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Report to Congressional Committees

May 2003

MILITARY TRANSFORMATION

Army's Evaluation of Stryker and M-113A3 Infantry Carrier Vehicles Provided Sufficient Data for Statutorily Mandated Comparison

GAO-03-671

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Army's Evaluation of Stryker and M-113A3 Infantry Carrier Vehicles Provided Sufficient Data for Statutorily Mandated Comparison

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Highlights

Highlights of GAO-03-671, a report to Congressional Committees

Why GAO Did This Study

The first step of the U.S. Army's ongoing transformation was to form two of six planned Interim, or Stryker, Brigade Combat teams and equip the brigades with a new interim armored vehicle—the Stryker. The fiscal year 2001 National Defense Authorization Act required the Secretary of the Army to develop a plan to compare the operational effectiveness and cost of an infantry carrier variant of the Stryker and a medium Army armored vehicle, the Department of Defense's (DOD) director of testing and evaluation approve the plan, and the Army to conduct the operational effectiveness and cost comparison. The Secretary of Defense was also to certify to Congress that Stryker Brigades did not diminish the Army's combat power.

As part of a series of ongoing reviews of Army transformation, GAO monitored the Army's 2002 efforts to (1) assess whether the Army's plan for the comparison met the legislative requirements and (2) determine whether the evaluation's resulting data were sufficient to measure the two vehicles' relative effectiveness.

What GAO Recommends

GAO is not making any recommendations. In commenting on a draft of this report, DOD concurred with the findings.

www.gao.gov/cgi-bin/getrpt?GAO-03-671.

To view the full product, including the scope and methodology, click on the link above. For more information, contact William M. Solis at (202) 512-8365 or solisw@gao.gov.

What GAO Found

The Army developed a plan, approved by DOD's Director, Operational Test and Evaluation, that met the requirements of the fiscal year 2001 National Defense Authorization Act. As required, the plan proposed comparing the operational effectiveness and cost of the Stryker and a troop-carrying medium armored vehicle selected by the Army—the M-113A3 armored personnel carrier. Regarding the operational effectiveness, the plan's scope included the use of various data, such as that obtained during operational vignettes, for which all participants and observers received training regarding the vehicles, and from technical testing. The plan focused on the armored vehicles' effectiveness; suitability in support of infantry units, such as maintenance; and survivability during operations. Regarding the cost comparison, the plan proposed that a comprehensive cost analysis be conducted between the two vehicles.

GAO determined, based on its observation and analysis of evaluation plans and results, that the Army's conduct of the plan provided sufficient data to determine the two vehicles' relative effectiveness. To obtain the data concerning the vehicles' operational effectiveness, survivability, and suitability, the Army conducted and evaluated operational training events and multiple technical tests. According to the Army Test and Evaluation Command, both the Stryker and the M-113A3 enabled the infantry to complete missions. However, the Command concluded that the Stryker provided more advantages in force protection, support for dismounted assault, and close fight and mobility and was more survivable against ballistic and nonballistic threats. The Army also conducted a comprehensive cost analysis. GAO determined that the costs used in the analysis were reasonable and provided sufficient data to determine the vehicles' relative cost—with the Stryker being more expensive to acquire than the M-113A3 but less so to operate and maintain. The Secretary of Defense, as required, certified to Congress that the Stryker Brigade Combat Team did not diminish Army combat power.

Army's Stryker and M-113A3 Armored Vehicles Used in Comparative Evaluation

Source: GAO.

Contents

Abbreviations

DOD	Department of Defense
MANPRINT	Manpower and Personnel Integration
MAV	Medium Armored Vehicles
PA&E	Program Analysis and Evaluation Directorate

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Congressional Committees

In early 2000, the U.S. Army began transforming its force to one that is expected to be more strategically responsive, rapidly deployable, and able to effectively operate in all types of military operations, whether small-scale contingencies or major theater wars. The first step was to form two of six planned Interim, or Stryker, Brigade Combat teams and equip the brigades with a new interim armored vehicle known as the Stryker. The first two brigades are located at Fort Lewis, Washington.

Because these brigades are an entirely new organizational design, many questions have arisen as to the unit's cost, combat effectiveness, and suitability. In the fiscal year 2001 National Defense Authorization Act,[1] Congress required

- the Secretary of the Army to develop a plan for comparing the operational effectiveness and cost of an infantry carrier variant of the interim armored vehicle and a medium armored vehicle currently in the Army inventory, although the legislation did not provide specifics regarding the comparison;

- the Director of Operational Test and Evaluation of the Department of Defense (DOD) to approve the comparison plan before the Army could carry it out;

- the Army to conduct the operational effectiveness and cost comparison; and

- the Secretary of Defense to certify that the Stryker brigade combat team did not diminish the Army's combat power.

The statute further provided that vehicles for the third brigade could not be acquired until 30 days after the certification.

See appendix I for the full text of the law.

[1] Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001, P.L. 106-398 (Oct. 30, 2000).

On the basis of the authority of the Comptroller General, we monitored and assessed the Army's efforts during 2002 to meet the requirements of the legislation. In doing so, we observed operational training events held at Fort Lewis, Washington, which the Army used to collect comparison data, and a vehicle survivability test at Aberdeen Proving Ground, Maryland. Our objectives were to (1) assess whether the Army's plan for the comparison met the legislative requirements and (2) determine whether the results of the evaluation provided the data needed to measure the relative effectiveness of the two vehicles. The report also discusses the Secretary of Defense's report to Congress and certification regarding the combat power of the Army. We are providing this report, our fifth in a planned series related to Army transformation,[2] to you because of your committees' oversight responsibility.

Results in Brief

The Army developed a plan, approved by DOD's Director, Operational Test and Evaluation, which met the requirements of the fiscal year 2001 National Defense Authorization Act. As contained in the congressional mandate, the plan proposed comparing the operational effectiveness and cost of the Stryker Infantry Carrier vehicle and the troop-carrying medium armored vehicle currently in the Army inventory—the M-113A3 armored personnel carrier. With regard to operational effectiveness, the plan's scope included the use of various data, such as that obtained during operational vignettes and technical testing. The plan focused on three main comparison issues relating to the armored vehicles—their effectiveness, suitability in support of infantry units such as vehicle employment and maintenance, and survivability during operational missions. Regarding the cost comparison, the plan proposed that a comprehensive cost analysis be conducted between the two vehicles.

[2] U.S. General Accounting Office, *Army Stryker Brigades: Assessment of External Logistics Support Should Be Documented for the Congressionally Mandated Review of the Army's Operational Evaluation Plan*, GAO-03-484R (Washington, D.C.: Mar. 28, 2003); *Military Transformation: Army Actions Needed to Enhance Formation of Future Interim Brigade Combat Teams*, GAO-02-442 (Washington, D.C.: May 17, 2002); *Military Transformation: Army Has a Comprehensive Plan for Managing Its Transformation but Faces Major Challenges*, GAO-02-96 (Washington, D.C.: Nov. 16, 2001); *Defense Acquisition: Army Transformation Faces Weapons Systems Challenges*, GAO-01-311 (Washington, D.C.: May 21, 2001).

Based on our observation and analysis of evaluation plans and results, the Army's implementation of the plan provided sufficient data to determine the relative effectiveness of the vehicles. The Army conducted and evaluated eight operational training events per vehicle type and data from technical tests to compare the operational effectiveness, suitability, and survivability between the two vehicles. Prior to the operational vignettes, all participants and evaluators received training pertinent to their roles. The Army also conducted a comprehensive cost analysis as part of the plan. After analyzing the Army's cost plan and data, we found that the costs used were reasonable and provided sufficient data to determine the relative cost of the two vehicles. Based on the results of the evaluation, the Secretary of Defense certified to Congress that the Stryker brigade combat team did not diminish the combat power of the Army. The Secretary of Defense also approved obligating funds for the Stryker vehicles to equip the third brigade.

In commenting on a draft of this report, DOD concurred with the report's findings.

Background

In October 1999, the Secretary and the Chief of Staff of the Army unveiled their vision to transform the U.S. Army into a more strategically responsive force that could dominate across the full spectrum of military operations—from small-scale contingencies to a major theater war. In testimony before the U.S. Senate in March 2000,[3] the Chief of Staff of the Army stated that the Army had to transform to meet current and future strategic requirements such as the rise of sub-national and transnational groups, including criminal and terrorist elements that may pursue objectives that threaten U.S. interests. The Army believes that the transformation is necessary to respond more effectively to (1) the growing number of peacekeeping operations and small-scale contingencies and (2) the challenges posed by nontraditional threats such as urban operations in biological/chemical environments. The Army plans to transform its forces over a 30-year period.

In initial efforts to meet this new vision, the Army's Training and Doctrine Command developed a concept that described the capabilities, organization, and operations of a new brigade combat team. This brigade

[3] Testimony before the Committee on Armed Services, U.S. Senate, Mar. 1, 2000.

would provide a capability that the Army did not possess: a rapidly deployable, early-entry combat force that is lethal, survivable, and capable of operating in all types of military operations, from small-scale contingencies to a major theater of war. As an early-entry force, the brigade is expected to have sufficient built-in combat power to conduct immediate combat operations upon arrival in theater if required. The brigade would be formed around a new, medium weight, armored vehicle. The Army chose an armored wheeled vehicle, designated as the Stryker, as its primary combat platform. The Army selected one light infantry brigade and one mechanized infantry brigade at Fort Lewis, Washington, to become the first Stryker brigade combat teams. The 3rd Brigade of the 2nd Infantry Division was selected to transform first.

Congress supported the Army's efforts to transform into a force that not only was lethal, versatile, suitable, and survivable but could also deploy rapidly. However, members agreed that the Army must conduct an evaluation that compared the operational effectiveness and cost between a medium armored vehicle currently in the Army's inventory and the Stryker Infantry Carrier vehicle planned for the brigades. The comparative evaluation was formalized in the fiscal year 2001 National Defense Authorization Act. For the comparison, the Army selected the M-113A3 armored personnel carrier as the medium armored vehicle currently in the inventory. Figures 1 and 2 show the Stryker Infantry Carrier vehicle and the M-113A3, respectively. The Army began conducting the comparison in September 2002.

Figure 1: Stryker Infantry Carrier Vehicle

Source: GAO.

Figure 2: M-113A3 Armored Personnel Carrier

Source: GAO.

Army's Comparative Evaluation Plan Met Legislative Requirements

The Army-developed and the DOD Operational Test and Evaluation Director-approved plan for evaluating the Stryker Infantry Carrier vehicle and the M-113A3 armored personnel carrier, currently in the Army's inventory, met legislative requirements to compare both operational effectiveness and cost. The Army developed a plan that compared the operational effectiveness and cost between the two vehicles. The congressional mandate did not provide specifics regarding the comparison but specified that DOD's Director, Operational Test and Evaluation, approve the Army's plan.[4] The purpose of the plan was to (1) assess and compare measures of operational effectiveness, suitability, and survivability and (2) compare the costs of the two vehicles. As required by the statute, the DOD Director, Operational Test and Evaluation, approved the operational effectiveness portion of the plan in August 2002 and the cost comparison portion in December 2002.

Army's Plan Evaluated Operational Effectiveness, Suitability, and Survivability of the Two Vehicles

The primary objective of the comparison evaluation was to assess and compare measures of operational effectiveness, suitability, and survivability for each of the vehicles. The Army Test and Evaluation Command developed a detailed comparison evaluation plan that, as the law required, was approved by DOD's Director, Operational Test and Evaluation, on August 23, 2002.[5] The plan's scope included using existing data and data developed during physical examination of the vehicles, modeling and simulation, and live fire testing of vehicle-mounted weapons. Data collected from production verification tests that evaluated vehicle performance—such as braking, acceleration, traction, and sustained speed over various types of terrain—was also included. The operational portion of the comparison involved a series of platoon level tasks, including operations in complex rural terrain and urban areas under various light and weather conditions. The plan focused on 3 main comparison issues and 10 sub-issues. The main comparison issues were defined as follows:

[4] The Director of Operational Test and Evaluation is the principal advisor to the Secretary of Defense, concerning operational testing, including assessments of operational effectiveness, suitability, and survivability of the items tested.

[5] The Army Test and Evaluation Command is the Army's independent operational test activity and is responsible for overall management of the Army test and evaluation programs.

- **Effectiveness:** How well the unit performs and what capabilities the vehicles provide in support of operational missions.

- **Suitability:** How the vehicles are deployed, operated, and logistically supported while performing tasks that support the infantry platoons in conducting their missions.

- **Survivability:** How well the vehicles protect the crew and infantry squad, vehicle system survivability, and the effect of vehicle damage on mission performance.

The plan included evaluating each of the issues and sub-issues (see table 1) during various evaluation events. These events included examination, modeling and simulation, technical testing, and operational testing.

- **Examination:** A review and analysis of available vehicle design and performance data. The vehicles would be physically examined to obtain specific measures and characteristics. Existing data was the primary source, but other appropriate data sources such as historical data were also used.

- **Modeling and Simulation:** Application of existing and collected data to determine the mobility characteristics of the vehicles.

- **Technical Testing:** The measurement of demonstrated performance characteristics and capabilities not available through existing data or modeling and simulation. Additional data were provided from events held during the acquisition process and ballistic survivability testing at the Aberdeen Proving Ground, Maryland, test center.

- **Operational Testing:** The Army designed operational vignettes to directly compare two equally organized and trained infantry platoons. The platoons conducted identical tasks and missions against a common opposing force with one platoon employing the M-113A3 and the other employing the Stryker Infantry Carrier vehicle. The opposing force consisted of mounted and dismounted military units, paramilitary forces, and civilians.

Table 1: Data Source Matrix for the Issues and Sub-Issues in the Army's Evaluation Plan of the Medium Armored Vehicles (MAV)

DATA SOURCE MATRIX				
Evaluation Event	**Examination**	**Modeling and Simulation**	**Technical Testing**	**Operational Testing**
Issue 1. Effectiveness. Does the vehicle support infantry operations?				
Sub-Issue 1-1. Mission Support				
The MAV must support infantry platoon missions and tasks.				X
Sub-Issue 1-2. Payload				
The MAV must provide the capability to effectively stow and transport personnel and prescribed equipment.	X		X	X
Sub-Issue 1-3. Tactical Mobility				
At gross combat weight, the MAV must demonstrate on-road and off-road mobility characteristics that support the conduct of combat missions.	X	X	X	X
Sub-Issue 1-4. Firepower				
The MAV crew must be able to employ the primary weapon systems to acquire, identify, engage, and defeat both point and area targets during the day and during periods of limited visibility.	X		X	X
Issue 2. Suitability. Is the vehicle suitable for infantry operations?				
Evaluation Event	**Examination**	**Modeling and Simulation**	**Technical Testing**	**Operational Testing**
Sub-Issue 2-1. Transportability				
The MAV must be strategically transportable and deployable by C-17 and/or C-5 aircraft to deploy the unit into a theater of operations. The MAV must also be transportable by C-130 for intra-theater deployment.	X		X	
Sub-Issue 2-2. Reliability and Maintainability				
The MAV must demonstrate acceptable reliability and maintainability characteristics to permit the brigade to complete its designated mission.	X		X	X
Sub-Issue 2-3. Integrated Logistics Support				
The MAV must be logistically supportable with existing and special tools, and the specified support and test equipment; demonstrate detection and isolation of component failures using its built-in test capability; and demonstrate an adequate power management capability.	X		X	X

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DATA SOURCE MATRIX				
Evaluation Event	**Examination**	**Modeling and Simulation**	**Technical Testing**	**Operational Testing**
Sub-Issue 2-4. Manpower and Personnel Integration (MANPRINT)				
The MAV must demonstrate characteristics that address human capabilities and limitations to enhance soldier performance and system operational effectiveness.	X		X	X
Issue 3. Survivability. Does the vehicle provide protection for crew and system survivability?				
Evaluation Event	**Examination**	**Modeling and Simulation**	**Technical Testing**	**Operational Testing**
Sub-Issue 3-1. Ballistic Protection				
The MAV must meet the following requirements: (1) Minimum direct fire ballistic protection levels in terms of integral 7.62-mm armor-piercing and 14.5-mm and hand-held High Explosive Anti-Tank weapons; (2) Overhead crew and passenger indirect fire ballistic protection against 152-mm high explosive airburst; (3) All-around crew and passenger protection against blast and overpressure effects of anti-personnel mines	X	X	X	
Sub-Issue 3-2. Non-Ballistic Protection				
The vehicle must perform its mission under battlefield conditions, including the presence of non-ballistic threats.	X	X	X	X

Source: GAO analysis of the U.S. Army Test and Evaluation Command's comparison evaluation plan.

Army Compared Costs as Required by the Statute

The Army directed its Cost and Economic Analysis Center to conduct a cost comparison between the Stryker Infantry Carrier vehicle and the M-113A3 armored personnel carrier. The Analysis Center developed a plan to determine and compare the life-cycle costs of the Stryker vehicle to the life-cycle costs of the M-113A3 currently in the Army inventory. The Army directed that the Analysis Center examine the costs of equipping, training, fielding, and maintaining the vehicles for use in the Stryker brigades. To determine these costs, the Analysis Center emphasized the costs associated with vehicle manufacturing, military personnel, replenishment parts, and fuel/petroleum for each vehicle. On October 4, 2002, the Army submitted the cost comparison portion of the plan to the Director, Operational Test and Evaluation, for approval. As required by the law, the Director, Operational Test and Evaluation, officially approved that portion on December 17, 2002, as the Secretary of the Army submitted the comparison evaluation report to DOD.

Evaluation Provided Sufficient Data for Comparison of Vehicles

Based on our observation of the vignettes, unit and evaluator training, and a technical test and on our analysis of the test results and review of cost comparison assumptions, the Army's conduct of the Army Test and Evaluation Command plan produced enough data to gauge the relative effectiveness and cost of the Stryker Infantry Carrier vehicle and the M-113A3 armored personnel carrier. To ensure competency during evaluation events, the Army certified that the units conducting the operational vignettes received comparable amounts of training in their vehicles and that the evaluators were familiar with appropriate infantry tactics and doctrine. The purpose of the comparison evaluation plan was to collect data to measure the relative effectiveness, suitability, and survivability of both vehicles. To do so, the plan consisted of operational vignettes, augmented by gunnery exercises, modeling and simulations; physical and other vehicle examinations; and technical testing. Comparison data included surveys, results of force on force exercises, and mission success and task performance ratings. The plan also assessed the costs of both vehicles.

Unit and Evaluators Certified Prior to Conduct of Operational Vignettes

Prior to conducting the operational effectiveness segment of the comparison evaluation, the two infantry platoons and the event evaluators received training specific to their roles in the comparison. The two infantry platoons received training that ensured all participating personnel were proficient with the vehicles, digitized equipment, and the associated support equipment. For example, one platoon trained on the Stryker vehicle while the other trained on the M-113A3 vehicle. All vehicle commanders were trained on the M2 .50-caliber machine gun and the MK19 grenade launcher—the weapon systems for the two types of vehicles. The two platoons participated in a 20-day training exercise and practiced incorporating the use of the two types of vehicles in missions assigned to a platoon in a Stryker brigade combat team. The brigade commander certified that the two platoons were trained according to doctrine and that both were similarly manned and trained.

During the comparison evaluation, subject matter experts[6] evaluated the units' performance during each operational vignette. Similar to the

[6] Subject matter experts are usually noncommissioned officers who have extensive experience with the studied equipment, recent unit experience, and a background as a trainer or in training development.

two platoons' personnel, the evaluators were certified as trained in current Infantry doctrine and tactics. Furthermore, personnel from the Army Test and Evaluation Command trained the subject matter experts in data collection methods, test instrumentation, and familiarization of the vehicle types and the terrain in which the vehicles were compared. Prior to conducting the operational vignettes, the evaluators participated in a pilot test where full data collection and test controls were rehearsed. After completing the pilot test, test officials certified that the subject matter experts were trained and that they complied with the established data collection procedures. The subject matter experts observed each unit and recorded comments on task performance and mission success by filling out performance matrices. Upon completion of an event, Army Test and Evaluation Command data collectors harvested and validated data collected during that particular activity. All data collected and validated were included in the Army's database and analyzed by the Army Test and Evaluation Command.

Vignettes, Gunnery, and Modeling and Simulation Used to Determine Operational Effectiveness

Effectiveness is an assessment of the extent to which a vehicle allows a unit to successfully perform tasks in support of infantry platoons conducting missions in an operational environment. To determine effectiveness, the Army compared the two vehicles' capability to (1) support infantry platoon missions, (2) move around the battlefield, (3) store and move personnel and equipment, and (4) employ their weapon systems during day, night, and limited visibility conditions. Data for the comparison came from operational vignettes, gunnery, physical examination of the vehicles, modeling and simulation, technical testing, and operational testing of the vehicles. The most visible of these data sources were the operational vignettes conducted at Fort Lewis, and the other data collection methods augmented those findings.

The Army conducted the comparison of the two types of vehicles during a scheduled training event held from September 12 to October 2, 2002, at Fort Lewis. The comparison, used to assess mission support, payload, and mobility, included two 2-hour road marches and two platoon-level training exercises designed by the 3rd Brigade of the 2nd Infantry Division and approved by the Army Test and Evaluation Command. During each exercise, the vehicles were loaded with all unit personnel and equipment according to unit procedures. The two road marches—designed to demonstrate the vehicles' ability to move on and off road, store and transport personnel and equipment, and provide

human factors data—were conducted over varying terrain like paved and gravel roads, rutted and uneven trails.

The operational vignettes required the platoons to execute selected small-scale contingency missions such as a raid or an attack with events lasting from 12 to 17 hours. The evaluations were conducted in environments designed to ensure similar training and conditions for both platoons and vehicles. For example, the missions were conducted in the same light conditions, against the same opposing force and using the same doctrine and tactics. Fort Lewis' terrain is densely wooded and open and undulating. Rocky terrain is common. During the vignettes, the vehicles were operated over different types of terrain, including paved and gravel roads, rutted and uneven wooded trails of varying slopes. In some vignettes, the vehicles traversed loose soil about 3 to 6 inches in depth. We observed that the Stryker and M-113A3 vehicles were operated over the same terrain during the operational vignettes.

The operational comparison was divided into two exercises. To compare how the platoons employed the vehicles, we attended the same vignettes for both exercises. We observed varying phases of the vignettes such as an obstacle breach, checkpoint security operations, civilian disturbances, and a rescue of endangered indigenous personnel to determine how the subject matter experts and the data collection personnel documented the key actions and outcomes as each of the platoons conducted its tactical missions.

During the first phase of the training events, we observed that the employment of the M-113A3s and the Stryker infantry carriers was minimal. For example, both platoon leaders used the vehicles primarily as a troop transport and had their soldiers egress from the vehicles before reaching the mission site. By doing so, the platoon leaders were unable to support their mission by employing the vehicles' weapons system. During the second training exercise, both platoons moved closer to the mission site and used the vehicles' weapons system to support their specific mission. Based on our observations and discussions with unit leadership, we concluded that this was due to the units' limited amount of experience in employing either of the vehicles. Other factors that impacted the vehicles' employment included platoon composition and command guidance. Both platoons were comprised of a mix of soldiers who had and had not previously served in mechanized infantry units, and the employment of the vehicle was entirely subjective on the part of the platoon leadership. Neither platoon had published platoon or company

standard operating procedures for the vehicles. These observations and conclusions on the employment of the vehicles were validated in the test team observation section of the Test and Evaluation Command's test data report.

Although providing data for all of the sub-issues measuring effectiveness, the Army augmented data collected from the vignettes through gunnery exercises and modeling and simulation. Upon completion of the vignettes, the Army sent both platoons to the Yakima Training Center, Washington, to conduct gunnery exercises. While at the training center, live fire of the weapons provided additional data to augment observations from the vignettes and the previous technical testing. To further evaluate mobility, the Army used modeling and simulation at Aberdeen Proving Ground to determine how well each vehicle would travel over different terrain types. Measurements included movement over simulated terrain in Korea, Europe, and Southwest Asia under both wet and dry weather conditions.

We did not observe any significant differences in the way the Army compared the two vehicles during the operational vignettes. Subject matter experts and test personnel were consistent in their data collection while observing vignettes for both the Stryker and the M-113A3 vehicles. Moreover, the vignettes provided sufficient data to determine the relative operational effectiveness of the two vehicles, and the additional data collected accentuated the findings. According to the Army Test and Evaluation Command, both vehicles enabled infantry squads to complete platoon missions and effectively transport personnel and prescribed equipment. The Stryker infantry carrier provided advantages in employing its weapon systems and mobility during most situations, and the M-113A3 had an advantage in off-road mobility.

Human Factors and Technical Data Used to Assess Vehicle Suitability

Suitability is an assessment of the extent to which a vehicle, when deployed to an objective area, can maneuver, be maintained, and supported in combat operations. To determine suitability, the Army compared (1) transportability, (2) reliability and maintainability, (3) integrated logistics support, and (4) MANPRINT[7] data for the two vehicles. Primary data for this comparison came from physical examination, technical testing, and operational testing of the vehicles. Of the four areas used to

[7] MANPRINT data measures human factors such as vehicle ride-ability, noise levels, and fatigue.

compare suitability, manpower and personnel integration was the only area that occurred during events that we directly observed. Data collected for the other three measures of suitability combined data and information from a variety of sources.

Data collection for manpower and personnel integration occurred during the vignettes at Fort Lewis and was used to compare the effect of the vehicles on soldiers performing necessary tasks. The Army's MANPRINT data collection team collected both quantitative and qualitative data by interviewing soldiers and collecting soldier surveys prior to and after the completion of certain events. The primary events used to facilitate MANPRINT collection were road marches and performance of common soldier tasks. Postvignette interviews with soldiers were also used to collect data.

The road marches were used to determine the effect that riding in vehicles had on soldiers' stress levels. Two self-assessment questionnaires, one a list of adjectives that soldiers checked to indicate their current feelings and the other an individual stress rating, were administered prior to and after each road march. In addition, data collectors took saliva samples from soldiers before and after each road march to determine changes in soldiers' stress levels.[8] To facilitate a comparison, soldiers rotated vehicles during the second road march.

To determine the effect of vehicles on common soldier tasks, the Army designed short events, entitled excursions, to collect data on the effects of entering and exiting the vehicles during a variety of different combat situations. After the first road march, each platoon arrived into assembly areas and conducted several excursions, with soldiers entering and exiting vehicles under duress, in chemical protective gear and while conducting casualty evacuations. Data collectors measured the length of time for each of these excursions, and upon completion of all events, soldiers filled out questionnaires. Figures 3 and 4 show examples of these excursions, with soldiers entering a Stryker infantry carrier and leaving a M-113A3.

[8] Within saliva, there is an enzyme called amylase. Research has shown that the concentration of salivary amylase reflects substances produced by the body in response to stress.

Figure 3: Stryker Infantry Carrier Ingress Excursion

Source: GAO.

Figure 4: M-113A3 Armored Personnel Carrier Egress Excursion

Source: GAO.

Upon completion of each training exercise, soldiers filled out another series of questionnaires designed to gauge ergonomic factors. Questionnaires, again administered by MANPRINT data collectors, asked soldiers about sound level, space, seat comfort, ability to communicate within the vehicle, situational awareness, and other safety issues.

To assess transportability, reliability and maintainability, and integrated logistics support, the Army relied on existing data from previous events, developed projections where data was lacking, or is in the process of collecting additional data during the continuing developmental testing. Using existing data, the Army determined that both vehicles were transportable; however, the M-113A3 was more deployable by air because of its reduced weight but less deployable by road because, for longer distances, it required either rail or truck support. To assess the Stryker vehicle's reliability and maintainability, the Army is continuing to collect data. While the Army is able to claim that there are no specific failure patterns, the relatively low number of Stryker miles prevents a statistically reliable forecast. To assess the M-113A3's reliability and maintainability, the Army primarily relied on existing data. Because the system is still in development, the Army used projections to determine that the Stryker vehicle is more logistically supportable because the family of vehicles and higher gas mileage reduce the overall size of the logistic footprint. For example, the Stryker vehicles are built on a common chassis and thus require fewer different parts. Moreover, the Stryker, as a wheeled-vehicle, requires fewer mechanics to maintain it.

We did not observe any significant differences in the way the Army compared suitability for both types of vehicles. According to our review of the Army Test and Evaluation Command report, both vehicles are transportable and both have manageable failures for maintenance and reliability. In terms of human factors, the MANPRINT data indicate that soldiers riding in a Stryker infantry carrier reported reduced fatigue; more ability to move within, inside, and outside the vehicle; lower levels of stress; less irritation; and a better ability to communicate than those riding in a M-113A3.

Vehicle Survivability Assessed against a Variety of Threats

Survivability is an assessment of the extent to which a vehicle survives under different threat conditions and protects the crew and the equipment. The Army's Test and Evaluation Command decided that vehicle survivability would be determined through a comparison of existing test data, technical data, and modeling and simulation. The vehicles had to

demonstrate that they could provide an adequate level of protection to the infantry squad and vehicle crew against threats such as small arms, artillery, and mines. The M113A3 was designed to provide protection against a standard 7.62mm threat. The Army intended the Stryker to have an all-around 7.62mm armor-piercing protection, plus 14.5 mm protection on the front, sides, and rear. The top will have 7.62 mm armor-piercing and 152mm high explosive airburst protection, and protection against antipersonnel mines through the vehicle floor. Stryker also has an embedded spall liner. Also assessed was the vehicles' ability to support missions under different battlefield conditions such as nuclear, biological, and chemical environments. Most of the technical evaluation occurred at the Aberdeen Proving Ground test center. The Test Command concluded that the Stryker vehicle was more survivable than the M-113A3 against both of these types of threats.

We also observed a vehicle survivability test at the Aberdeen test center. Based on our observations of the testing and data collection process, we determined that the test community had systems designed to collect objective, technical data on the vehicles. We obtained and analyzed the Test and Evaluation Command's evaluation report; however, we are unable to comment on specific test results because the results are classified and technical testing remains ongoing. Our observations and analysis do allow us to generally comment that the technical testing procedures appeared to be objective and sufficient to provide data to determine the relative survivability of the two types of vehicles.

DOD and the Army Assessed the Costs of Stryker and the M-113A3 Vehicles

The Army's Cost and Economic Analysis Center and DOD's Program Analysis and Evaluation Directorate (PA&E) estimated the life-cycle costs of equipping the brigade teams with either the Stryker or the M-113A3 vehicle. The Center included both investment and operating costs in its calculations and defined the appropriate life cycle as 20 years. PA&E, using the Center's cost calculations, applied a slightly different methodology to assess the costs for one Stryker brigade. Both PA&E and the Army concurred that the Stryker infantry carrier is more expensive than the M-113A3. However, each report had a slightly different methodology. We reviewed the assumptions of the cost comparison and found they conformed to cost analysis guidance provided to federal agencies by the Office of Management and Budget. We found no instances in which these cost assumptions seemed to favor one vehicle over another. Based on this review, the magnitude of the increased costs of the Stryker vehicle appeared reasonable.

The Stryker vehicle has a higher investment cost than the M-113A3. According to both PA&E and the Army cost reports, acquiring a Stryker vehicle is $1.42 million each. The acquisition cost for an M-113A3 depends on how it is acquired, either through reassigning vehicles currently in the Army inventory or upgrading existing M-113A2s.

The Army currently has 4,100 M-113A3s in its inventory, so a zero cost investment option would be to assign these existing vehicles to the new Stryker brigades. According to the Army, pursuing this course would adversely affect the readiness of the losing units, which would then be equipped with older versions of the M-113. PA&E noted that the loss of vehicles could be accepted as an additional risk to the current force structure, which will begin transforming to the future force in 2008. A second option would be to upgrade existing M-113A2s. PA&E and the Army reports agree that the cost of upgrading an M-113A2 is about $303,000 per vehicle with an inherited value of $67,000 per vehicle, making the total cost of upgrading at least $370,000 per vehicle.

Capabilities costs are also not reflected in the investment costs of the M-113A3. Unlike the M-113A3, the Stryker vehicle was designed with two significant capabilities: 14.5-mm armor protection and a Remote Weapon Station. The M-113A3's armor protection is less than the Stryker vehicle's and an upgrade package will cost about $73,000 per vehicle. The M-113A3 does not have the Remote Weapon Station, which would cost another $200,000 per vehicle. Not included in this estimate are the costs of testing and integrating the Remote Weapon Station with the M-113A3, assuming that it can be done at all. Moreover, this estimate does not include the effect that the additional weight from the armor protection and Remote Weapon Station would have on the M-113A3's transportability or suitability.

PA&E and the Army agreed that the Stryker infantry carrier has lower operating costs than the M-113A3. Over a 20-year lifespan, both agencies estimated that each Stryker vehicle would cost $2.9 million to operate and maintain compared to $3.1 million for the M-113A3. These cost savings come from three main areas: fuel efficiency, replacement parts, and training costs. Both agencies agree that the Stryker vehicle is more fuel-efficient and requires fewer repair parts and consumables. Additionally, training costs encompass several different areas, namely the cost to train and staff mechanics, as well as instruct new crews on how to operate the vehicles.

With the exception of the number of brigades used to calculate costs, the methodology used by PA&E and the Army to calculate operating costs was consistent. The Army based its cost calculations on equipping 6 brigades, for a total of 686 vehicles. In contrast, PA&E based its calculations on equipping 1 brigade, for a total of 118 vehicles. Although the two methods result in different total costs for the vehicle systems, they do not change the relative price difference, or the fact that the Stryker vehicle is more expensive than the M-113A3.

The Director, Operational Test and Evaluation, officially approved the Army's cost comparison on December 17, 2002. The comparison found that the Stryker infantry carrier vehicle was more costly than the M-113A3. Based on our review of the methodologies used, we concluded that the cost comparison was reasonable.

Secretary of Defense Certified to the Combat Power of the Army and Released Funding for the Third Brigade's Vehicles

The Army completed the comparison evaluation and developed a report that included reports from the Army Test and Evaluation Command and the Army Cost and Economic Analysis Center. On December 17, 2002, the Secretary of the Army forwarded a memorandum of certification to the Secretary of Defense. The Secretary of the Army certified that, in terms of operational effectiveness, the comparison evaluation demonstrated that the Stryker infantry carrier vehicle is more survivable and provides better overall performance and mobility when employed in combat operations than the M-113A3. The Secretary of the Army also certified that the Stryker brigade combat team increased the aggregate combat power of the U.S. Army.

However, in the report submitted to Congress, DOD's conclusions were not quite as positive. The DOD report, prepared by its PA&E Directorate, summarized conclusions based on the Department of the Army report that included the Army Test and Evaluation Command and the Army Cost and Economic Analysis Center reports. The Director, Operational Test and Evaluation, also provided comments from a draft report. The DOD report stated that neither vehicle was preferred for all the criteria. The Stryker vehicle was superior under some criteria, the M-113A3 was superior on others, and the two vehicles were equal on yet others. However, DOD and the Army both agreed that the Stryker brigade combat teams would not diminish the combat power of the Army, and DOD so certified. As a result of the evaluation, the Deputy Secretary of Defense approved obligating the funding for the Stryker vehicles to equip the third brigade.

Agency Comments

In commenting on a draft of this report, DOD concurred with the report's findings. DOD's response also provided technical comments for clarifying two areas in the report, which we incorporated. Appendix II contains the full text of DOD's comments.

Scope and Methodology

To determine whether the Army's plan for the comparison was adequate to satisfy legislative requirements, we focused our efforts on understanding the Army's overall comparison evaluation plan. We obtained and analyzed the Army's Comparative Evaluation plan, data collection plans, and technical test plans and reviewed comments of the plan provided by various DOD and Army agencies. We interviewed officials and analysts involved in both the design and evaluation of the plan at Office of the Secretary of Defense; Office of the Secretary of the Army; Headquarters, Department of the Army; Army Forces Command; Army Training and Doctrine Command; Army Tank and Automotive Command; Army Operational Test Command and Army Test and Evaluation Command; Army Cost and Economic Analysis Center; and I Corps, Fort Lewis, Washington.

To determine whether the comparison evaluation plan and its implementation would provide the data needed to measure the relative effectiveness of the vehicles, we attended the operational vignettes and associated training events scheduled in the Army's plan and reviewed the results taken from those events. For example, we reviewed the training procedures and attended the training sessions for the data collectors and subject matter experts administering the operational vignettes held at Fort Lewis, Washington. We examined the methods used by the test administrators to collect, store, and process the data. To determine if the conditions favored one vehicle over the other, we observed the terrain to be used during the operational vignettes. We observed 8 of 16 events conducted during the operational vignettes. These events included the road march, loading of vehicles, and various tactical missions. In addition, we rode in and drove both types of vehicles. We also interviewed the Army Operational Test Command officials who were administering the test, as well as representatives from the office of DOD's Director of Operational Test and Evaluation and the Institute for Defense Analysis and Army commanders of the unit participating in the evaluation. Upon completion of the vignettes, we interviewed soldiers who had participated in the events. For technical testing, we visited Aberdeen Proving Ground, Maryland. We received briefings from the Developmental Test Command as to how the

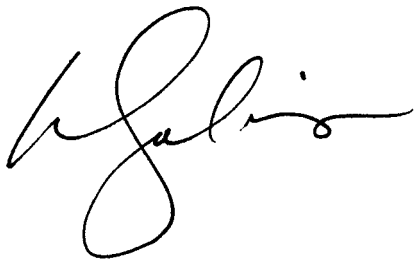
Army conducts technical tests on vehicles. We obtained and analyzed classified and unclassified ballistic testing plans and observed a vehicle survivability test that was comparable to other types of technical testing. We also reviewed the reports issued by the Office of the Secretary of Defense; Program Analysis and Evaluation Directorate; Secretary of the Army; the Army Test and Evaluation Command; and the Army Cost Economic and Analysis Center. We compared the results and conclusions of these reports to our own observations.

We reviewed the Army's Cost Economic and Analysis Center's cost report and the comments on the report made by the PA&E and the Office of the Secretary of Defense regarding cost comparison methodology. While we verified the general procedures and assumptions used in these analyses, we did not perform detailed checks of the many calculations they entailed.

Our review was performed from May 2002 to May 2003 in accordance with generally accepted government audit standards.

We are sending copies of this report to the Secretary of Defense and the Director, Office of Management and Budget. We will also make copies available to appropriate congressional committees and to other interested parties on request. In addition, the report will be available at no cost on the GAO Web site at http://www.gao.gov. If you or your staff have any questions about this report, please call me at (202) 512-8365.

Major contributors to this report were Reginald L. Furr, Jr.; Leo B. Sullivan; Robert Ackley; Timothy A. Burke; Kenneth Daniell; M. Jane Hunt; William McNaught; Jim Melton; and Sidney Schwartz.



William M. Solis
Director, Defense Capabilities
and Management

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Section from Public Law 106-398 Concerning Limitations on Army Transformation Actions

SEC. 113. REPORTS AND LIMITATIONS RELATING TO ARMY TRANSFORMATION.

(a) SECRETARY OF THE ARMY REPORT ON OBJECTIVE FORCE DEVELOPMENT PROCESS.—The Secretary of the Army shall submit to the congressional defense committees a report on the process for developing the objective force in the transformation of the Army.

The report shall include the following:

(1) The operational environments envisioned for the objective force. (2) The threat assumptions on which research and development efforts for transformation of the Army into the objective force are based. (3) The potential operational and organizational concepts for the objective force. (4) The operational requirements anticipated for the operational requirements document of the objective force. (5) The anticipated schedule of Army transformation activities through fiscal year 2012, together with—(A) the projected funding requirements through that fiscal year for research and development activities and procurement activities related to transition to the objective force; and (B) a summary of the anticipated investments of the Defense Advanced Research Projects Agency in programs designed to lead to the fielding of future combat systems for the objective force. (6) A proposed plan for the comparison referred to in subsection (c).

If any of the information required by paragraphs (1) through (5) is not available at the time the report is submitted, the Secretary shall include in the report the anticipated schedule for the availability of that information.

(b) SECRETARY OF DEFENSE REPORT ON OBJECTIVE FORCE DEVELOPMENT PROCESS.—Not later than March 1, 2001, the Secretary of Defense shall submit to the congressional defense committees a report on the process for developing the objective force in the transformation of the Army. The report shall include the following:

(1) The joint warfighting requirements that will be supported by the fielding of the objective force, together with a description of the adjustments that are planned to be made in the war plans of the commanders of the unified combatant commands in relation to the fielding of the objective force. (2) The changes in lift requirements that may result from the establishment and fielding of the combat brigades of the objective force. (3) The evaluation process that will be used to support

decisionmaking on the course of the Army transformation, including a description of the operational evaluations and experimentation that will be used to validate the operational requirements for the operational requirements document of the objective force.

If any of the information required by paragraphs (1) through (3) is not available at the time the report is submitted, the Secretary shall include in the report the anticipated schedule for the availability of that information.

(c) COSTS AND EFFECTIVENESS OF MEDIUM ARMORED COMBAT VEHICLES FOR THE INTERIM BRIGADE COMBAT TEAMS.—(1) The Secretary of the Army shall develop a plan for comparing—(A) the costs and operational effectiveness of the infantry carrier variant of the interim armored vehicles selected for the infantry battalions of the interim brigade combat teams; and (B) the costs and operational effectiveness of the troop-carrying medium armored vehicles currently in the Army inventory for the use of infantry battalions. (2) The Secretary of the Army may not carry out the comparison described in paragraph (1) until the Director of Operational Test and Evaluation of the Department of Defense approves the plan for that comparison developed under that paragraph.
(d) LIMITATION PENDING RECEIPT OF SECRETARY OF THE ARMY REPORT.—Not more than 80 percent of the amount appropriated for fiscal year 2001 for the procurement of armored vehicles in the family of new medium armored vehicles may be obligated until—(1) the Secretary of the Army submits to the congressional defense committees the report required under subsection (a); and (2) a period of 30 days has elapsed from the date of the submittal of such report.

(e) LIMITATION PENDING COMPARISON AND CERTIFICATION.—No funds appropriated or otherwise made available to the Department of the Army for any fiscal year may be obligated for acquisition of medium armored combat vehicles to equip a third interim brigade combat team until—(1) the plan for a comparison of costs and operational effectiveness developed under subsection (c)(1), as approved under subsection (c)(2), is carried out; (2) the Secretary of Defense submits to the congressional defense committees, after the completion of the comparison referred to in paragraph (1), a certification that—(A) the Secretary approves of the obligation of funds for that purpose; and (B) the force structure resulting from the acquisition and subsequent operational capability of interim brigade combat teams will not diminish the combat power of the

Army; and (3) a period of 30 days has elapsed from the date of the certification under paragraph (2).

(f) DEFINITIONS.—In this section:

(1) The term "transformation", with respect to the Army, means the actions being undertaken to transform the Army, as it is constituted in terms of organization, equipment, and doctrine in 2000, into the objective force.

(2) The term "objective force" means the Army that has the organizational structure, the most advanced equipment that early twenty-first century science and technology can provide, and the appropriate doctrine to ensure that the Army is responsive, deployable, agile, versatile, lethal, survivable, and sustainable for the full spectrum of the operations anticipated to be required of the Army during the early years of the twenty-first century following 2010.

(3) The term "interim brigade combat team" means an Army brigade that is designated by the Secretary of the Army as a brigade combat team and is reorganized and equipped with currently available equipment in a configuration that effectuates an evolutionary advancement toward transformation of the Army to the objective force.

Comments from the Department of Defense

OPERATIONAL TEST AND EVALUATION

OFFICE OF THE SECRETARY OF DEFENSE
1700 DEFENSE PENTAGON
WASHINGTON, DC 20301-1700

May 13, 2003

Mr. William M. Solis
Director, Defense Capabilities and Management
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Solis,

This is the Department of Defense response to the GAO draft report, GAO-03-671, "MILITARY TRANSFORMATION: Army's Evaluation of Stryker and M113A3 Infantry Carrier Vehicles Provided Sufficient Data for Statutorily Mandated Comparison," dated April 21, 2003, (GAO Code 350179). The Department of Defense concurs with the report. GAO concluded that the Army conducted an objective and unbiased evaluation, data collected was sufficient to support a meaningful evaluation, and the evaluation met legal requirements.

We request GAO modify their report in two areas. First on page 12, paragraph titled "Vehicle Survivability Assessed Against a Variety of Threats," add the sentences: The M113A3 was designed to provide protection against a 7.62mm ball threat. The Army intends Stryker to have an all-around 7.62mm armor piercing protection, plus 14.5mm protection on the front, sides, and rear. The top will have 7.62mm armor-piercing and 152mm high explosive airburst protection, and protection against anti-personnel mines through the vehicle floor. Stryker also has an embedded spall liner. Secondly, would like to clarify the subheading on page 12 of the report, "Department of Defense and the Army Assessed the Costs of Stryker and the M113A3 Vehicles." The paragraph implies that the Office of the Secretary of Defense, Program, Analysis and Evaluation did an independent life cycle cost estimate of equipping the brigade teams with either the Stryker or M113A3. Program, Analysis and Evaluation estimated operating cost for one brigade, and compared its cost with the Army's estimate for all six brigades.

With these technical adjustments, we believe the GAO report will more accurately capture key points of Stryker survivability and cost data.

The Department of Defense appreciates the opportunity to comment on the final report.

VR

Stephen C. Daly
Deputy Director,
Conventional Systems

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