreed in principle with GAO's recommendations but believes that it has taken steps to address the concerns raised in this report. The Department believes that the requirement placed on the Army in August 1989 by the Defense Acquisition Board--to perform further cost-effectiveness analysis before program approval of several Block II components--is in general accord with GAO's recommendation that the Army needs to perform more cost-effectiveness analysis. The Department of Defense has stated its intention to examine GAO's concerns in the context of ongoing analyses. The Department further believes that sufficient test information will be available at the Defense Acquisition Board's milestone III production decision in August 1991 to reduce program risks and allow an informed decision to be made on whether the program should proceed from development into production.

However, GAO's concern is with program decisions made before milestone III because (1) advanced procurement and long-lead funds may be obligated without further review; (2) potential problems, particularly in software and armor development, are of a magnitude to delay the Block II program and prevent the Army from reaching its performance goals; and (3) events that have occurred since GAO's review was conducted raise further questions. For example, the Army has recently requested an additional $95 million in research, development, test, and evaluation funds to finish full-scale development; preliminary test results in the armor program have not met expectations; and there is some question as to whether the Army will be able to meet its schedule for live-fire testing. Taken together, GAO believes, these issues suggest the need for the Office of the Secretary of Defense to review the program well in advance of the milestone III production decision. As part of this review, the Army should demonstrate the cost-effectiveness of the proposed tank using current and accurate information. It should also state its plans to develop and test the tank, evaluate test results, and make appropriate hardware and software changes before the Block II tank enters production.

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ABBREVIATIONS

BIT	built-in test
BITE	built-in test equipment
CASTFOREM	Combined Arms and Support Task Force Evaluation Model
CITV	commander's independent thermal viewer
COEA	cost and operational effectiveness analysis
CORBAN	Corps Battle Analyzer
CSC	Conventional Systems Committee
DAB	Defense Acquisition Board
DOD	Department of Defense
FSD	full-scale development
GAO	General Accounting Office
GDLS	General Dynamics Land Systems
ICWS	improved commander's weapons station
OSD	Office of the Secretary of Defense
POS/NAV	position/navigation
STAR	system threat assessment report
TRADOC	Training and Doctrine Command

decided, but like the Block II development program, it is made up of a number of components that are in various stages of development. The next generation tank, unlike the Block II, however, will likely contain a number of significant structural changes. These may include a new gun, a new chassis, an autoloader for the main gun tank rounds, an external suspension, a new transverse mounted engine, and a redesigned electronic architecture to control tank systems.

THE BLOCK II PROGRAM

The Block II tank modification package is designed to meet the future Soviet tank threat of the mid-1990s. Definition of this threat is based on the expected fielding of the Soviet tank known as the "FST2." The full-scale development program for Block II includes seven components that are in various stages of development. The Army has approved five of these components for Block II production. In addition, General Dynamics Land Systems (GDLS), the system integrator, is developing a digital electronic system called the "core tank" to integrate the new components into the existing M1A1 tank configuration. Components to be produced are shown in table 1.1.

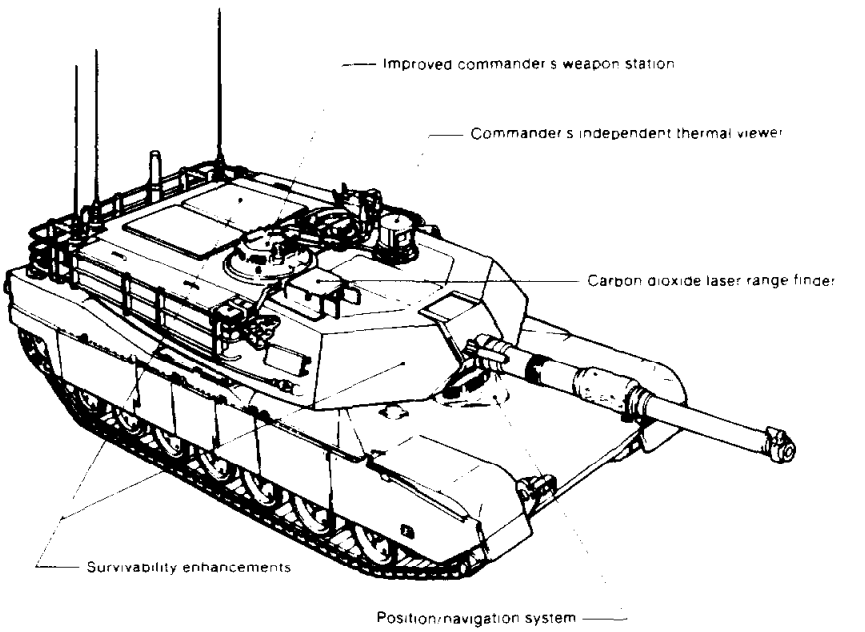
Table 1.1: Block II Production Components

Component	Contractor	Full-scale development award date
Core	GDLS	Dec. 1988
Commander's independent thermal viewer	Texas Instruments	Jan. 1989
Survivability enhancements	Armor packages being competed[a]	Dec. 1989 July 1990
Improved commander's weapons station	GDLS	Sept. 1986
Position/ navigation system	Smith Industries	Jan. 1989
Carbon dioxide laser range finder	GEC Avionics	Aug. 1987

aCandidate armor packages have been submitted by the Army's Materials Technology Laboratory, the Ballistics Research Laboratory, and private companies participating in the Defense Advanced Research Projects Agency's joint armor program.

Figure 1.1: Planned Block II Production Improvements to the Abrams Tank

Figure 1.1



A driver's thermal viewer to improve vision and an inter-vehicular information system for better communication will be developed and tested during FSD but will not be put into production.

NEW DIGITAL ELECTRONICS CONFIGURATION PLANNED TO INTEGRATE COMPONENTS

The Army believed that the cost of adding each Block II component on a piece-by-piece basis would be expensive. As a result, it contracted with General Dynamics to integrate the components into one system. The "core tank," as it is called, uses a set of common hardware and software shared by the new components. The system

In December 1988, the Army presented its proposed Block II program. The DAB approved an additional $300,000 per tank to produce a modified M1A2 at a production rate of 516 per year for the 5-year planning period (fiscal years 1990 to 1994). Funds were included in the fiscal year 1990/1991 budget submission. The DAB also conditionally approved the Block II program after the Army agreed to perform a cost and operational effectiveness analysis, to identify the costs and quantities associated with a baseline tank program and various cost and quantity alternatives, and to update the test and evaluation master plan. As part of the COEA effort, the Army was required to update the system threat assessment report (STAR) and conduct a fleet-level analysis to compare the relative military values of a tank fleet of the current tanks to a tank fleet of M1A2s.[2] This analysis was to be accompanied by a system-level analysis of the cost-effectiveness of the M1A2 tank itself.

The CSC met in June and July 1989 to consider the Army's analysis. The Army presented the results of its COEA, which showed all components except the carbon dioxide laser range finder to be cost-effective. The Army stated that it plans to continue with the total program and pursue development of a less costly range finder. The Army's proposed program, however, exceeded the $300,000 cost ceiling by $232,000. The CSC provided further guidance to the Army in lieu of program approval because the Army had not satisfied all of the Office of the Secretary of Defense's (OSD) conditions. The CSC restated its earlier direction that the Army present a program within the $300,000 cost cap. It stated that the Army needed to better identify various costs associated with the tank. It also stated that the Army needed to identify the incremental effectiveness of each component, if possible. The CSC directed the Army to specifically address the relationship between Block II and future tank modernization efforts by addressing the options of (1) incorporating several parts from the next generation tank development program into the M1A2 and (2) skipping the Block II production and using results from the development effort to more aggressively pursue the next generation tank development. The CSC stated that the Army should compare a fleet of M1A1s to a fleet of fewer M1A2S (because of the M1A2's higher unit cost). At its July 1989 meeting, the CSC reversed its position and recommended that the program be forwarded to the DAB.

The DAB again reviewed the Block II program on August 31, 1989. According to OSD officials, it approved continued full-scale development with the understanding that the Army would secure moneys to cover a small shortfall in research, development, test, and evaluation funding. It also approved a unit production cost ceiling of $3.037 million per tank, based on baseline tank and

[2]The STAR provides an assessment of threat doctrine and systems the tank is likely to face.

-- testers from the Operational Test and Evaluation Agency, the Test and Evaluation Command, the Combat Systems Test Activity, and TRADOC's Armor and Engineering Board;

-- armor developers from the U.S. Army's Ballistics Research Laboratory and the Defense Advanced Research Projects Agency;

-- analysts from the intelligence community; and

-- officials from OSD.

Documents we analyzed include the M1A2 COEA, the Test and Evaluation Master Plan, the System Threat Assessment Report, cost estimates, and results of the M1A2 preliminary design review. We evaluated the assumptions, results, and conclusions of the Army's Combined Arms and Support Task Force Evaluation Model (CASTFOREM) and Corps Battle Analyzer (CORBAN) model simulations for the Block II program. We did not verify or validate the models' internal calculations. Our work was conducted from March to August 1989 in accordance with generally accepted government auditing standards.

Candidate armor packages were tested in the summer of 1989 according to a pass-fail criteria. The Army plans to request bids from those contractors who passed. Full-scale development contracts for armor are scheduled to be awarded in December 1989 and in July 1990.

NOT ALL ARMOR TO BE ADDED BECAUSE ADDITIONAL WEIGHT FURTHER STRESSES TANK PERFORMANCE

Estimates show that adding the entire Block II package will bring the tank's weight to over 72 tons. This exceeds the Army's 69.5-ton weight limit. The tank is already required to use caution in all bridge crossings, and no recovery vehicle is capable of pulling the tank under all required conditions at its current weight. In order to keep the weight of the tank below this ceiling, the Army plans to initially add only portions of the armor packages. Consequently, the program's survivability objectives may not be achievable. The Army plans to add the remaining portions of the Block II survivability enhancements only as corresponding weight reductions are achieved.

Added Tank Weight Will Exacerbate Current Problems

The anticipated weight increase of the M1A2 to 69.5 tons may increase logistical problems with tank support equipment and may cause new problems for the tank's suspension system.

Army analysis concluded that additional weight will place further strains on the Army's ability to get the tank to battle and successfully retrieve it when damaged. Most Army tactical bridges, for example, have a weight limit of 60 tons, and fielded tanks are currently required to make "cautionary" crossings. The increased weight of the M1A2 will make these crossings even more difficult and will also accelerate bridge deterioration. Finally, without the M88A1 tank recovery vehicle program, which was required to recover 70-ton tanks, the Army's tank recovery task may be more difficult and may make towing an M1A2 more dangerous.

According to the Army, it will also need to modify the tank suspension system to support the added weight of the Block II package. Testing of a 70-ton tank at the Army's Aberdeen Proving Ground has shown that several suspension components of the currently produced tank cannot support a heavier tank body. The Army plans to replace the failing components and retest the tank.

Future Weight Reductions Planned

In April 1989, the Army implemented a weight reduction program in hopes of adding more of the desired armor packages. Major items

CHAPTER 3

ARMY-PREFERRED BLOCK II PROGRAM EXCEEDS OSD CEILINGS

The Army's estimated costs of the complete Block II modification package appear accurate but exceed current OSD-approved cost ceilings for the program. The Army estimates that Block II modifications will cost an additional $532,000 per tank, which represents a unit cost increase over the current tank of about 20 percent. At its August 1989 program review, the DAB established a per-tank cost ceiling of $3.037 million. It approved this amount to produce the M1A1 tank with the CITV and the ICWS in a core configuration, but not the other Block II components. The Army must either reduce costs or request additional funding from OSD in order to produce the full Block II package.

Throughout OSD's review of this program, however, the Army's preferred alternative was to accept fewer tanks in order to produce the entire Block II package. On the basis of current budget projections and the current price tag for Block II improvements, the Army calculated that procuring the fully modified Abrams tank would result in 253 fewer tanks' being procured during the first 4 years of the program. The resulting number of tanks would have fallen below the minimum sustaining rate of production and, in turn, would have further increased unit costs. It appears that any drop below the OSD-directed minimum would now require OSD approval.

The Army has projected that future savings are possible in the currently produced tank. We question the validity of these projections.

ARMY PROGRAM COSTS APPEAR ACCURATE

The Army has obtained cost estimates for the Block II program that Army and OSD cost analysts believe are accurate. These estimates appear reasonable, as many of the estimated component costs are based on contract proposals. The engineering estimates are based on manufacturing drawings, engineering designs, and vendor technologies.

Table 3.1 lists the Army's per-tank cost estimates for each proposed Block II modification.

alternative configuration of the Block II components would meet its needs. As an alternative, the Army has appeared willing to buy fewer M1A2s. However, it is unlikely that OSD will permit this.

The Army plans to procure a total of 2,926 M1A2 tanks between fiscal years 1991 and 1997. After that time, the Army plans a new tank for production. Under current budget plans, the Army expects to buy the M1A2 as part of a 5-year contract for fiscal years 1990 to 1994. (The M1A1 will be produced until the M1A2 is cut in as a modification.) Although the Army plans to procure 2,926 tanks, the number of M1A2 tanks it will actually procure could depend on the unit cost of the Block II modification package selected. It conducted an analysis that compared the Army's preferred program with the OSD program approved in December 1988. Table 3.2 shows the number of M1A2 tanks the Army could procure based on its planned funding profile through fiscal year 1994.

Table 3.2: Alternative M1A2 Procurement Quantities

	Quantity of tanks procured	
Fiscal year	$300K program	$532K program
1990	0	0
1991	261	215
1992	516	434
1993	516	454
1994	516	453
Total	1,809	1,556

Note: The Army plans to continue M1A1 tank production until the middle of fiscal year 1991.

The Army has determined that procuring the M1A2 with modifications costing $532,000 per tank will result in purchasing 253 fewer tanks over the first 4 years of M1A2 production. Although this analysis was done under the previous OSD cost ceiling of $300,000 per modifications package and the differential might have decreased under the new ceiling of $3.037 per tank, the resulting cost-quantity dilemma remains.

By producing fewer tanks, the Army would drop below the OSD-directed level and minimum sustaining rate of 516 tanks per year. A lower production rate would result in a higher unit cost. The Army has appeared willing to accept fewer tanks because it believes that the M1A2, as designed, is needed to kill the projected threat and to provide a technology bridge to a new tank. However, OSD is unlikely to allow the Army to produce at lower rates. Under the most recent OSD funding guidance, the Army will not be able to procure the full complement of Block II components given current costs.

CHAPTER 4

BENEFITS FROM CORE INTEGRATION NOT SUBSTANTIATED, AND TEST SCHEDULE INCREASES PROGRAM RISK

The Army has stated that the Block II program is risky but that it is willing to accept that risk in part to field a tank that contains a digital electronics, or "core," package. The Army believes that fielding the core tank will provide a number of combat-related enhancements and also provide the experience it wants for future tank development. However, the core tank may not perform as promised. Test results are required to determine performance, but OSD has raised questions about the testing associated with the Army's high risk, compressed acquisition schedule. The compressed schedule further complicates the training of personnel to operate and maintain the tank. Finally, OSD has repeatedly stated that the Army needs to clearly assess the value to its future tank programs of producing and fielding the Block II package.

The Army believes that integrating components of the Block II electronics package into a new digital electronic configuration, or "core," will result in a less expensive M1A2 tank and provide numerous advantages not available if each individual component is separately integrated, or "hard-wired," with the existing analog electronic system. According to Army presentations to OSD and others, these advantages are expected to include greater efficiency in the way the tank systems operate together, reduced vulnerability, ease of maintenance through a built-in diagnostic system, and sustained reliability while adding components. These justifications for the core have not been proven and have, in some cases, been contradicted by Army studies. Specifically, the efficiency gained by using a core architecture to operate subsystems rather than attaching components in increments has not been measured; the Army's claims for reduced vulnerability have been discounted by a vulnerability analysis; and improvements from the built-in diagnostic system will be limited.

The Army's compressed acquisition schedule further increases the risk of the Block II program. The Army will commit $166.4 million in advanced procurement funding for production long-lead items and to prepare the tank assembly line for production before development prototype testing begins. Decisions to purchase $39.4 million of long-lead items for production are scheduled for November 1989 and July 1990. In addition, nonrecurring production start-up costs of $127 million are to be expended throughout fiscal year 1990 in preparation for production. However, Army testing of development prototype tanks is not scheduled to begin until early in fiscal year 1991 after advanced procurement funds are committed to Block II production.

requires significant time and manpower to operate. Therefore, the replacement of such equipment by automated built-in diagnostics, called the "BIT," is strongly supported by Army officials. Although the Army believes that the BIT/BITE system will ease tank maintenance, the COEA was not able to quantify differences between the current equipment and the BIT diagnostic times because of the drastic differences in testing philosophies and hardware configurations. The capabilities of the BIT system in a tank are unknown. In its vulnerability analysis, the Army's Ballistics Research Laboratory recommended that testing take place while the tank design is still flexible enough to make any necessary changes. In addition, the Ballistics Research Laboratory's vulnerability analysis, as well as tank crew members, has pointed out that failure of the BIT may make maintenance even more difficult, particularly in a combat environment. The more sophisticated systems envisioned for the core tank will be harder to diagnose manually than components now in the tank, and electronics diagnosis and repair will require special skills.

Another drawback is that the BIT will not support all M1A2 systems. The Ballistics Research Laboratory's vulnerability analysis pointed out that, because the M1A2 fire control system will consist of components of various technological vintages, some faults in the M1A1 components will not be detected by the diagnostic system and will require existing test equipment. However, the program manager has decided that manuals will be used for diagnosing those parts of the M1A2 that are not covered by BIT until the diagnostic and test equipment can be replaced.

Cost Benefits From Core Tank Not Substantiated

According to Army officials, the contractor estimates that the core configuration will save operational and support costs. However, those estimates have been made without any data on the reliability of the core system, which is an important determinant of operational and support requirements.

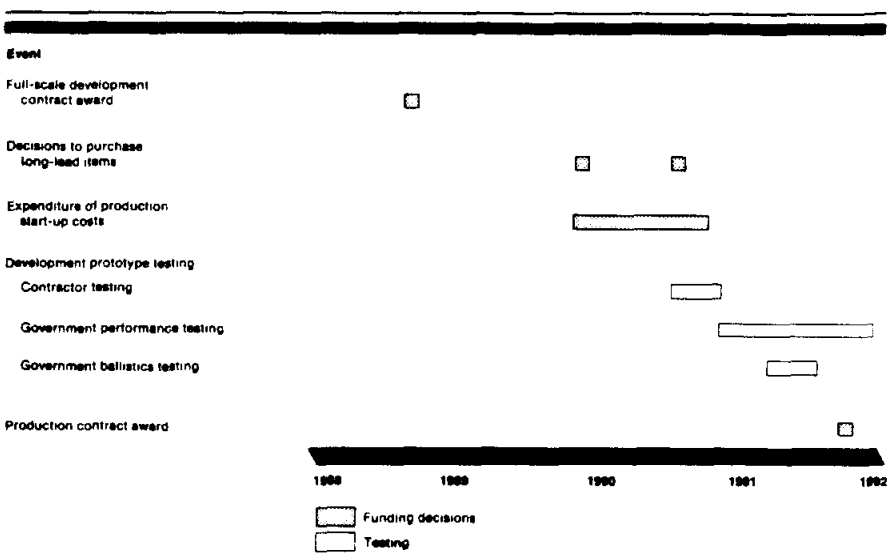
HIGH DEGREE OF CONCURRENCY INCREASES DEVELOPMENT SCHEDULE RISK

Due to the compressed M1A2 program schedule, the Army will commit $166.4 million in advanced procurement funding for production long-lead items and begin preparing the tank assembly line for production before development prototype testing begins. The Army believes that its compressed, high-risk schedule is technically achievable because conceptual models of the major Block II components have already been developed and are within the state of the art. However, the task of actually developing the components and integrating them into prototype tanks within the compressed development schedule could be very challenging because the core electronics systems has not been used in a ground combat vehicle.

programs, the Army must budget advanced procurement funds for the early purchase of items that have material acquisition times of up to 2 years. Currently, the Army has budgeted $39.4 million for the procurement of long-lead items. In addition, the Army in fiscal year 1990 plans to commit $127 million in nonrecurring production costs to begin preparing for production of the Block II tank. These funds are budgeted for pilot tanks, manufacturing preparation and tooling, future system technical support, and component hardware.

Figure 4.1 shows the program's development, testing, and production phases.

Figure 4.1: Dates of Funding Decisions and Testing for the M1A2



As shown in figure 4.1, advanced procurement decisions are scheduled for November 1989 and July 1990 to buy long-lead items for production and to invest in nonrecurring production items. The November 1989 decision is to be made about 8 months before contractor testing of development prototype tanks begins. The July 1990 decision is to be made 3 months prior to the start of Army testing in October 1990. Consequently, the Army plans to make advanced production commitments before Army testing of prototype vehicles begins.

and location of soldiers who are trained with the number and location of tanks to be fielded.

For tank crews, the problem will arise during rotations from Europe, where M1A2s will be fielded, to the United States, where units will have the older M1A1s. M1A2 tank maintenance crew members will receive additional skill identifiers in conjunction with their military occupational specialties. However, the Army assigns individual soldiers according to their specialties rather than their identifiers. Therefore, once individuals have been specially trained for the M1A2, the Army cannot ensure that they will be assigned to the M1A2. Similar problems were encountered with the fielding of the M1 Abrams tank, a system that represented significant changes over the system it replaced. Since encountering problems, the Army has abandoned the idea of assigning identifiers for those systems; instead, it provides all crews with the specialized training needed for the more sophisticated systems. However, according to Army training officials, training the entire tank force may be more costly in terms of both time and money.

TECHNOLOGY BRIDGE INCOMPLETELY DEFINED

The Army believes that experience with a fielded electronic tank system is needed to provide the lessons critical to developing its next generation tank. The computer architecture under development for the next generation tank will likely be based on elements of the electronic system being developed for Block II. However, Army engineers believe that the current data bus standard used as the basis for the Block II core tank may be inappropriate for the next generation tank. More power than can be supplied by the standard data bus will be needed to support added capabilities. At the same time, much less power is needed to manage simple automotive functions such as turning on the headlights, and costs dictate that a less powerful bus be used whenever possible. Therefore, the applicability of lessons learned from a fielded hybrid analog-digital tank to the all-digital configuration expected in the next generation tank is questionable. The Army has constructed a sophisticated new laboratory testing facility at the Tank-Automotive Command, where much of the testing of the new architecture will be conducted. Such testing is expected to be relatively easy, and making needed changes is expected to be inexpensive. The Block II changes will entail small physical but radical electronic changes, which might be more appropriately developed and tested in a laboratory than on a fielded vehicle. The Army's next generation tank, by contrast, is expected to entail radical changes in tank design and configuration but relatively small changes in electronics. For example, Army engineers believe that it is likely that the new gun being developed for the next generation tank will drive the tank's physical design.

specific user requirements. However, in its guidance to the Army throughout this program, OSD has emphasized the importance of defining the linkages between Block II and future tank program plans; and in program reviews it has directed the Army to define those linkages. OSD appears to have retreated from its position, since the August 1989 DAB guidance contained no such direction.

Given the schedule risk and the potential performance problems in the Block II program, particularly as they relate to new M1A2-specific software, it appears that significant program development remains before the production decision is scheduled to be made. Further, the Army has not yet identified the links between the Block II and next generation tank program, and it is unlikely to do so since OSD has dropped its requirement.

simulations were used to determine the impact that Block II components would have on forces equipped with tanks fighting a combined arms battle at battalion, brigade, and corps levels.

On the basis of the CASTFOREM analysis, the Army judged the M1A2 tank to be more effective. The CITV was the key component responsible for the increase.

The CORBAN analysis (which used a defensive scenario and equipped only certain units in the force with Block II tanks based on Army fielding plans and tank availability) also indicated an improvement. Again, the CITV was the key component. These results, however, were based on certain assumptions not supported by operational data.

EFFECTIVENESS OVERSTATED
DUE TO ASSUMPTIONS NOT SUPPORTED
BY OPERATIONAL DATA OR REASSESSED
ON THE BASIS OF UPDATED INFORMATION

The model simulations' accuracy in representing the effectiveness of tanks in battle depends in large part on how closely operational procedures in actual combat are reflected in the models' assumptions. Key assumptions concerning tank commanders' search capabilities and other responsibilities and tank engagement ranges did not reflect actual combat experience. According to Army analysts, if data on actual tank commanders' activities were available to them and agreed to by the Army community, it could be incorporated into the analysis.

M1A2 Effectiveness Overstated Because
the Tank Commander's Visual Capabilities
and Responsibilities Were Ignored

The CASTFOREM simulation model assumed that M1A1 tank commanders did not search for targets. In actual field experience, however, the M1A1 tank commander searches and directs his tank using open and protected hatch positions as well as periscopic vision blocks when the hatch is closed. According to Army analysts, the assumption about the M1A1 tank commander's role could have been changed if data had been provided to the modelers. The models also assumed that the M1A2 tank commander, with his thermal viewer, would spend all his time searching for new targets.

However, according to Army tankers, each platoon of four tanks has a platoon leader tank commander and a platoon sergeant tank commander who have broader responsibilities within their operational units. In battle, they would be devoting much of their time to directing the platoon, checking navigation, and coordinating with other units at critical points. These responsibilities were not considered in the analysis. Again, Army

AGENCY COMMENTS AND OUR EVALUATION

In commenting on a draft of this report, DOD noted that the M1A2 COEA has been widely praised for its comprehensiveness. DOD representatives believe, however, that a sensitivity analysis could be done as part of ongoing COEA work to measure the impact on the M1A2's operational effectiveness of changing the assumptions we question in this report. The Army had not done such an analysis for the M1A2 COEA. We believe that additional analysis should be performed to determine the impact of current threat and armor information and to reflect realistic operational assumptions as identified in this report.

advanced production decisions are made and will not have time to make corrections until after the program has moved from development to production. Further, OSD has not approved the test and evaluation master plan. Additional development may prove necessary after the tank enters production because of the Army's lack of experience with a hybrid digital-analog electronic system on a ground combat vehicle. These delayed corrections could prove costly in both time and resources, particularly because there will be no period of low-rate initial production for the M1A2. Any slip in the program calls into question the Army's justification for the Block II program as an interim tank solution, given that the next generation tank is planned to enter production in fiscal year 1997.

The Army conducted a cost and operational effectiveness analysis as directed by OSD. Although the COEA found that the Block II program is generally cost-effective, the Army made a number of assumptions that are not supported by operational analyses and that may have the effect of overstating the modified tank's effectiveness. These include the assumptions that (1) more new armor than can be realistically mounted on the tank will be added, (2) the armor will be adequate against a new Soviet threat, (3) the commander of the M1A2 tank will spend all of his time searching for targets and the commander of the M1A1 will spend none, and (4) tank battle engagement ranges will be greater than they have been historically. The Army continues to support the addition of a carbon dioxide laser range finder despite the COEA finding that it would not be cost-effective. To determine the true cost-effectiveness of the Block II program, the Army needs to conduct an analysis that includes assumptions based on actual field experience.

The Army also believes that fielding the Block II modification package is required to provide a technological link to future tank modernization efforts. However, the Army does not have analyses supporting such linkages. The development of the next generation tank is in the early stages of design, but preliminary engineering indications are that the electronic system in the Block II package will not be sufficient to meet the requirements expected for the next generation tank. The Army is unlikely to develop such an analysis because OSD has dropped its requirement that it be done.

The Army has stated that it recognizes that risks do exist in several areas of the Block II program but that it is willing to undertake those risks because the tank represents a necessary stepping-stone to meet the threat and to future tank programs. However, the number and variety of unresolved issues surrounding the program, identified in part by OSD, raise concerns about the Army's ability to field a tank that has been adequately tested and will perform as promised in the time frames allotted. These issues, in turn, raise questions about the Army's belief that the tank is needed as an interim solution. If problems develop in the Block II program, they could prove costly and delay future tank improvements.

results, and make appropriate hardware and software changes before the Block II tank enters production.

Other DOD comments have been noted, as appropriate, throughout the report.

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Therefore, we recommend that the Secretary of Defense withhold approval of the obligation of advanced or other procurement funds for the Block II tank program until

-- the Army is able to demonstrate the cost-effectiveness of the system, using a current assessment of armor protection and threat capabilities and realistic tactical and tank crew-fighting assumptions in a new cost and operational effectiveness analysis, and

-- the Army modifies its acquisition strategy to allow time to complete and evaluate live-fire and operational testing and to take corrective actions before beginning production of the Block II modifications.

AGENCY COMMENTS AND OUR EVALUATION

The Department of Defense provided official oral comments on a draft of this report. It agreed in principle with our recommendations but believes that it has taken steps to address the concerns raised in this report. The Department believes that the requirement placed on the Army in August 1989 by the Defense Acquisition Board--to perform further cost-effectiveness analysis before program approval of several Block II components--is in general accord with our conclusions and recommendation. The Department of Defense has stated its intention to examine our concerns in the context of ongoing analyses. The Department further believes that sufficient test information will be available at the DAB's milestone III production decision in August 1991 to reduce program risks and allow an informed decision to be made on whether the program should proceed from development into production.

However, our concern is with program decisions made before milestone III because (1) advanced procurement and long-lead funds may be obligated without further review; (2) potential problems, particularly in software and armor development, are of a magnitude to delay the Block II program and prevent the Army from reaching its performance goals; and (3) events that have occurred since our review was conducted raise further questions. For example, the Army has recently requested an additional $95 million in research, development, test, and evaluation funds to finish full-scale development; preliminary test results in the armor program have not met expectations; and there is some question as to whether the Army will be able to meet its schedule for live-fire testing. Taken together, we believe, these issues suggest the need for the Office of the Secretary of Defense to review the program well in advance of the milestone III production decision. As part of this review, the Army should demonstrate the cost-effectiveness of the proposed tank, using current and accurate information. It should also state its plans to develop and test the tank, evaluate test

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

The Army believes that producing the Block II modification package is necessary to meet a future Soviet tank threat and that such modifications will improve the Abrams tank's survivability, lethality, and fightability. The Army also believes that moving the Block II program into production is needed to test certain new concepts that will support future tank efforts. The Office of the Secretary of Defense has raised serious questions about the program and has directed the Army to consider alternative tank modernization strategies, including forgoing Block II tank production. However, OSD has recently approved a part of the program for production and has retreated from its position that the Army needs to develop a coherent linkage between Block II and future planned tank modernization efforts.

Improved survivability is one of the Army's top tank modernization priorities. However, the Army may not meet its Block II survivability goals until well into the tank's production. The capability of the armor packages will not be known when production decisions are made; new threat information calls into question the adequacy of specifications in the armor development program; and weight constraints prevent the addition of much of the planned armor until future weight reductions can be realized. Therefore, the Army's belief that the Block II tank's survivability will be increased may not be substantiated.

The Army's cost estimates for the Block II modification package appear accurate. However, affordability concerns exist with respect to individual tank costs--the Army's proposed tank continues to exceed the production cost ceiling of $3.037 million per tank set by OSD--and additional funding will be required if the Army is to meet its quantity objectives. The Army has concluded that estimated future savings in its baseline tank will support the increased costs of the modifications. Because the unit cost of tank production is so heavily dependent on quantities, the cost of individual M1A2 tanks will have to be carefully balanced against the quantities necessary to maintain economic rates of production if the Army hopes to avoid cost penalties and to pursue an affordable program.

The Army's program is predicated on its ability to field a tank in advance of the FST 2 threat projected for the mid-1990s. Its haste requires a high risk acquisition strategy. Numerous questions have been raised by OSD and Army studies as to whether the tank will actually perform as expected. Since the development schedule is compressed and several components, including the software needed for the core, are in the early stages of development, the Army will lack critical test information before

analysts believe that if such data had been available to them, it could have been used.

CASTFOREM's Overestimation of Tank Engagement Ranges Further Overstated the Effectiveness of M1A2 Improvements

According to Army officials, CASTFOREM has a history of simulating weapons at longer ranges than experienced in field exercises and tests. This is because the model assumes that any target that can be seen, according to the tank system's capabilities, will be seen. In reality, many targets are obscured by terrain or other obstacles. These longer ranges unfairly favored the M1A2 because the CITV provides enhanced viewing. The use of closer engagement ranges would have provided for a more accurate analysis.

The Army determined actual engagement ranges in 1987, when it conducted an operational assessment of the Bradley Fighting Vehicle working with M1 tank units. These were not reflected in the modeling. In addition, exercises at the National Training Center also confirm that shorter engagement ranges are predominant.

Army's Estimates of the Effectiveness of Armor Enhancements No Longer Valid

Army models assumed that the M1A2 would have a full complement of armor. Since the time the analysis was conducted, the Army has determined that all armor cannot be added to the tank because of weight constraints. The model also assumed the existence of certain Soviet anti-armor threat munitions, the effectiveness of which were less than that currently predicted. Both assumptions might have resulted in an overstatement of the M1A2's increased capabilities because the assumptions did not take into account the fact that the M1A2 will most likely not be protected by all the armor proposed in the Block II program and that the Soviets will likely field stronger, more capable munitions than were predicted when the simulation was conducted.

CONCLUSIONS

The Army has conducted a cost and operational effectiveness analysis as required by OSD. The analysis showed major increases in the combat effectiveness of the proposed M1A2 tank over the currently fielded M1A1 tank for the system as a whole and for all components except the carbon dioxide laser range finder. However, the magnitude of the increase is questionable because assumptions used in the model are not supported by operational data or have not been reassessed on the basis of events that have occurred since the analysis was conducted. Without an accurate measure of combat effectiveness, the Army cannot rely on the COEA results to conclude that the Block II improvements are cost-effective.

CHAPTER 5

COST-EFFECTIVENESS HAS NOT BEEN ESTABLISHED FOR ALL COMPONENTS

The Army had not conducted a cost and operational effectiveness analysis on the Block II program when it presented the program to the Defense Acquisition Board in December 1988. OSD requires such an analysis for all major system acquisitions to help determine whether the increased effectiveness is worth the increased cost. At the DAB's direction, the Army has since performed an analysis that compares the combat effectiveness of the currently produced M1A1 tank to that of a Block II-modified tank. The Army has also compared the increase in effectiveness provided by each of the Block II modifications to the cost of making the modification.

The analysis showed significant improvements in effectiveness for the complete Block II package, with varying degrees of improved effectiveness for individual components. Adding the commander's independent thermal viewer caused the single largest increase in effectiveness over the M1A1. The Army, however, made assumptions in its analysis that are not supported by operational data or have since been shown to be invalid. Certain assumptions about tank commanders' functions and tank tactics might have caused the Block II-modified tank to appear to outperform the current M1A1 by too high a margin.

COEA CONDUCTED TO DETERMINE SYSTEM AND COST-EFFECTIVENESS

The Army's Training and Doctrine Command conducted a cost and operational effectiveness analysis that was directed by OSD's Defense Acquisition Board. The Army was directed to analyze the effectiveness of a tank equipped with Block II components as compared with the currently fielded M1A1. The analysis included performance comparisons of individual tanks and of different sized groups of tanks against Soviet forces. The analysis measured the effectiveness of each Block II component as well as the effectiveness of 16 component combinations. The Army also compared the cost of components integrated into a new digital electronic core configuration to their cost when attached to the tank separately. Finally, the Army compared training for and logistics costs of the current and modified tanks.

The Army's analysis of Block II components showed improvements in performance and effectiveness over the M1A1. It showed all components except the carbon dioxide laser range finder to be cost-effective.

To estimate system and force improvements, the Army used two simulation models--the CASTFOREM and the CORBAN. These

CONCLUSIONS

There have been a number of questions raised about the performance of the core tank; the schedule for its development, testing, and production; the training of tank and maintenance crews to use and support the tank; and the value to future tank programs of actually producing and fielding a tank containing the core's digital electronics system. Some of these questions have been identified in the various presentations the Army has made to OSD since the program review began last December. To date, however, the Army has not been able to develop an adequate test plan or clearly define the linkage between the digital electronics system for the Block II program and future needs. In addition, potential combat-related improvements provided by the core have not been proved or have been seriously questioned by the Army's own studies. The Army's attempt to quickly field the Block II tank requires a compressed acquisition schedule that further increases program risks. If delays in the program do occur, the Army's justification for the Block II program as an interim tank solution may not be valid.

AGENCY COMMENTS AND OUR EVALUATION

In its comments on a draft of this report, DOD recognized the schedule risks present in the Block II program and noted that the funding exposure was limited to the advanced procurement funds. One action the Army has taken since our report was drafted to attempt to reduce schedule risks is to request $14 million in research, development, test, and evaluation funding to build two additional M1A2 prototypes for testing. These prototypes may allow for more timely test and evaluation.

DOD noted that developing the software portion of the test and evaluation master plan is difficult but that a plan is expected within the next 4 months. The Army has requested an additional $18.5 million needed for software development and testing since our report was drafted.

DOD also commented on our discussion of the potential shortcomings of the core tank and its ties to the next generation vehicle. DOD believes that design changes have been made to correct deficiencies we identify in our report and that these will result in reduced system vulnerability. A number of these changes appear to be in the right direction. Their value, however, will not be known until appropriate software is developed in some cases and testing occurs in others. DOD also noted that a new maintenance concept for the tank is under discussion because of changes brought about by discontinuing currently used test equipment.

In commenting on our discussion of the next generation vehicle, DOD noted that the Block II core configuration had not been developed to provide a bridge to the future; rather, it was the most cost-effective way of using current technology to meet

There will be limited contractor testing, and key mission items will be untested before the award of contracts for long-lead items. Further, there is to be no period of low-rate initial production, which would be used to resolve problems uncovered in development. As a result, the Army may risk increased production costs and schedule delays should testing uncover performance problems.

CORE-RELATED SYSTEMS MAY IMPOSE ADDITIONAL TRAINING BURDENS

The Block II modifications will require the Army to train tank and tank maintenance crews to perform new tasks. The specialized training required for the core and related systems may create rotational and reassignment problems that the Army has not yet resolved. In addition, the Army is not yet certain of the configuration of the new equipment and cannot plan for specific training needs.

Additional Training Requirements Are Not Developed

The Army is attempting to determine what specialized training will be required to operate and maintain the M1A2. Training for earlier Abrams modifications was conducted as new equipment was assigned, but the M1A2 will require specialized training. The extent of necessary training is difficult to estimate until the Army further defines the physical design of the tank equipment and the actual maintenance and tank crew tasks involved. Each component of the Block II program will require new training, since most will involve new tasks for the tank crew to perform. Likewise, maintenance crews will need additional skills, most of which are associated with the core electronics system.

The primary source of information to date on training estimates is the cost and operational effectiveness analysis. These estimates were developed by Army training experts and based on M1A1 data, simulations, and information provided by the system contractor. However, Army training officials believe that existing estimates for M1A2 tank crew training are not accurate. For example, they believe that the COEA estimates for tank crew training needs are likely to be within 25 percent of the actual figures. Estimates for maintenance crew training have varied from the 5 hours stated in the COEA to 35 hours. A design review held in September 1989 may provide better information on which training estimates can be based.

Specialized Training May Create Crew-Rotation Problems

Army officials believe that a significant training problem that will be encountered with the M1A2 will be coordinating the number

Further, there is a significant overlap in development, testing, and acquisition schedules over the life of the program. Any slip in the development schedule could delay the introduction of the Block II improvements into production.

OSD has raised concerns about the adequacy of the Army's test plans and has not approved the test and evaluation master plan. OSD has also recognized that if the program is delayed over a year, the Army's justification of the Block II modifications as an "interim tank solution" may not be substantiated.

Testing Schedule Is Optimistic

The Army has recognized that the schedule for developing the Block II program is optimistic and allows minimal time to test and fix the tank. It believes that the use of mature technologies and mature contractors should result in minimal technological problems. However, the core configuration does not fit this characterization. The Block II core has never been integrated into a ground combat system, and engineers will have to merge the new digital system with existing analog components. The resulting hybrid tank may pose problems as yet unknown.

The Army believes that developing the core tank will be low to medium risk, in part because it will use the military standard 1553B data bus to transmit information around the tank. However, one of the major developmental challenges of the core tank lies in developing the new software required. Army engineers are concerned that the individuals with the expertise to do this have not yet been identified and may not be available in the time frames required. OSD officials have also stated their concerns about developing adequate software in the time allotted. Software test plans do not define how performance will be measured. As currently written, criteria will be determined as testing takes place.

Test Plans Not Approved

The Army's test and evaluation master plan had not been approved by OSD as of August 1989. OSD has some concerns because the plan contains no provision for post-production quality assurance, which is needed to establish conformity with preproduction goals. In addition, OSD is concerned that the Army has not sufficiently planned live-fire and operational testing, which needs to be completed and evaluated before the production decision is made in August 1991.

Procurement Funding Required Before Prototype Testing

In its fiscal year 1990 budget, the Army has allocated procurement funds to the Block II program for the procurement of long-lead items and production start-up costs. In tank acquisition

Training issues associated with the M1A2, specifically the new core capabilities and maintenance requirements, are not resolved.

The Army believes that fielding a tank that contains a new digital electronic system such as the core configuration is critical to gathering information needed for future tank development. However, OSD believes that the Army's aggressive campaign to produce the Block II package as an interim measure requires further thought. On several occasions, the Conventional Systems Committee has directed the Army to specifically identify the path between Block II and future tank systems. In June, it directed the Army to analyze the option of forgoing M1A2 production altogether in favor of accelerating the next generation tank program. At the time we received comments on a draft of this report, the linkages were still unclear.

CORE ATTRIBUTES UNSUBSTANTIATED

The Army believes that the core tank will decrease the tank's vulnerability by providing a redundant electronic capacity (allowing one system to perform some functions of another if it is disabled); decreasing the maintenance burden by replacing the simplified test equipment used on the M1A1 with built-in diagnostics; and allowing more efficient, and therefore effective, tank operation. The impact of the core on the tank's vulnerability has not been tested. The built-in diagnostics will not support all of the M1A2 systems, and should the built-in diagnostics fail, more difficult repairs will result than on the M1A1. The assumptions regarding the core's contribution to greater efficiency in tank operations, with its consequent impact on combat effectiveness, are untested.

The Army's Ballistics Research Laboratory, in support of the M1A2 COEA, conducted a qualitative vulnerability assessment of the core tank in March 1989 that was based on previous test and preliminary design information. The Army believes that redundant capabilities and other core characteristics decrease the tank's vulnerability. The analysis did not fully support the Army's expectations of the core's impact on tank vulnerability. The vulnerability implications of much of the new system can only be proven through testing.

The analysis also determined that finding space for future components will pose a considerable problem.

Limited Ease of Maintenance From Built-in Test Equipment

A major improvement expected from the M1A2 core technology is the easier maintenance expected from the built-in test/built-in test equipment (BIT/BITE) diagnostic system. The M1A1's simplified test equipment's diagnostic package, which is heavy and cumbersome,

FUTURE TANK SAVINGS IDENTIFIED BUT QUESTIONABLE

The Army believes that it can achieve cost savings on the baseline tank, which will keep overall tank costs down. It has estimated savings that it believes can be obtained by 1992 when the Block II modifications go into production. Army calculations show that if its projected savings can be achieved, adding the entire Block II package would keep the tank price at $3.022 million, below the OSD ceiling.

The program manager has estimated future savings resulting from new multiyear contracts for fiscal years 1991 to 1995 for the final drive and transmission, production rate increases to the minimum sustaining rate above earlier Army production rate projections, and changes in the scope of special armor programs. However, the multiyear contracts have yet to be negotiated, and savings in special armor programs have already been identified for reprogramming to cover a $95 million shortfall in the Block II development program. Further, initiatives such as the weight reduction program may increase the tank's cost. Accordingly, we believe the basis for these savings to be questionable.

CONCLUSIONS

Army cost estimates for the Block II modification package appear accurate. However, producing the entire Block II package will increase tank costs by about 20 percent and exceed the current OSD cost ceiling of $3.037 per tank. The Army believes that producing the Block II package is necessary despite affordability concerns. However, unless costs can be reduced, additional funding will be required to attain the Army's quantity objectives. Without additional funds, with an OSD-directed minimum annual production rate, and considering that future savings are questionable, the Army is unlikely to be able to produce the full Block II package. An M1A2 with fewer components, in turn, raises questions about the Army's cost-effectiveness calculations in which the cost-effectiveness of the tank was based on the entire package.

AGENCY COMMENTS AND OUR EVALUATION

In its comments on a draft of this report, DOD reiterated that the Army would not be allowed to procure tanks at uneconomical production quantities, that is, below 516 tanks per year. DOD also noted that the DAB cost goals set in December 1988 have been successful in convincing the Army to maintain reasonable tank prices. Nevertheless, given current funding levels and costs, the Army will not be able to procure the entire Block II package of modifications at economical rates. Producing tanks with only some of the proposed modifications may change the tank's operational effectiveness gains as compared with the M1A1 and, therefore, may call into question the tank's justification based on cost-effectiveness criteria.

Table 3.1: Production Cost Estimates of Block II Components

Component	Estimate	Basis of estimate
Core tank	$254,000	Not-to-exceed contract ceiling price and engineering estimates
Commander's independent thermal viewer	111,000	Not-to-exceed contract ceiling price
Position/navigation system	20,000	Not-to-exceed contract ceiling price
Carbon dioxide laser range finder	56,000	Production option in development contract
Survivability enhancements	65,000	Engineering estimate
Improved commander's weapons station	26,000	Contractor's engineering change proposal
Total	$532,000	

The Army believes that the extra $254,000 associated with producing each core tank is justified in part because its cost analysis shows that the core will reduce the tank's additional procurement cost from $714,000 for a hard-wired tank to $532,000 for the digital core tank. The analysis assumes that all components will be added and that the full program of 2,926 tanks will be procured. It did not include $227.4 million in development costs that had already been invested in the core tank. OSD agreed with the Army's finding that the integrated core configuration would be cheaper than hard-wired additions if all components were added.

ARMY HAS NOT FULLY ADDRESSED OSD'S AFFORDABILITY CONCERNS

At the December 1988 DAB review, the DAB established a cost ceiling of $300,000 for the Block II package and directed the Army to revise its program to keep the cost of the Block II program within the ceiling. The DAB also authorized a production rate of 516 tanks per year. From December 1988 to August 1989, in discussions with OSD, the Army continued to state that it could not accept a tank with anything less than the full configuration. In fact, the Army was prepared to accept fewer tanks rather than accept a tank with less than the full complement of components. However, the Army has not revised its program. In all subsequent presentations, it has restated its position that no less expensive

in the tank being considered for weight reduction are shown in table 2.1.

Table 2.1: Weight Savings Opportunities for the Abrams Tank

Item	Weight savings objective (pounds)	Scheduled effective date
Ammunition racks	200	Aug. 1990
Aluminum wire race ring	630	Oct. 1992
External suspension	1,000	Apr. 1993
Lightweight track	1,000	Apr. 1993
Composite items	2,690	Fiscal year 1993/1994
Ceramic skirt	879	Apr. 1993
Other contractor proposals	265	Fiscal year 1993/1994
Total	6,664	

The Army plans to add portions of planned Block II armor on a trade-off basis as planned weight savings are achieved. However, most of the Army's planned weight reductions are scheduled for development and are not expected to be realized until after the start of M1A2 production.

CONCLUSIONS

Improved survivability is one of the Army's top priorities in tank development. Yet a number of factors suggest that the goal of improved survivability to justify Block II production is questionable.

AGENCY COMMENTS AND OUR EVALUATION

In commenting on a draft of this report, DOD stated that it was confident that Block II armor packages would be developed in sufficient time, with sufficient protection capabilities, and within current overall weight requirements to enter production as planned. Testing that has been completed since our report was drafted, however, shows that some candidates for the armor package have failed to meet expectations. Award of full-scale development contracts has been moved back. Thus, development of the armor packages is now behind in meeting an already compressed development schedule. In addition, OSD has not approved any part of the survivability enhancement package for production.

CHAPTER 2

PROPOSED ARMOR PACKAGES MAY NOT IMPROVE SURVIVABILITY

The Army may not reach its Block II survivability goals because (1) the Block II armor specifications are understated and (2) weight constraints preclude adding most of the additional armor. As a result, the Army's survivability justification for the Block II program is questionable. Increased tank survivability is a long-standing Army priority and is an important justification for the current Block II program.

Current plans call for the survivability enhancement portion of the Block II program to enter full-scale development at the same time as the M1A2 advanced procurement decision is to be made. That schedule depends on successful testing of the armor packages.

Even with successful and timely results, the Army will not be able to add all armor currently under development because its additional weight will further constrain available tank support equipment and the tank's suspension system. The Army's weight goal for the tank is 68.5 tons, and its limit is 69.5 tons. Currently planned Block II additions will bring the weight to over 72 tons. Although the Army has program goals for weight reduction, these goals are not planned to be met until after the start of M1A2 production.

BLOCK II ARMOR SPECIFICATIONS ARE UNDERSTATED

Performance specifications for part of the Block II armor development program do not sufficiently account for all threat munitions expected to be in the field. In addition, recently revised threat projections may neutralize other planned increases in protection.

CAPABILITY OF PROPOSED SURVIVABILITY ENHANCEMENT IS UNCLEAR

Development of new armor packages for the Block II survivability enhancements will not be complete before the Army's advanced procurement decisions are made. A number of private companies and two government laboratories are developing candidate armor packages.

The armor developers have been given expected threat capabilities, weight limits, and size dimensions for each survivability enhancement package against which their armor will be measured. The packages vary widely in their technologies and designs. At least one of the government candidates exceeds the weight limit.

estimated component costs and production quantities of 516 tanks per year (in constant dollars). This cost ceiling replaced its earlier ceiling of $300,000 for the Block II package. The DAB believes the per-tank unit cost ceiling to be sufficient to produce the M1A2 tank with the CITV and the ICWS, using the integrated core approach. This amount does not include sufficient funding to produce the survivability enhancements, the position/navigation unit, and the carbon dioxide laser range finder. Production of these components was made contingent on the Army's ability to (1) demonstrate, through further analysis, their cost-effectiveness or (2) reduce component or baseline tank costs to meet the $3.037 million ceiling.

The DAB also directed the Army to demonstrate, before the milestone III production decision, that the tank will meet program specifications. These specifications include the results of full-up live-fire testing. Such tests are currently scheduled for February to July 1991, with the production decision scheduled for August 1991. The DAB retreated from its earlier requirement, however, that the Army demonstrate the linkages between the Block II program and its next generation tank.

Since the DAB review, the Army has requested additional research, development, test, and evaluation funding and now estimates that it needs $94.9 million to complete full-scale development. A significant amount ($18.5 million) is for core software development.

OBJECTIVES, SCOPE, AND METHODOLOGY

The House Committee on Armed Services asked that we review the Army's Block II tank modernization program. Our objectives were to examine the Army's justification for the Block II program and to determine (1) whether the improved performance the Army expects of the proposed modification package can be realized; (2) whether the Army's acquisition strategy allows for adequate testing and evaluation to be performed before production decisions must be made; and (3) what impact, if any, the Block II program will have on future tank modernization plans.

To do so, we examined Army and DOD documents that supported and analyzed the program. We discussed their contents with

-- officials and engineers from the Tank-Automotive Command;

-- analysts at the Training and Doctrine Command (TRADOC) Analysis Center at the White Sands Missile Range;

-- tank commanders, gunners, and other officials from the Armor Center and School;

consists of six segments, which provide the means to monitor and control electrical power for tank subsystems, process data and transmit it among subsystems, and display information to the tank crew. The core system will use some existing components but will require newly developed software. The software will connect existing tank components, which are for the most part analog, with new digital components.

The Army hopes that the core integration will decrease the costs of future tank modifications because future capabilities will only require software changes. The Army also posits that the core will add important capabilities above and beyond cost savings with no loss of reliability. These capabilities include increased survivability, ease of maintenance, and needed experience with digital electronics in a ground combat vehicle. The Army believes that such experience is important, given its plans for the next generation tank, which call for an all-digital electronics system.

ADDITIONAL MODIFICATIONS PLANNED FOR THE M1A2 TANK

The Army plans to make a series of production changes to the Abrams tank that are not part of the Block II development program. One significant change, to the fire control system, is required to integrate improved munitions being developed in the Army's Armament Enhancement Initiative. This initiative is the Army's program to improve the effectiveness of the current generation of munitions. One munition, designed for the secondary tank mission of air defense, is expected to achieve a higher probability of hitting its target because of changes made possible by the new core configuration. The Army plans to retrofit existing M1A1 tanks with fire control system changes for this and other improved Armament Enhancement Initiative munitions.

Another change that the Army plans to retrofit to Abrams M1A1 tanks includes new torsion bars, which are needed to support the increased weight of the current M1A1 production model, which has heavier armor than previous versions.

PROGRAM HAS NOT RECEIVED PRODUCTION APPROVAL BY THE OFFICE OF THE SECRETARY OF DEFENSE

During the fiscal year 1990 budget preparation, DOD's Conventional Systems Committee (CSC) determined that the Block II program would be reviewed by the DAB as part of its oversight responsibility. The DAB provides the Secretary of Defense with advice on major weapons systems acquisitions. Likewise, the CSC, as one of the DAB's 10 acquisition committees, works with the Army to identify and resolve program issues whenever possible and formulate recommendations for the DAB's consideration when appropriate.

The Block II components are intended to address the following deficiencies in current tank capabilities, as identified by the U.S. Army Armor Center and School:

-- A commander's independent thermal viewer (CITV) will allow the commander to detect and acquire targets independent of the gunner. The commander and gunner currently use the same sight to search for targets.

-- Survivability enhancements in the form of new armor packages are designed to increase the tank's protection against threat munitions.

-- An improved commander's weapons station (ICWS) is required because of changes caused by the addition of armor and space requirements for the CITV. This station is intended to provide the commander with a greater field of view and an integrated display of data from tank systems.

-- A position/navigation (POS/NAV) system will assist the tank crew in identifying its location on the battlefield.

-- A carbon dioxide laser range finder, which will replace the current range finder, will be safer to use and will improve precision gunnery in some foggy and smoky environments in which the current range finder cannot be used.

These improvements are shown in figure 1.1.

CHAPTER 1

INTRODUCTION

The Army's Abrams main battle tank (the M1) was developed in the late 1970s, and the Army authorized full-rate production of it in 1981. The Army's plan called for adding capabilities through "block improvements." The most recent major block improvement, the M1A1, was fielded in December 1986 and included a larger main tank gun, improved armor, and a nuclear, biological, and chemical protection system. Additional armor has since been added. The Army's current upgrade package, called the "Block II program," is the third in the series of block modifications to the Abrams tank. Production costs are expected to be about $1.5 billion.

THE ARMY'S TANK MODERNIZATION PROGRAM

In December 1988, the Department of Defense's (DOD) Defense Acquisition Board (DAB) gave the Army conditional approval to proceed with its Block II program, and the Army awarded a full-scale development (FSD) contract to General Dynamics Corporation shortly thereafter. The Army believes that the Block II program will provide an interim response during the mid-1990s to an increasing Soviet threat by improving the lethality, survivability, and fightability (the ease and efficiency with which the crew can operate the tank) of the M1A1 until the next generation tank can be produced. The Army performed a cost and operational effectiveness analysis (COEA), which it believes justifies the expenditure of additional funds for the proposed upgrades.

The Block II program is expected to proceed into full-rate production as the M1A2 tank in August 1991 and stay in production until fiscal year 1997. The Army's fiscal year 1990 budget request contains over $166 million for procurement of long-lead items and nonrecurring production start-up costs.

The Army's heavy force modernization program calls for the fielding of a follow-on to the Abrams tank in fiscal year 1997. This next generation tank, which is being developed under the Army's heavy force modernization concept,[1] is sometimes referred to as "Block III." The Army, however, has not decided whether its next generation tank will be a follow-on to the Abrams or part of the Abrams series.

The Army is to begin systems engineering analysis for its next generation tank in fiscal year 1990. Its design has not yet been

[1]This concept calls for a common chassis to be used for all heavy combat vehicles.

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Additional Department of Defense comments have been noted, as appropriate, throughout the report.

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Defense's commitment to the program at the time of the production decision.

Performance Capabilities of Integrated System Unknown

The proposed electronics package of the tank's digital core, which will integrate the Block II components, has not previously been used in a tank. The Army expects to realize numerous advantages from the core configuration, such as improved tank reliability, increased survivability, lower operation and support costs, and fewer maintenance problems. However, the Army does not have analyses that support these expectations. In addition, developing adequate software is critical to the performance of the core system. Army and Office of the Secretary of Defense officials believe that this will be a difficult developmental task and that much needs to be accomplished in a short amount of time.

Effectiveness Gains Overstated

The Army performed a cost and operational effectiveness analysis, which concluded that the major gains in effectiveness expected with the Block II improvements supported the increased program cost of $532,000 per tank. The analysis was based on certain key operational assumptions that are not supported by actual experience. For example, the analysis assumed that commanders of currently fielded tanks do not search for targets. Tank commanders, however, routinely perform that task. Likewise, the analysis assumed that with the new independent thermal viewer, commanders would spend all of their time searching. In fact, some commanders (two of four in a platoon) have numerous additional responsibilities, a factor that was not considered. These assumptions resulted in the overstatement of the new tank's effectiveness.

Linkage Between Block II and Future Tanks Not Defined

The Army believes that it needs to produce and field the digital electronics system, or core tank, planned for the Block II package to test out certain new concepts that will support future tank efforts. However, the Army has not determined a system configuration for its next generation tank, and preliminary indications are that there may be little commonality between the two models.

RECOMMENDATIONS

GAO recommends that the Secretary of Defense withhold approval of the obligation of advanced or other procurement funds for the Block II tank program until

In December 1988, the Defense Acquisition Board conditionally approved the Block II program for development but placed a $300,000 per tank cost limit on the modifications. The Block II package, as currently designed by the Army, is expected to cost roughly $532,000 per tank. Total program production costs are expected to exceed $1.5 billion to procure 2,926 tanks. In August 1989, the Office of the Secretary of Defense approved continued development and established a new production cost ceiling of $3.037 million per tank. This amount is not sufficient to produce the entire Block II package, given current costs.

RESULTS IN BRIEF

The Army believes that it needs the Block II program to improve the Abrams tank's survivability, fightability, and lethality to meet an increased Soviet tank threat expected in the mid-1990s. The Army also believes that the Block II improvements are needed to provide a link to the next generation tank, which is expected to meet the Soviet threat at the turn of the century. However, the currently approved tank does not include all survivability, fightability, and lethality enhancements that were assumed to be available when the Army performed its cost and operational effectiveness analysis. Further, the Army has not demonstrated its additional justification--the link between this and the next generation tank. In its attempt to field an upgraded Abrams tank within this time frame, the Army has adopted a compressed acquisition strategy. This strategy is risky because key components of the Block II package are in the early stages of development, and testing and evaluation of the components and the integrated system will not be complete when certain production decisions are made. This means that under current plans, the Army will commit advanced procurement funds before test results of the system are available.

The compressed development schedule, the lack of test data, and the absence of a trial period of low-rate initial production may result in performance problems after the program enters full-rate production. These problems could delay the Block II program and raise its cost, thereby calling into question the Army's justification for the M1A2 as an interim solution to meet the threat and hindering future critical tank modernization efforts.

PRINCIPAL FINDINGS

Enhanced Survivability Questionable

The proposed Block II armor packages may have only limited impact on the tank's survivability--one of the Army's top tank modernization priorities. The Army may not reach its Block II survivability goals. In addition, a tank made heavier with the addition of armor will further stress tank suspension and support systems. The Army's planned weight reduction program will not show

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United States
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National Security and
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The Honorable Les Aspin
Chairman, Committee on Armed Services
House of Representatives

Dear Mr. Chairman:

This report responds to your request that we review the Army's plans to modernize the Abrams tank. We have also provided several briefings on the program to your staff.

The Army's Block II Abrams modification program entered full-scale development in December 1988. The Army plans to make a production decision on the program in August 1991. However, procurement funds are being requested in the fiscal year 1990 budget for long lead time and non-recurring items. The full program has not been approved for production by the Secretary of Defense. This report focuses on the Army's justification for the Block II program and problems that have been or may be encountered in the development phase. It contains recommendations to the Secretary of Defense.

We are sending copies of the report to the Chairmen of the Senate Committee on Armed Services and on Appropriations and the House Committee on Appropriations and the Secretaries of Defense and the Army. We will also make it available to other interested parties with appropriate clearances.

The report was prepared under the direction of Richard Davis, Director, Army Issues, who may be reached on (202) 275-4141 if you or your staff have any questions. Other major contributors are listed in appendix I.

Sincerely yours,

Frank C. Conahan

Frank C. Conahan
Assistant Comptroller General

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its issue date. At that time, we will send copies to the Chairmen of the Senate Committee on Armed Services and the Senate and House Committees on Appropriations; the Director, Office of Management and Budget; and the Secretaries of Defense and the Army. We will also make it available to other interested parties.

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