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BY THE U.S. GENERAL ACCOUNTING OFFICE

Report To The Secretary Of Defense

Department Of The Army's Program To Modify 155-mm. M109 Self-Propelled Howitzers To An M109A5 Configuration

The Army plans to modify 1,500 of its 155-mm. M109 howitzers to an M109A5 configuration at a cost of \$1.5 billion. The modifications are intended to improve the howitzer's effectiveness and availability. In April 1984, the Army plans to decide whether the program should proceed into full-scale development. If the decision is to proceed, several issues need to be addressed early in the next phase, the most important of which concerns the howitzer's companion supply vehicle.

When reloading its ammunition, the M109 howitzer operates alongside an unarmored ammunition supply vehicle which is unprotected against many types of munitions, and its low survivability could impair the howitzer's effectiveness and endanger its crew. The Army is procuring a new armored ammunition supply vehicle but only in sufficient numbers to field with howitzers deployed in Europe. GAO recommends that the Secretary of Defense determine whether it is cost effective to modify the remaining 800 to 1,000 M109 howitzers that would continue to operate with the vulnerable vehicle. If not, the Army should consider modifying fewer howitzers and applying the saving to the procurement of additional armored ammunition supply vehicles.



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UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

NATIONAL SECURITY AND
INTERNATIONAL AFFAIRS DIVISION

B-214410

The Honorable Caspar W. Weinberger
The Secretary of Defense

Dear Mr. Secretary:

We have reviewed the Army's program for modifying 1,500 of its 2,200 155-mm. M109 self-propelled howitzers to an M109A5 configuration. The objectives of our review were to evaluate the program's progress and identify any issues that should be considered in making program and funding decisions.

The M109A5 is in the acquisition cycle's concept formulation phase. The Army plans to make a decision in April 1984 on whether the program should proceed into full-scale development. The modification program's estimated cost is \$1.5 billion, or \$1 million per howitzer. The principal modification involves replacing the cannon, the gun mount, and the recoil system which are major contributors to the current howitzer's low 41-percent wartime availability. The Army's goal is to obtain a howitzer that will achieve a 75-percent wartime availability. Other modifications are to improve the hydraulics and suspension, incorporate a mechanical device to facilitate loading the ammunition, install a computer as part of the fire control system, and install a new radio communications system.

The Army has deferred approving the M109A5's entry into full-scale development, originally scheduled for March 1983, because decisionmakers were lacking certain critical program information needed for the decision. Missing were (1) a cost and operational effectiveness analysis that is still in progress, (2) more definitive information on the number of howitzers that should be modified, which is to be determined by an Army study of the field artillery's howitzer and rocket launcher needs, and (3) an updated program cost estimate. Program officials are planning to assemble enough information on these issues to warrant a decision by the Army in April 1984 on whether to go forward with the system.

We believe the Army exercised exemplary caution in withholding its approval to move the program out of concept formulation to the next phase, considering the program uncertainties that were present. The Army also consistently showed its concern about the program's affordability when it rejected several costly alternative modification programs it had considered earlier for upgrading the howitzer.

At this point, we have three concerns to bring to your attention. While not of such an immediate nature as to warrant postponing the full-scale development decision, they need to be resolved early in the next phase if a decision is made to proceed. The most important of these relates to the howitzer's ammunition supply vehicle.

A key factor in determining the howitzer's cost and operational effectiveness is the ammunition supply vehicle on which the howitzer depends for replenishing its supply of rounds. Because of their proximity in combat (the vehicle and the howitzer are interconnected during reloading), the vehicle's survivability and the howitzer's effectiveness are directly related. The Army's current ammunition supply vehicle, the M548, is unarmored and affords little protection to the crew, ammunition, and equipment carried on board. An Army study has concluded that crew casualties could almost be cut in half if the ammunition supply vehicle were armored.

The Army has a program separate from its howitzer modification program to procure a new armored ammunition supply vehicle, the M992. The price of each vehicle, under the first production contract for 54 vehicles, awarded in May 1983, was \$372,000. For affordability reasons, however, the Army plans to procure only enough M992s to support the 155-mm. M109 and 8-inch M110 howitzers deployed in Europe, where it feels their need is most critical. This would leave over half the M109A5 howitzers--800 to 1,000--with artillery units in the United States and other locations that will continue to be supported by the vulnerable M548 vehicle. These units may eventually be needed in wartime to reinforce the troops in Europe.

The extent that the benefits resulting from improvements to the M109 howitzers may be offset by the fact that the great majority of the howitzers will continue to operate with an M548 vehicle lacking in adequate protection for the crew, ammunition, and on-board equipment requires consideration in any program decisions. Such an analysis is necessary to determine which combination of M109A5's and M992 supply vehicles is the most effective for a given level of funding. The cost and operational effectiveness study now in progress will not provide this information since it is not measuring the M109A5's effectiveness when operating with the M548.

More information is also needed on two other aspects of the program. The M109's present cannon will be replaced primarily because breakdowns and maintenance time have reduced the amount of time the cannon is available to operate. The Army is proposing to modify a cannon for the M109A5 which will cost about

\$250,000 each and has potentially greater operational availability during wartime. Achievement of improved availability will have to be demonstrated early in the next program phase. A second unknown is the effect on the howitzer's mobility of about 4,000 pounds of weight added by the proposed modifications.

In addition, the benefits of two other elements of the modification are not clear at this time. The first is the fact that the modified cannon's selection is also based on its ability to increase the M109A5's range from 23.5 to 30 kilometers; however, currently only one ammunition round which is expected to be used less than 10 percent of the time can attain this range. The second element is a mechanical assist loader which would increase the howitzer's rate of fire. Whether this will appreciably increase the amount of damage the howitzer can inflict is uncertain as other contributing factors, such as response time and storage capacity, will still be less than what is needed.

Our findings are presented in greater detail in the enclosure.

RECOMMENDATIONS

We recommend that you direct the Secretary of the Army, during full-scale development, to

- perform an analysis that would determine whether it is cost effective to modify the number of M109 howitzers that will continue to operate alongside the vulnerable M548 ammunition supply vehicles and, if it is not,
- consider the option of modifying a lesser number of howitzers than the 1,500 now in the program and apply the savings toward the procurement of additional, more survivable, M992 vehicles, if affordability considerations continue to limit the funds available for both programs.

We also recommend that if the decision is to continue into full-scale development, before contracting for modification of a large number of howitzers, the Secretary of the Army

- ensure that the tests in the next acquisition phase adequately demonstrate that the selected cannon replacement will achieve the Army's availability goal and that the added weight resulting from the modifications will not materially degrade the howitzer's mobility.

AGENCY COMMENTS AND OUR EVALUATION

The Department of Defense, in commenting on a draft of this report, provided some updated information on the modified howitzer program and suggested some changes to the text in the interest of accuracy. We have incorporated these in the report.

The Department did not agree that a cost and operational effectiveness analysis should be made that would consider the modified howitzer's performance with M548 vehicles. It regards the M109A5 improvements as independent of the cost and survivability of the ammunition supply vehicle. The Department plans to put the howitzer modifications under a development contract shortly after the April 1984 program decision is rendered, if it is a favorable one.

We continue to believe that because of their dependence on the ammunition supply vehicles, it is important to determine by analysis whether it would be cost effective to modify all 1,500 howitzers when the majority of howitzers would continue to operate with the less survivable M548 vehicles. The benefit derived from modifying the howitzers without the concurrent increase in the survivability of the accompanying ammunition supply vehicle may be so little as to warrant spending the money in some other way.

Should such an analysis show this combination (modified M109A5 howitzer operating with the M548 vehicle) not to be cost effective, the Army would still have another option--to modify a lesser number of howitzers than the 1,500 now in the program and apply the savings toward the procurement of additional M992 vehicles.

The Department also stated it had done sufficient analysis of the effect of replacing the present cannon with the selected cannon. The Department believes that this analysis and the Army's testing of the modified howitzer's mobility with the added weight that would result from the modifications are sufficient to warrant proceeding to the next acquisition phase where the new cannon and modified suspension can be further tested and evaluated.

We have reviewed the analyses done by the Army thus far on availability and mobility and agree that they are proper bases for deciding whether to begin full-scale development. However, we believe that if the Army decides to proceed into this phase, availability and mobility should be demonstrated in testing before proceeding to a large-scale modification program. The Department of Defense stated that evaluation of these two elements would continue to be an integral part of the program until fielding.

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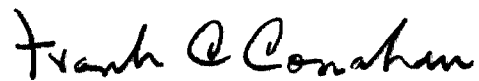
As you know, 31 U.S.C § 720 requires the head of a federal agency to submit a written statement on actions taken on our recommendations to the House Committee on Government Operations

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and the Senate Committee on Governmental Affairs not later than 60 days after the date of the report and to the House and Senate Committees on Appropriations with the agency's first request for appropriations made more than 60 days after the date of the report.

We are sending copies of this report to the Chairmen of the above Committees; the Chairmen, House and Senate Committees on Armed Services and Appropriations; the Director, Office of Management and Budget; and the Secretary of the Army.

Sincerely yours,



Frank C. Conahan
Director

Enclosure

DEPARTMENT OF THE ARMY'S PROGRAM TO MODIFY 155-MM. M109
SELF-PROPELLED HOWITZERS TO AN M109A5 CONFIGURATION

BACKGROUND

The M109 howitzer was developed in the late 1950's and was first fielded in 1963. Since that time it has been through several modification programs.

The howitzer was modified to an M109A1 beginning in 1973 when a longer gun tube, to extend the howitzer's range, was installed. Further modifications were made to the M109A1 to improve the loader, the rammer, ammunition stowage, and crew safety. These improvements were incorporated in a new howitzer designated the M109A2, whose production began in 1979. A version that resulted from retrofitting the M109A1's to incorporate these same improvements was designated the M109A3. The M109A2 and M109A3, then, are virtually identical. There are about 2,200 of these in the inventory today.

The approximately 2,200 M109A2 and M109A3 howitzers are presently being modified at a unit cost estimated at \$235,000 each, to improve their survivability and reliability. This modification program, which is distinct from the M109A5 program, includes improved engine cooling, some self-diagnostic capability, and an automated gun-laying capability. The Army plans further improvements to 1,500 of the 2,200 howitzers to configure them to an M109A5. Additional modifications to be incorporated in the M109A5 include replacing the cannon assembly, the recoil system, and the gun mount; improving the hydraulics and suspension; and installing a mechanical device to facilitate loading the ammunition, a computer for the fire control system, and a radio communications system. The M109A5 modifications are estimated to cost \$1 million per howitzer. The approximately 600 howitzers that will not undergo these additional modifications will be designated as M109A4's.

Thus far, the Army has proceeded cautiously with the program. In arriving at the current program, the Army previously rejected several costly alternatives for upgrading the howitzer. Also, the Army has delayed for more than a year the decision on whether to enter full-scale development because critical information needed by decisionmakers to assess the howitzer's cost effectiveness and affordability was lacking.

Army rejected several other
proposed M109A5 alternatives

In April 1983, when we began our review, the M109A5 program was in its third year of concept formulation. During this phase

the Army had considered several alternatives. Three involved product improvement programs of varying sophistication, including either modified versions of the cannon and ammunition loader or a new cannon and loader. A fourth alternative called for developing a completely new howitzer. The fifth alternative involved procuring an existing howitzer, the SP-70, codeveloped by the United Kingdom, the Federal Republic of Germany, and Italy, and modifying it to meet Army requirements. All five alternatives included plans for acquiring a new ammunition supply vehicle to accompany the howitzer on a one-for-one basis.

None of the alternatives was selected, four for reasons of cost and one, the least sophisticated of the product improvement programs, because it did not meet a sufficient number of the 52 performance requirements called for by the mission element needs statement, prepared in 1980.

After the rejection of these alternatives, the Army's user representative, the Training and Doctrine Command (TRADOC), proposed a sixth alternative system at mid-1983 briefings of the Army Systems Acquisition Review Council (ASARC) principals and the Vice Chief of Staff. This alternative combined features of the two more sophisticated of the three proposed product improvement alternatives not selected earlier. It, too, was deemed too costly and, further, its cost effectiveness had not been sufficiently studied. This alternative would have cost about \$7.5 billion, according to Army estimates. TRADOC proposed to modify 1,942 howitzers at a unit cost of \$2.4 million and to acquire an equivalent number of new ammunition supply vehicles at a unit cost of \$1.5 million. Recognizing that meeting all the specified performance requirements would be costly, the Army reexamined its need and identified the 21 most important affordable requirements for retention in the M109A5 modification program.

OBJECTIVES, SCOPE, AND METHODOLOGY

The objectives of our review were to evaluate the program's progress and identify any issues that should be considered in making program and funding decisions. We performed our work primarily at the U.S. Army Armament Research and Development Center, Dover, New Jersey, and at the Field Artillery Center, Fort Sill, Oklahoma. We also met with several officials associated with the M109A5 program in the Office of the Secretary of Defense and at Army Headquarters. We examined the Army's justification documents for the program and numerous other program documents and special studies prepared by the program manager and the field artillery center. All cost estimates in this report are presented in escalated dollars. Our review was performed in accordance with generally accepted government auditing standards.

PLANNED HOWITZER WILL NOT MEET
MANY ORIGINAL ARMY REQUIREMENTS

The mission element needs statement delineated several deficiencies in the Army's current howitzers. These relate primarily to the howitzer's (1) availability, (2) survivability, (3) responsiveness, and (4) ability to inflict damage. Most of the improvements to enhance the howitzer's availability that TRADOC proposed to the ASARC principals and the Vice Chief of Staff in the summer of 1983 are still in the program. The Army hopes to increase the howitzer's wartime availability from the present 41 percent by installing a cannon, a gun mount, and a recoil system that are more reliable and easier to maintain. The Army also plans to improve the hydraulics, suspension, and built-in test equipment.

Although other improvements address the three other categories of deficiencies, several major modifications that TRADOC had proposed in these areas were dropped. They were

- a nuclear, biological, and chemical overpressure system to protect the crew compartment from contamination if these types of warfare were encountered;
- an automatic loader which would have enhanced responsiveness and permitted the crew to be reduced in number; and
- a modification which would permit increasing the rounds of ammunition carried on board from the current 36 rounds to a range of 44 to 60, thereby reducing the frequency of reloading.

Another alternative eliminated was a planned upgrading of the engine, transmission, and suspension. The upgrading was to have compensated for a weight increase of 9,500 pounds from the modifications proposed in the rejected TRADOC alternative. The upgrading would have also increased the howitzer's mobility and permitted implementing a "shoot and scoot" tactic (fire and then immediately move to a different location) to enhance survivability. A road test using the M109A2 howitzer, with 9,500 pounds of dead weight added, indicated that the extra weight degraded handling and braking performance and caused the vehicle to bottom out.

According to M109 project officials, the planned system, although it meets only minimum requirements, will improve the howitzer's availability and provide enough increased effectiveness to warrant the \$1.5 billion program cost associated with

it. They believe it will serve adequately as an interim system until a new system can be acquired. There is a concept now in basic research which envisions development of a new state-of-the-art howitzer whose fielding is projected for around the year 2000.

ISSUES REQUIRING PROMPT ATTENTION IF
THE PROGRAM ENTERS THE NEXT PHASE

If the Army decides the M109A5 program should move into full-scale development, three issues will have to be addressed early in that phase. They are:

- whether operating with an unarmored ammunition supply vehicle degrades the M109A5's effectiveness to the point where, if affordability considerations continue to limit the funds available to both programs, the Army should consider modifying fewer howitzers in order to buy more armored supply vehicles,
- demonstrating whether improved availability can be achieved with the selected cannon, and
- demonstrating whether suspension improvements will safeguard the howitzer's mobility against the added weight of the modifications.

Evaluation of howitzer's cost effectiveness
should consider accompanying ammunition
supply vehicle's survivability

The Army's field artillery school at Fort Sill is conducting two studies which will help determine the cost effectiveness of the M109A5 modifications. The first study will try to determine the mix of howitzers and rocket launchers that would provide maximum battlefield effectiveness. The planned quantity of M109A5 howitzers and the program cost could change based on the study results. The study is not due until September 1984, but according to the Army, a preliminary study does support the planned quantity of 1,500 to be modified.

The second study is a cost and operational effectiveness analysis being prepared for an April 1984 program decision on whether to go into full-scale development. This study is particularly significant because the scaled-down modifications in the current program offer considerably less improvement to the howitzer than would be required to overcome the howitzer deficiencies noted in the mission element needs statement.

This analysis will assess the planned M109A5 modifications to determine whether their estimated cost provides a corresponding increase in the howitzer's performance potential. However, the Army is not including in its analysis how the M109A5's

effectiveness will be affected by the survivability of its companion ammunition supply vehicle.

The effort to make the M109 howitzer fleet more effective and survivable could be degraded if, as is now planned, more than half the howitzers are not supported by better ammunition supply vehicles. The M548 tracked vehicle is now deployed with the Army's self-propelled howitzers to carry backup howitzer crew members; crew supplies; and a resupply of projectiles, propellant charges, and fuzes. This vehicle provides no armor protection for its crew or cargo and is vulnerable to almost every conceivable type of munition. The vehicle's deployment tactics apparently vary, but its location next to the howitzer is unavoidable since they are hooked up by a conveyor belt during the reloading process. The vehicle's relatively high potential for destruction and the loss of its ammunition could damage the howitzer's effectiveness. A field artillery school study estimates that during combat operations, howitzer crew casualties could be reduced from 11 percent to 6 percent if armored supply vehicles were used instead of the M548.

The Army plans to replace the M548 with a new vehicle, the M992, developed under another program. The new vehicle has on-board ammunition handling equipment and a larger cargo capacity. Most important, it provides armor protection equal to the M109 howitzer's.

Affordability limits the number of new ammunition supply vehicles to be procured. The Army plans to buy only enough vehicles to accompany the M109 and the 8-inch M110 howitzers deployed in Europe where the Army believes the new vehicle is most needed. This would leave another 800 to 1,000 M109A5's in the United States and in other locations dependent on the M548 vehicle. The Army has awarded an initial production contract for 54 M992 vehicles in May 1983 at a unit cost of \$372,008.

We did not review the M992 supply vehicle's operational and development test results in detail. However, responsible officials, including the program's project manager, maintain that it is far superior to the M548, meets operational performance requirements, and will enhance the combat effectiveness of the howitzer force.

Cannon availability and howitzer
mobility must be demonstrated in testing

The howitzer's mobility and the availability of its cannon are key contributors to the M109A5's effectiveness. The Army estimates that replacing the M185 cannon currently on the M109A2 and M109A3 howitzers will cost about \$250,000 each. The cannon,

the gun mount, and the recoil system have been major contributors to the howitzer's low wartime availability of 41 percent. The Army's objective is to raise this wartime availability to 75 percent by increasing the cannon's reliability and maintainability.

The Army considered three alternatives for reducing cannon failures and maintenance time. One was to modify the M185 cannon. A second was to modify the M199 cannon, currently used with the M198 towed howitzer, so that it could be used with the M109A5. A third was to develop a new cannon. The alternative chosen was a modified M199 cannon. Before selecting this alternative, the Army analyzed the potential of all three candidates for achieving the required availability. Whether the modified M199 cannon can achieve the needed availability will have to be demonstrated in hardware testing.

The modifications now in the program will increase the howitzer's weight by 4,000 pounds. The Army has done some testing of an M109 howitzer with the same amount of weight added and has identified suspension modifications necessary to maintain the howitzer's mobility at the increased weight. These modifications are estimated to cost about \$14,000 per unit. Whether they can offset the effect of the added weight on the howitzer's mobility remains to be demonstrated.

Contributions made by longer range cannon
and mechanical assist loader not yet clear

In addition to greater availability, the Army would like the M109A5 to have a cannon with a range greater than the M109A2's and M109A3's 23.5 kilometers. This would enable deeper penetration into enemy territory and would permit setting the howitzer further back from the front line, if desired. The range a cannon can achieve depends on the type of ammunition and propellant charge used. All three elements must be compatible. The following table shows the maximum range achievable with the principal types of howitzer ammunition included in an ammunition supply vehicle's typical load.

<u>Howitzer</u>	<u>Cannon</u>	<u>Ammunition</u>	<u>Maximum range (kilometers)</u>
M198	M199	M549A1	30.0
M109A2 and M109A3	M185	M549A1	23.5
M198	M199	M483A1	17.5
M109A2 and M109A3	M185	M483A1	17.5

The M483A1 ammunition's maximum range is limited by its incompatibility with more powerful propellant charges. The M549A1's maximum range varies with the cannon (30 kilometers with the M199 cannon and 23.5 kilometers with the M185 cannon).

The Army would like a range for the M109A5 of as much as 30 kilometers. However, only one conventional round, the M549A1 rocket-assisted projectile, can achieve this range. The propellant that provides the charge needed to fire out to 30 kilometers is not compatible with the M185 cannon; hence, the selection of the M199 cannon was also based on compatibility with the M549A1 projectile in gaining the desired range.

However, based on doctrine and tactics studies by the field artillery school which dictate how artillery weapons are to be used and supported in various combat scenarios, the M549A1 projectile will be used only 9 per cent of the time. This small usage raises the question of whether the costs associated with attaining the longer range capability are worth it. The primary round to be used, constituting 73 percent of its typical load, is the M483A1 improved conventional munition whose maximum range is 17.5 kilometers. However, defense officials maintain the longer range would be better utilized in the future as several rounds are under development which would take advantage of the cannon's longer range capability.

In addition, the benefits seem unclear with regard to the Army plans to incorporate a mechanical device into the M109A5, called a mechanical assist loader. Its purpose is to facilitate loading the ammunition, thereby increasing the howitzer's firing rate from the current four rounds per minute to six rounds per minute in order to help inflict greater damage on the enemy. The program's cost estimate includes \$88,500 a unit for this modification.

By itself, a mechanical assist loader that would increase the rate of fire may not be sufficient to achieve the desired increase in damage to the enemy. The Army is still to determine the optimum rate of fire. Other factors, which are important to consider in a cost and operational effectiveness analysis, include the type of munition used, the time it takes to respond to the need to fire, and the number of rounds that can be stowed to decrease reloading frequency. However, the M109A5 version is to have the same stowage capacity as its predecessors, and response time, though improved, will still be twice as long as analyses by the laboratory at Picatinny Arsenal show is needed to inflict the desired amount of damage on the enemy.

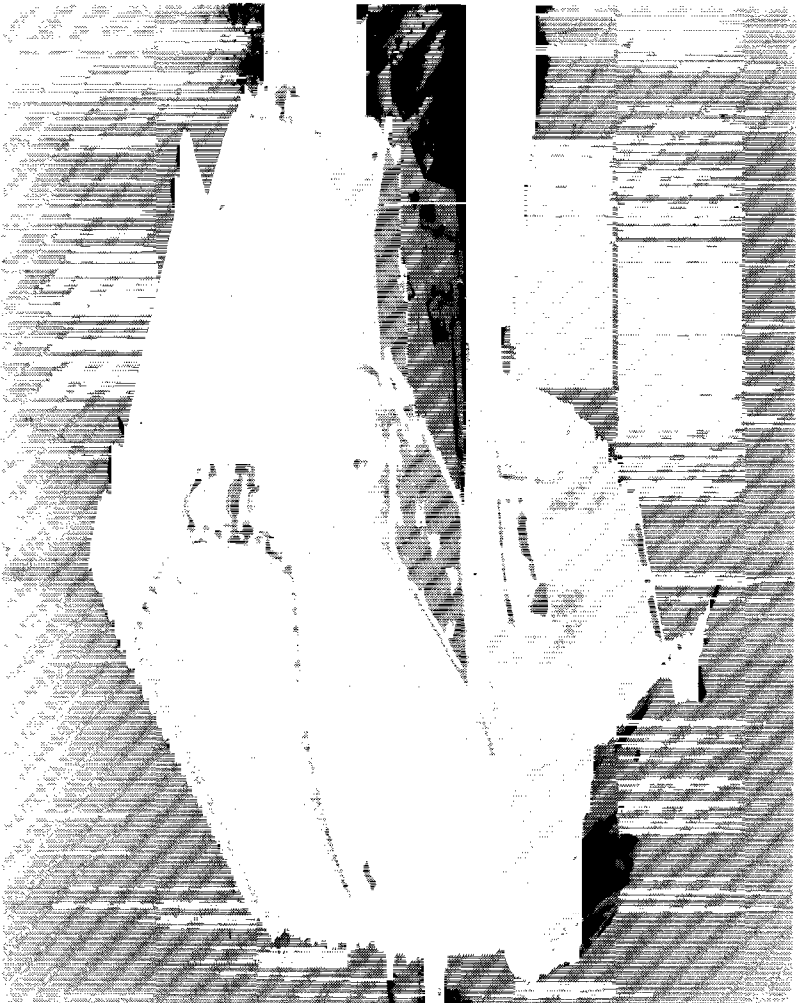
CONCLUSIONS

The Army made a sound decision not to progress from conceptual development of the M109A5 to a more advanced development phase, as originally planned. Important information, critical to determining whether additional funds should be committed to this program, was unavailable. The Department of Defense should be in a better position to make programming and funding decisions after the M109A5 program's affordability and cost effectiveness can be better assessed, based on Army studies now in progress. If the decision is made to enter full-scale development, then three issues must receive prompt attention in that phase.

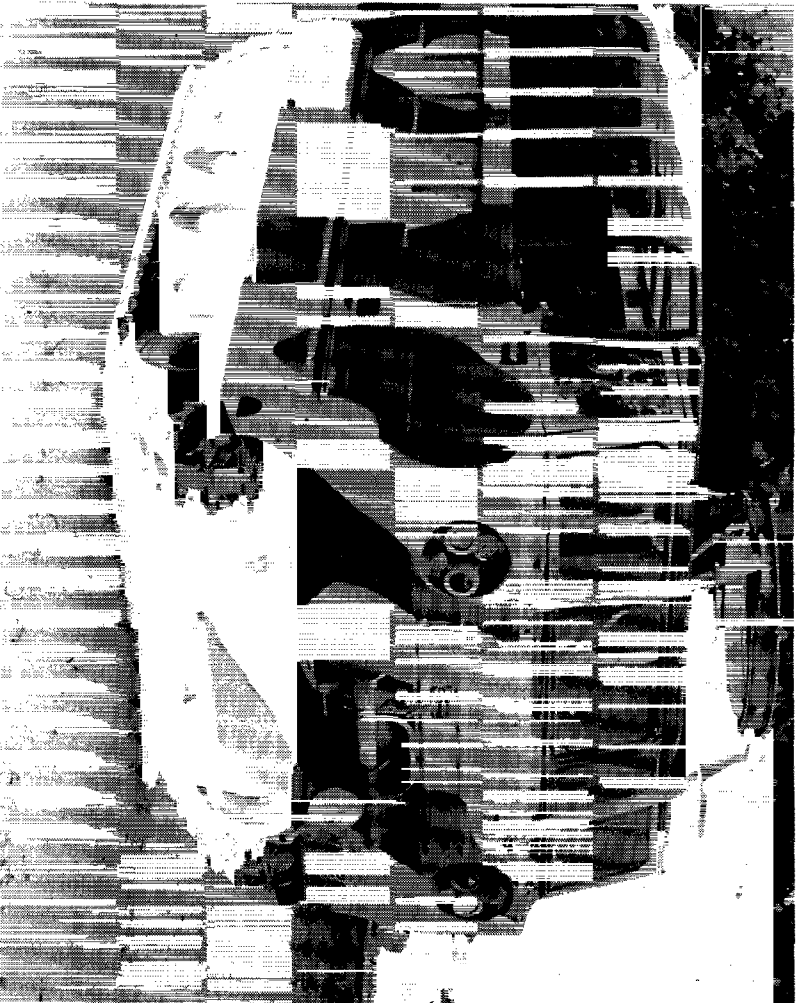
We believe that because of their proximity in combat during the reloading process, the ammunition supply vehicle's survivability and the howitzer's effectiveness are directly related. For affordability reasons the majority of M109A5 howitzers will continue operating with the vulnerable M548 vehicles. Whether it is cost effective to modify these howitzers is a matter to be determined. If it is shown not to be cost effective, the Army has the option to modify a lesser number of howitzers than the 1,500 now in the program and apply the savings toward the procurement of additional quantities of the new M992 armored vehicle, if both programs are to stay within present funding levels.

More information is needed in two other key areas. First, the Army should demonstrate that the selected M199 cannon replacement will help meet the desired 75-percent wartime availability goal. Second, the Army should demonstrate that the suspension modifications it is proposing will counteract the effect on the howitzer's mobility of adding 4,000 pounds to its weight.

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M992 armored supply vehicle.



M548 unarmored supply vehicle.





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