Report No. D-2009-047 January 29, 2009

Inspector General
United States Department of Defense

DoD Testing Requirements for Body Armor

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Acronyms and Abbreviations

BFD	Back Face Deformation
COPD	Contract Purchase Description
COTR	Contracting Officer Technical Representative
DOT&E	Director, Operational Test and Evaluation
ESAPI	Enhanced Small Arms Protective Inserts
IG	Inspector General
PEO	Program Executive Office
QMD	Quantitative Methods Directorate
SAPI	Small Arms Protective Inserts
USSOCOM	U.S. Special Operations Command

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January 29, 2009

MEMORANDUM FOR SECRETARY OF THE ARMY
DIRECTOR, OPERATIONAL TEST AND EVALUATION
PROGRAM EXECUTIVE OFFICER SOLDIER

SUBJECT: DoD Testing Requirements for Body Armor (Report No. D-2009-047)

We are providing this report for review and comment. We considered comments on a draft of the report when preparing the final report.

DoD Directive 7650.3 requires that all recommendations be resolved promptly. The Secretary of the Army's comments were responsive to Recommendation A.1. The Principal Deputy Assistant Secretary of the Army (Acquisition, Logistics, and Technology) endorsed and forwarded comments from the Program Executive Officer Soldier which were responsive to Recommendations A.2.a. and A.2.b. The comments of the Director, Operational Test and Evaluation were responsive to Recommendations B.1. and B.2. We expanded Recommendation A.1. to include a request for a plan of action to implement the recommendation within 30 days of the report. Recommendation A.2.c. was added to the final report. We request comments on Recommendations A.1. and A.2.c. by March 30, 2009.

Please provide comments that conform to the requirements of DoD Directive 7650.3. If possible, send your comments in electronic format (Adobe Acrobat file only) to AudJ&OO@dodig.mil. Copies of your comments must have the actual signature of the authorizing official for your organization. We are unable to accept the / Signed / symbol in place of the actual signature. If you arrange to send classified comments electronically, you must send them over the SECRET Internet Protocol Router Network (SIPRNET).

We appreciate the courtesies extended to the staff. Please direct questions to me at (703) 604-8905 (DSN 664-8905).

Paul J. Granetto
Principal Assistant Inspector General
for Auditing

Report No. D-2009-047 (Project No. D2008-D000JA-0263.000)
January 29, 2009

Results in Brief: DoD Testing Requirements for Body Armor

What We Did

We reviewed whether first article testing for the Enhanced Small Arms Protective Inserts for Army contract W91CRB-04-D-0040 (Contract 0040) was conducted in accordance with contract requirements. We also reviewed the basis for first article testing criteria used by the U.S. Army and U.S. Special Operations Command (USSOCOM). We did not review the safety of the ballistic inserts; therefore, we did not determine whether these inserts provide the protection intended.

What We Found

First article testing for Army Contract 0040 was not consistently conducted or scored in accordance with contract terms, conditions, and specifications. Consequently, we believe three of the eight ballistic insert designs that passed first article testing actually failed (ballistic insert designs M3D2S2, MH3, and MP2S2). We had concerns about another first article test (design M4D2), but insufficient test data precluded us from determining the impact of the inconsistent testing and scoring processes. As a result, the Army does not have assurance that all inserts purchased under Contract 0040 provide the level of protection required by the contract. This underscores the need for internal controls to ensure adequate oversight of the first article testing process and proper review and approval of the first article test results.

The contracting officer technical representative made an unauthorized change to Contract 0040 by instructing the testing facility officials to deviate from the Contract Purchase Description without approval from the contracting officer. Because we reviewed only one contract, we can not report on the effect of the unauthorized change on other body armor contracts. The audit team conducting DoD Inspector General Project No. D2008-D000CD-0256.000, "Research on DoD Body Armor Contracts," will determine whether unauthorized changes were made to the body armor contracts under their review and the effect of those changes on the first article test results.

DoD does not have standardized ballistic testing criteria for body armor ballistic inserts. Army and USSOCOM officials developed separate ballistic testing criteria for body armor. The criteria differed significantly, even when testing against the same threats. Differences included the number of plates tested (sample size), the shot pattern, the environmental conditions, the type of tests, and the pass/fail guidelines. As a result, DoD does not have assurance that its body armor provides a standard level of protection.

What We Recommend

We recommend that the Army immediately identify and facilitate the return of the 16,413 sets of design M3D2S2, MP2S2, and M4D2 ballistic inserts purchased under Army Contract 0040, and remove the ballistic inserts from inventory. Return of the MH3 design is not required as no inserts of that design were purchased.

We recommend that the Army implement controls to ensure that changes to body armor contracts are approved by the contracting officer in accordance with the Federal Acquisition Regulation.

We recommend that the Director, Operational Test and Evaluation (DOT&E) develop a test operations procedure for body armor ballistic inserts and involve the Services and USSOCOM to verify the procedure is implemented DoD-wide.

Client Comments and Our Response

Recommendation A.2.c. was added to the final report. Officials from the Army and DOT&E disagreed with our finding that ballistic insert designs M3D2S2, M4D2, and MP2S2 actually failed first article testing and that the designs should be returned. However, the Secretary of the Army agreed to order the identification and collection of the designs pending Deputy Secretary of Defense adjudication of the issue to ensure there is no question concerning body armor effectiveness (Recommendation A.1.). The Army and DOT&E agreed with Recommendations A.2.a., A.2.b., B.1., and B.2. See the recommendations table on page ii.

Recommendations Table

Client	Recommendations Requiring Comment	No Additional Comments Required
Secretary of the Army	A.1.	
Program Executive Officer Soldier	A.2.c.	A.2.a. and A.2.b.
Director, Operational Test and Evaluation		B.1. and B.2.

Please provide comments by March 30, 2009.

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Introduction

Objectives

The overall objective of our audit was to evaluate ballistic testing requirements for body armor components. We specifically reviewed whether the Enhanced Small Arms Protective Inserts (ESAPI) first article testing criteria for Army contract W91CRB-04-D-0040 (Contract 0040) were in accordance with the contract. We also reviewed the basis for first article testing criteria used by the U.S. Army and U.S. Special Operations Command (USSOCOM). Although an announced objective, we did not review first article testing criteria for the other contracts reviewed as part of DoD Inspector General (IG) Report No. D-2008-067, "DoD Procurement Policy for Body Armor," March 31, 2008. That objective will be addressed in DoD IG Project No. D2008-D000CD-0256.000, "Research on DoD Body Armor Contracts."

Background

This report is the third in a series of reports on DoD body armor and armored vehicles issued in response to requests from Representative Louise M. Slaughter, 28th District, New York, and Senator James H. Webb, Virginia. DoD IG Report No. D-2007-107, "DoD Procurement Policy for Armored Vehicles," June 27, 2007, and D-2008-067 addressed Representative Slaughter's request that the DoD IG review the procurement of body armor and armored vehicles to determine whether DoD officials followed contracting policies. DoD IG Project No. D2008-D000CD-0256.000 was initiated in August 2008 as a follow-on to D-2008-067 to examine the contracting processes for body armor and the related test facilities. The Defense Criminal Investigative Service addressed Senator Webb's request that the DoD IG conduct a special investigation into Army body armor testing conducted in 2005 at the H.P. White Laboratory Inc., Street, Maryland, and in 2007 at the Army Test Center, Aberdeen, Maryland. That investigation was closed. Audit personnel who assisted with the investigation identified procedural issues concerning body armor ballistic testing requirements. This report addresses those issues.

DoD Body Armor

The Army and USSOCOM use two primary types of body armor—Interceptor Body Armor and the Special Operations Forces Personal Equipment Advanced Requirements. Both types are designed to offer increased protection to the warfighter by stopping or slowing bullets and fragments and reducing the number and severity of wounds.

The Army uses Interceptor Body Armor, which consists of an Outer Tactical Vest, front and back ESAPI; Deltoid and Axillary Protectors; and Enhanced Side Ballistic Inserts (see Figure 1). The Program Executive Office (PEO) Soldier, Project Manager, Soldier Equipment, is the Army program office responsible for managing the Interceptor Body Armor program.

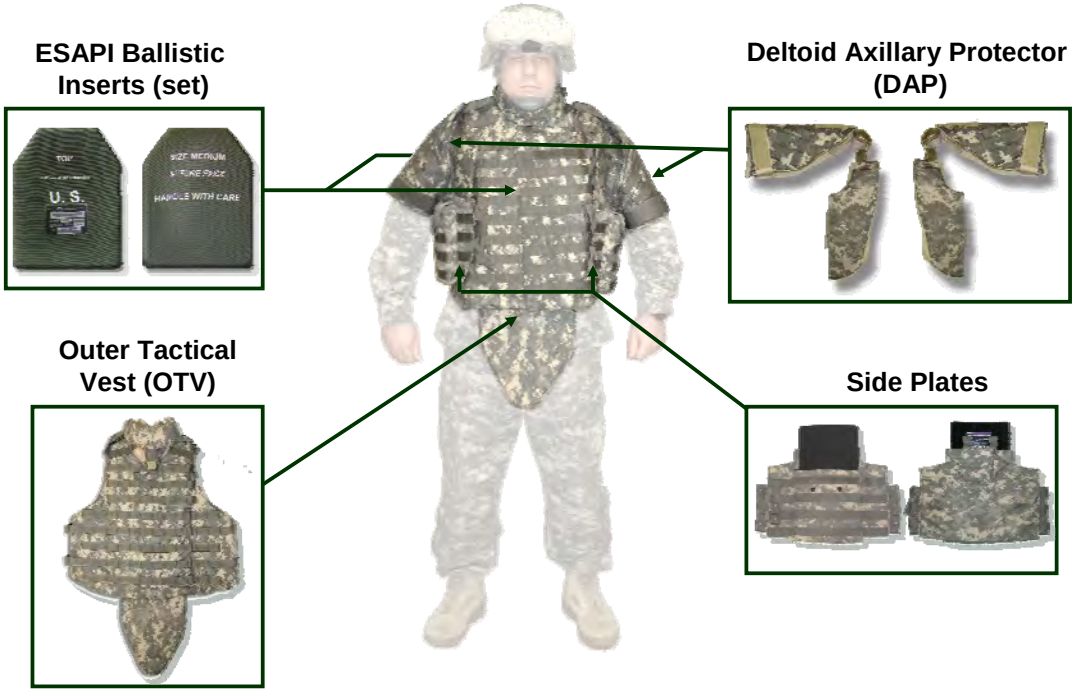

Figure 1. Interceptor Body Armor

The USSOCOM Special Operations Forces Personal Equipment Advanced Requirements program includes the Releasable Body Armor Vest, hard armor plates, and soft armor inserts. Ancillary components, such as shoulder plates, side plates, and groin and neck protectors, can be used with the Releasable Body Armor Vest (see Figure 2). The vest also incorporates a "quick-release" mechanism that can be used in emergencies to allow the warfighter to rapidly remove the vest. The PEO Special Operations Forces Warrior Program Manager, Special Operations Forces Survival Systems, is responsible for managing the Special Operations Forces Personal Equipment Advanced Requirements program.

Figure 2. Releasable Body Armor Vest

Body Armor Ballistic Testing

Body armor ballistic testing is conducted to determine the resistance to penetration and the ballistic limit of body armor test samples. The objective of resistance to penetration or "V_0 testing" is to fire projectiles at a constant velocity to demonstrate that the armor samples provide specified protection against required threats. This test determines at what velocity the bullet will have a 0 percent chance of penetrating a given piece of armor. For each threat, the body armor must defeat the specified number of impacts within the parameters established in the Contract Purchase Description (COPD) or performance specification. Those parameters include the acceptable number of complete and partial penetrations and the maximum depth of the back face deformation (BFD) for partial penetrations. A complete penetration occurs when the threat projectile, fragment of that projectile, or fragment of the armor material is imbedded or passes into the clay backing material (the clay is a substitute for a warfighter's body mass). A partial penetration is any fair impact that does not result in a complete penetration. The BFD is the depth of the crater left in the clay for each partial penetration and represents the blunt force trauma inflicted on the wearer, which can contribute to injury, incapacitation, or death. See Figure 3 for an illustration of partial and complete penetrations.

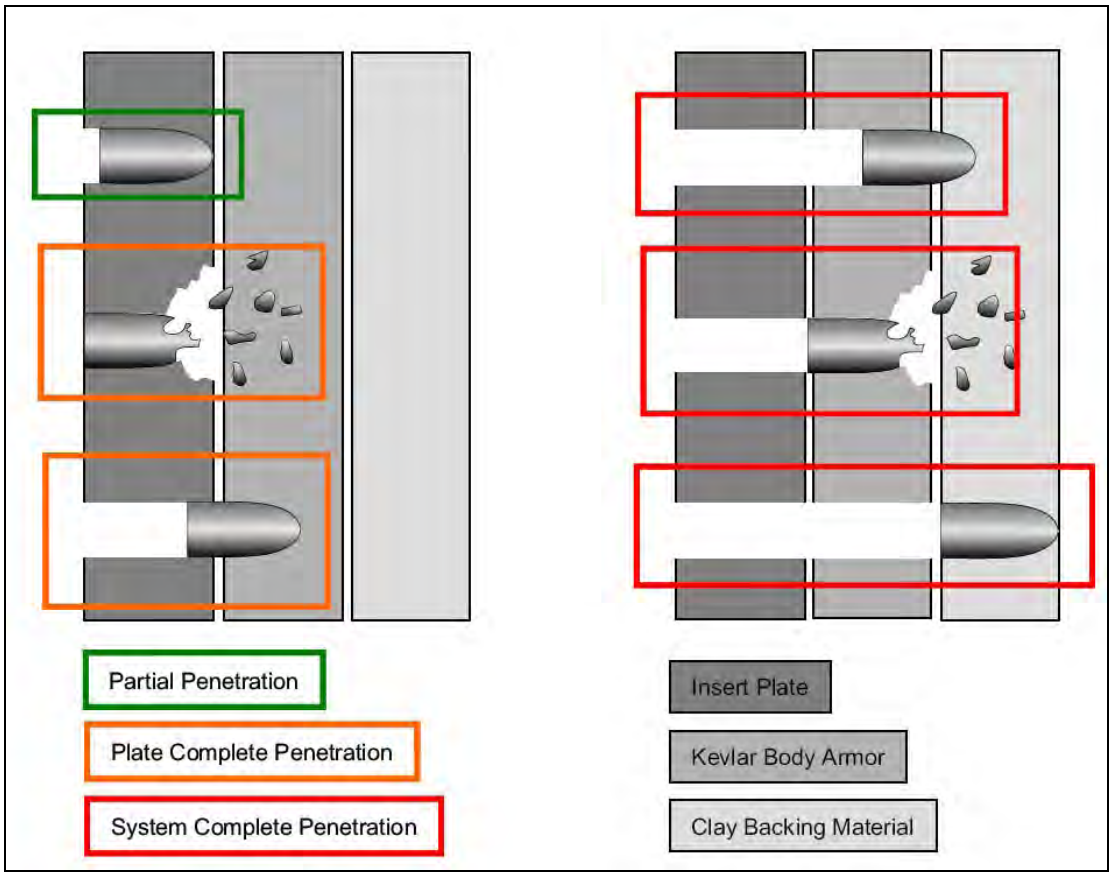

Figure 3. Illustration of Partial and Complete Penetrations

Ballistic limit or "V_{50} testing"[1] is conducted to determine the velocity at which a complete penetration or incomplete penetration of the body armor is equally likely to occur. The V_{50} is determined by shooting the piece of armor several times, with the same type of threat, across a broad range of velocities. The COPD contains the V_{50} requirement, and the calculated V_{50} during the test must meet that requirement.

DoD ballistic testing is conducted at National Institute of Justice certified indoor ranges with a specific test setup (see Figure 4) and test condition requirements as defined in the applicable contract. The body armor samples are tested under "ambient" or room temperature conditions and after being subjected to selected environmental conditions such as hot and cold temperatures, saltwater, oil, fuel, or after being dropped. Once the body armor is ready for testing, it is strapped to the clay backing material, and ballistic testing is conducted.

[1] We limited our review to analyze V_0 testing since the V_{50} test results are not always used to determine whether body armor samples pass or fail first article testing.

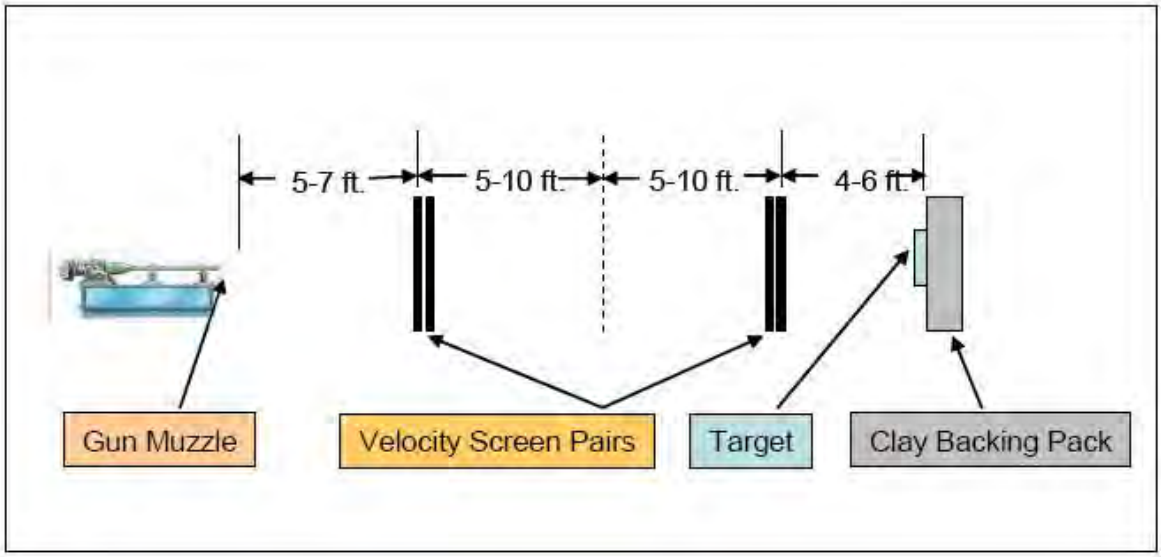

Figure 4. Typical Indoor Range Setup

First Article Testing

First article testing determines whether the proposed product design conforms to contract requirements before or in the initial stage of production. During first article testing, the proposed design is evaluated to determine the probability of consistently demonstrating satisfactory performance and the ability to meet or exceed evaluation criteria specified in the COPD. Successful first article testing certifies a specific design configuration and the manufacturing process used to produce the test articles. Failure of first article testing requires the contractor to examine the specific design configuration to determine the improvements needed to correct the performance of subsequent designs. Any change to the design configuration or manufacturing process (designs, materials, machines, process parameters) invalidates the previous first article test and requires additional first article testing to verify that the product still meets requirements.

Scope Limitation

We limited the scope of our audit to first article testing of the front and back ballistic inserts used in the Army's Interceptor Body Armor and the USSOCOM Special Operations Forces Personal Equipment Advanced Requirements program. We did not review first article testing for other hard or soft body armor components, such as the side plates and tactical vests. In addition, we limited our review to analyze V_0 testing since the V_{50} results are not always used to determine whether a contractor passes or fails the first article test. We did not review the safety of the ballistic inserts, and therefore, we did not determine whether these inserts provide the protection intended.

Review of Internal Controls

We determined that material internal control weaknesses existed within the Army's testing and scoring processes for body armor first article testing as defined by DoD Instruction 5010.40, "Managers' Internal Control Program Procedures," January 4, 2006.

The Army did not have internal control procedures to ensure adequate oversight of the first article testing process and proper review and approval of the first article testing results. Implementing Recommendations A.2.a. and A.2.b. will improve the Army's body armor first article testing process by ensuring that the testing facility and scoring officials follow contract terms, conditions, and specifications. We will provide a copy of the report to the senior Army official responsible for internal controls.

Finding A. First Article Testing for Contract W91CRB-04-D-0040

First article testing for Contract 0040 was not consistently conducted or scored in accordance with contract terms, conditions, and specifications. Specifically, for the 21 first article tests conducted for Contract 0040,

- testing facility officials did not consistently follow the test plan or COPD requirements for the fair shot determination, measurement of BFD, or plate size; and
- the PEO Soldier scoring official could not provide adequate documentation that explained why certain plates were selected for scoring and others were disregarded during the scoring process.

The inconsistent testing and scoring processes resulted in a passing first article test for ballistic insert designs M3D2S2, MH3, and MP2S2, when otherwise those designs would have failed. In addition, insufficient test data concerning the first article test for ballistic insert design M4D2 precluded us from determining the impact of the inconsistent testing and scoring processes on the results of that test. First article testing is conducted to ensure that a design meets established contract requirements; inconsistent testing and scoring processes increase the risk that the designs not meeting technical requirements will not be detected. Although the ballistic inserts must also pass lot acceptance testing before being fielded, the Army's lot acceptance testing process for body armor is less stringent than first article testing, and its results do not ensure that the contractor's design meets all contract specifications.

Although we did not review the safety of these ballistic inserts, the Army does not have assurance that all inserts purchased under Contract 0040 provide the level of protection required by the contract. Therefore, the Army should immediately identify and facilitate the return of the M3D2S2, MP2S2, and M4D2 design ballistic inserts and remove them from inventory. Return of the MH3 design is not required as no inserts of that design were purchased. In addition, to improve first article testing, the Army needs to establish the controls necessary to prevent and reduce the risk of further noncompliance and error during the testing and scoring processes.

We were also concerned that the contracting officer technical representative (COTR) made an unauthorized change to Contract 0040 by instructing the testing facility officials to deviate from the COPD and use an offset correction technique (a mathematical formula used to adjust the BFD). The PEO Soldier COTR communicated this change by e-mail to the testing facility without approval from the contracting officer. Because we reviewed only one contract, we can not report on the effect of the change on the Army's other body armor contracts. The audit team conducting DoD IG Project No. D2008-D000CD-0256.000 "Research on DoD Body Armor Contracts," will determine whether these conditions exist on the body armor contracts under their review and the effect of

those changes on the first article test results. To prevent future unauthorized contract changes, the Army should implement controls to ensure that future changes to the contract are executed by the contracting officer in accordance with Federal Acquisition Regulation 43.102.

Contract 0040

Contract 0040 was one of seven contracts awarded under Solicitation W91CRB-04-R-0033, which was issued by the U.S. Army Research Development and Engineering Command Acquisition Center on May 19, 2004. The solicitation was for the purchase of three types of body armor ballistic inserts for the Interceptor Body Armor—the Small Arms Protective Inserts (SAPI), overweight SAPI, and ESAPI. The SAPI were designed to provide protection from three ballistic threats (A, B, and C).[2] The overweight SAPI provided the same ballistic protection as the SAPI but did not meet the SAPI weight requirements. The SAPI were replaced by the ESAPI, which were designed to defeat an additional threat (threat D).

Contract 0040 was awarded on August 19, 2004, for SAPI and overweight SAPI only. The contract award did not initially include the ESAPI because the contractor had not passed first article testing for its ESAPI design. In June 2005, the contractor's ESAPI design passed first article testing and in September 2005, Contract 0040 was modified to include the ESAPI. All of the 21 first article tests conducted for Contract 0040 were conducted on ESAPI, the contractor having met first article testing requirements for SAPI during a previous contract. Of those 21 first article tests, 13 resulted in failures and 8 resulted in passing scores. The Army purchased 51,334 sets of ESAPI for $57,107,890.00 under Contract 0040.

The Research Development and Engineering Command Acquisition Center administered Contract 0040 until the contractor met all deliverables in February 2008. PEO Soldier had technical responsibility for the contract.

First Article Test Plan and Scoring Criteria

The first article test plan was an attachment to Contract 0040 and defined the size and number of plates the contractor was required to submit for testing. The plan also identified the threats that the SAPI, overweight SAPI, and ESAPI were required to defeat. For SAPI, the contractor was required to submit 35 plates for first article testing: 5 extra small, 9 small, 8 medium, 8 large, and 5 extra large. Of those 35 plates, 9 were used for V_{50} testing, 16 for V_0 testing, and the Government and the contractor each retained 5 plates as the manufacturing standard. During V_0 testing, the SAPI were required to stop three shots against threats A, B, and C. For ESAPI, the contractor was required to submit 35 plates for first article testing, 7 of each size. Of those 35 plates, 12 plates were used for V_{50} testing, 13 for V_0 testing, and the Government and the contractor each retained 5 plates as the manufacturing standard. During V_0 testing, the ESAPI were required to stop three shots against threats A, B, and C, and two shots against threat D.

[2] The specific ballistic threats are classified so we refer to the threats as A, B, C, and D.

The COPD contained the criteria for passing SAPI and overweight SAPI first article testing. According to the COPD, the contractor passed if the plates experienced no complete penetrations on the first, second, or third shots and if the BFD did not exceed 43 millimeters on the first or second shot. If a complete penetration did occur or the BFD exceeded 43 millimeters, the contractor failed the first article test.

The COPD also contained the criteria the plates had to meet to pass ESAPI first article testing. However, PEO Soldier officials stated that they did not use the criteria in the COPD because industry could not meet the BFD or partial penetration requirements. Therefore, PEO Soldier officials developed a separate scoring system to score the first article tests. According to PEO Soldier officials, the ESAPI lot acceptance scoring criteria, which were documented in solicitation W91CRB-04-R-0033, were used as a baseline for scoring the ESAPI first article tests. The lot acceptance scoring criteria were based on catastrophic and limited failures and a penalty point system that was applied to the limited failures. A catastrophic failure was defined as a complete penetration of both hard and soft armor on the first shot, or a BFD of greater than or equal to 48 millimeters on the first shot. A limited failure could occur on either a first or second shot and was assigned penalty points as follows:

- A complete penetration of the hard armor and a partial penetration of the soft armor on the first shot received 1 point.
- A complete penetration of both the hard and soft armor on the second shot received 1.5 points.
- A BFD greater than or equal to 44 millimeters but less than or equal to 47 millimeters on the first shot received 1 point.
- A BFD greater than or equal to 44 millimeters on the second shot received 1 point.

The points resulting from limited failures are assigned only when testing against threat D. For threats A, B, or C, any complete penetration on the first, second, or third shot resulted in a failed first article test. For threat D, the accumulation of more than six penalty points resulted in a failed first article test.

Compliance With Testing and Scoring Criteria

During the 21 first article tests conducted for Contract 0040, the testing facility officials did not always follow the COPD and test plan requirements for fair shot determination, BFD measurement, or plate size (see Appendix C for our analysis of each of the 21 first article tests). In addition, the testing facility officials did not consistently conduct retests after deviating from the testing requirements. Because of the deviations from the test requirements and the retests that were conducted by the testing facility officials, in some instances the PEO Soldier scoring official had the opportunity to select certain plates for scoring while disregarding others. The scoring official could not provide documentation that explained why he selected certain plates for scoring and disregarded others. For three of the eight first article tests the contractor passed, the selection of certain plates for scoring resulted in the contractor passing the first article test when otherwise the contractor would have failed. In addition, insufficient test data concerning an additional

passed first article test precluded us from determining the impact of the inconsistent testing and scoring processes on the results of that test.

Fair Shot Determination

The testing facility officials were inconsistent in their decision to follow the fair shot determination criteria specified in the COPD during 2 of the 21 first article tests. The COPD states that a fair shot occurs when the bullet strikes the plate in the required location and within the required velocity range. For over velocity shots, the COPD states that:

- if the shot does not result in a complete penetration, the shot should be considered fair and the test should proceed; but
- if the shot results in a complete penetration, the shot should not be considered fair, and the plate should be discarded.

The treatment of over velocity shots is based on the premise that if the plate can withstand a higher velocity, it should withstand the required velocity. For under velocity shots, the COPD states that:

- if the shot results in a complete penetration, the shot should be considered fair and the test should proceed;[3] but
- if the shot does not result in a complete penetration, the shot should not be considered fair, and the plate should be discarded.

The treatment of under velocity shots is based on the premise that if the plate can not withstand the lower velocity, it would not withstand the required velocity.

The inconsistencies that we identified concerned the treatment of over velocity shots. During first article testing conducted on February 20 and November 7, 2007, shots on six of the plates were over the required velocity. Because none of the shots resulted in a complete penetration, the shots should have been considered fair, and the test should have proceeded, according to the COPD. During the November 7, 2007, test, the testing facility official complied with the COPD and correctly proceeded with testing. However, even though the scenario was exactly the same for the February 20, 2007, test, the testing facility official conducted retests on additional plates. The testing facility official documented all of the shots, including the retests, and provided the test results to PEO Soldier for scoring.

When scoring the test results for the February 20, 2007, first article test (design M3D2S2), the PEO Soldier scoring official chose to use the test results for the retested plates when he computed the test score. Use of the retested plates resulted in a score of 5.5 points, and the contractor passed the first article test. Had the scoring official followed the fair shot acceptance criteria as stated in the COPD and used the initial plates

[3] If the first shot results in a complete penetration, the design fails the first article test. If the second shot results in a complete penetration, the plate receives 1.5 points and the test proceeds.

that withstood the over velocity shot, the contractor would have accumulated an additional 1.5 points (complete penetration on the second shot) and would have failed the first article test with 7 points.

BFD Measurement

PEO Soldier instructed the testing facility to deviate from the COPD and use an offset correction technique (a mathematical formula used to adjust the BFD) when measuring the BFD. The testing facility official used this technique during 2 of the 21 first article tests conducted under Contract 0040. The COPD required that the testing facility officials measure the BFD at the deepest point in the clay depression after the bullet impacted the plate. However, PEO Soldier officials stated that contractors complained that the BFD measurement was not fair if the deepest point in the clay was not behind the point of impact. Therefore, a PEO Soldier official instructed the testing facility in an April 25, 2005, e-mail to use the offset correction technique if the deepest point in the clay depression was not behind the bullet's point of impact.

During the July 10, 2007, first article test (design MH3), the testing facility official used the offset correction technique to decrease the BFD measurement on three plates. Use of the technique resulted in the BFD being revised from 44 to 42 millimeters on the first plate, 46 to 43 millimeters on the second plate, and 48 to 44 millimeters on the third plate. Had the PEO Soldier scoring official followed the COPD when grading the first article test, the design would have failed because of a 48 millimeter BFD on the third plate. The testing facility official also used the offset correction technique during the October 25, 2007, test (design M4D2), but because the original measurement was not documented, we can not determine whether the contractor would have passed or failed had the technique not been used.

Plate Size

The testing facility officials did not use the correct size plates required by the first article test plan during 18 of the 21 first article tests for Contract 0040. In addition, the testing facility officials were inconsistent in their decision to conduct retests when the incorrect size plate was used.

The first article test plan requires a specific size plate for each test but does not provide direction as to what testing facility officials are required to do if they test the incorrect size plate. Analysis of the Contract 0040 test results indicated that the testing facility officials tested the wrong size plate multiple times during 18 of the 21 first article tests but conducted only one retest using the correct size plate during the September 12, 2007, test (design MP2S2). During this test, the testing facility official initially tested a small, medium, and large plate at threat D under ambient conditions instead of testing an extra small, large, and extra large plate as required by the test plan. The testing facility official subsequently tested an extra large plate and forwarded the results for all four plates to PEO Soldier.

Although the PEO Soldier scoring official accepted and scored the incorrect size plates for 17 of the 18 tests, he did not do so when scoring the MP2S2 design test results.

Instead, he scored the extra-small, large, and extra-large plate and disregarded the medium size plate. Scoring the extra-large plate instead of the medium plate resulted in a passing test score, with 4 points. Had the scoring official scored the originally shot medium plate (as he did with the other 17 tests), the contractor would have accumulated an additional 2.5 points (1 point for a partial penetration on the first shot and 1.5 points for a complete penetration on the second shot) and would have failed the first article test with 6.5 points.

Increased Risk of Design Problems

Because of the inconsistent testing and scoring processes, the Army does not have assurance that all inserts purchased under Contract 0040 provide the level of protection required by the contract. Specifically, the inconsistencies during the February 20, July 10, and September 12, 2007 first article tests for Contract 0040 resulted in a passing test when otherwise the contractor would have failed (designs M3D2S2, MH3, and MP2S2). In addition, for the M4D2 design, the Army was unable to provide sufficient data to allow us to determine whether the BFD offset correction technique resulted in a passing test when otherwise the contractor would have failed.

First article testing ensures that a product meets contract technical specifications. A failed first article test increases the risk that the product will not perform to those specifications. Because of the implications of fielding ballistic inserts that may not fully meet technical specifications, the Army should immediately identify and facilitate the return of the M3D2S2, MP2S2, and M4D2 design ballistic inserts (return of the MH3 design is not required as no inserts of that design were purchased) and remove them from inventory. The Army has facilitated a return of ballistic inserts in the past. Specifically, the Army required a return of 8,018 ballistic inserts in December 2008.

Although the ballistic inserts must also pass lot acceptance testing before being fielded, we do not consider lot acceptance testing a substitute for first article testing. For Contract 0040, lot acceptance testing required 5 plates in a lot containing from 151 to 1,200 plates to be tested under ambient conditions against threat D. In contrast, first article testing included 25 plates tested against threats A, B, C, and D in 7 environmental conditions. Therefore, the lot acceptance testing process is not as comprehensive or rigorous as first article testing and should not be relied upon to validate a plate design.

Controls Over the First Article Testing and Scoring Processes

To improve first article testing, the Army needs to establish the controls necessary to prevent further noncompliance and reduce error during testing and scoring. During the testing process, a Government representative should be present to ensure that the testing facility officials follow the testing requirements in the contract, COPD, and first article test plan. The PEO Soldier scoring official stated that he tries to attend all first article tests, and if he can not attend, he sends another PEO Soldier official in his place.

However, H.P. White Laboratory Inc.[4] maintains a database of all visitors that attend the ballistic tests. According to the H.P. White Laboratory Inc. database, a PEO Soldier official was present during only 4 of the 21 first article tests for Contract 0040. A Government official was not present during three of the four tests first article tests that we believe actually failed. PEO Soldier officials should require that a Government official witness all first article testing and verify that the testing facility officials follow the contract requirements. If deviations from the contract requirements occur and the contracting officer approves the deviations through a contract modification, the official should properly document the changes.

For the scoring process, the PEO Soldier scoring official scored the first article tests for Contract 0040 and informed the contracting officer as to whether the contractor passed or failed. The COTR stated that he was not required to send his results for higher level review prior to submitting them to the contracting officer. After reviewing the COPD, test plan, and first article tests, we determined that multiple inconsistencies and errors occurred during the scoring of the tests for Contract 0040. PEO Soldier should establish better controls over the scoring process by requiring higher level review and approval of first article tests. Doing so will reduce the risk of continued scoring inconsistencies.

Client Actions

For the most recent body armor contract issued on October 3, 2008, the Army plans to discontinue use of the BFD offset correction technique and instead use a laser scanner to measure BFD. Military Standard 3027, "DoD Test Method Standard for Performance Requirements and Testing of Body Armor," September 30, 2008, requires use of the laser scanner and states that the laser scanner provides a more accurate measurement of the deepest point of the BFD. Because the Army is taking this action, we are not making a recommendation concerning the use of the BFD offset correction technique.

In September 2008, the Army began non destructive testing of fielded body armor. The body armor is collected in Kuwait for testing while soldiers are on rest and recuperation leave. The test consists of a visual examination to determine whether there is any external damage to the body armor. If external damage is present, the plate is rejected for use. The plates are also x-rayed for cracks, and if cracks are evident, the plate is submitted to Aberdeen Test Center, Aberdeen Proving Ground for ballistic testing. The Army has begun to collect data from the non destructive testing and the subsequent ballistic testing and is producing reports based on the data. We commend the Army for initiating this testing and believe that it will provide needed data concerning the durability and sustainability of the fielded body armor that can be used to improve future body armor designs.

[4]All first article testing for Contract 0040 was conducted at H.P. White Laboratory Inc., a National Institute of Justice certified laboratory.

Client Comments on the Finding and Our Response

Secretary of the Army Comments

The Secretary of the Army disagreed with our finding that the three ballistic insert designs (M3D2S2, MP2S2, and M4D2) failed first article testing. The Secretary agreed with DOT&E's conclusion concerning the tests. DOT&E's concluded that, "the DoD Inspector General has identified significant issues with the documentation of the test process and analysis (scoring). However, the three designs meet the performance specification in place at the time of each test." The Secretary stated that DOT&E is the Government's preeminent and independent authority on testing of this nature.

The Secretary stated that, in order to resolve the disagreement between the Army and the DoD IG, he has requested, in accordance with DoD Directive 7650.3, that the Deputy Secretary of Defense adjudicate the matter. However, to ensure that there can be no question concerning the effectiveness of every soldier's body armor, the Secretary stated that he ordered that the plates at issue be identified and collected until the disagreement is adjudicated.

The Secretary also stated that he associated himself with the January 16, 2009, memorandum provided by the Principal Deputy Assistant Secretary of the Army (Acquisition, Logistics, and Technology), which endorsed comments from PEO Soldier. He further stated that as the Principal Deputy's memorandum explains, the Army, with DOT&E oversight, initiated comprehensive action to fix its testing system beginning in June 2007.

The Secretary of the Army concluded that there is no higher priority for the Army than the safety of the soldiers. He stated that anything that threatens the safety or erodes the confidence of the soldiers, or the American people in the Army's commitment to their safety, is a matter of utmost importance to Army leadership.

Our Response

We agree that the Secretary of the Army has no higher priority than the safety of soldiers, and he demonstrated that by agreeing to identify and collect the ballistic insert designs that we believe failed first article testing (Recommendation A.1.). However, we disagree with the Secretary's position that the M3D2S2 and M4D2 designs met the performance specifications in place at the time of each test. During first article testing for the M3D2S2 design, the testing and scoring officials did not comply with the COPD requirement for fair shot determination, and during first article testing for the M4D2 design, the testing facility officials did not comply with the COPD requirement for measuring BFD. Had the testing facility officials followed the requirements in the COPD, the designs would have failed. For the MP2S2 design, our issue did not pertain to noncompliance with performance specifications, but with the testing and scoring officials' decision to conduct and score a retest. This was the only first article test (out of 18 tests) for which a retest was conducted when an incorrect size plate was initially shot; had the initial plate been used to determine the first article test score, the MP2S2 design would have failed.

The Secretary of the Army stated in his comments that his position is adequately supported by DOT&E, who concluded that the M3D2S2, M4D2, and MP2S2 designs passed first article testing after a review of the first article test results and our draft report. However, as we state in our response to DOT&E's comments to finding A and Recommendation A.1., DOT&E did not conduct a comprehensive analysis of all 21 first article tests, reviewing only the first article tests for the M3D2S2, M4D2, and MP2S2 designs. Our review was based on a comprehensive analysis of all 21 first article tests. Therefore, we do not consider the scope of the DOT&E review as sufficient to support a revision to our finding and recommendation.

PEO Soldier Comments

The Principal Deputy Assistant Secretary of the Army (Acquisition, Logistics, and Technology) endorsed and forwarded comments from PEO Soldier. PEO Soldier agreed that testing facility officials did not consistently follow the test plan criteria or COPD requirements when conducting first article testing for Contract 0040. However, PEO Soldier disagreed that the inconsistencies resulted in passing scores for three tests that we believe actually failed (ballistic insert designs M3D2S2, MH3, and MP2S2). He also disagreed that the M4D2 first article test data were insufficient to determine the impact of the inconsistencies on the results of that test. PEO Soldier maintained that all first article tests for Contract 0040 were valid and that the first article tests in question were scored correctly and supported by sufficient, reliable, test data provided to the audit team. He added that an experienced official from DOT&E independently reviewed the test data and concluded that the designs successfully completed first article testing.

Regarding the inconsistent application of fair shot criteria to over velocity first shots, PEO Soldier stated that he recognizes the critical nature of first and second shot selection on scoring, and that commonly accepted industry standards are used to determine fair shots. He added that the COPD was unclear on second shot scoring but that the issue has been discussed with testing facility officials and the body armor manufacturers and that future COPDs will clearly describe second shot scoring. PEO Soldier stated that because an over velocity first shot stresses a plate beyond the acceptable V_0 range, a plate can not be awarded points or penalized for failing a second shot that follows an over velocity first shot. PEO Soldier stated that for the example cited on page 10 of the draft report, the PEO Soldier official did not "choose" to use the test results for the retested plates when he computed the score but instead followed consistent test scoring practices by requiring that a second plate be used to determine the score. For the February 20, 2007, first article test, use of a second plate resulted in a passing score of 5.5 and therefore, the M3D2S2 design passed that test. PEO Soldier further stated that the M3D2S2 design passed a subsequent November 7, 2007, first article test in which the PEO Soldier official scored second shots occurring after over velocity first shots because, although the second shots accumulated penalty points, the number of points did not result in a failed first article test.

On the use of the offset correction technique for measuring BFD, PEO Soldier stated that the COPD requires that the BFD be measured using the deepest point of penetration.

When the aim point of the projectile (point of impact) is different than the deepest point of penetration, PEO Soldier stated that use of the offset correction technique is a common industry standard to measure BFD and that the audit team was provided documentation showing use of the technique by one of the body armor manufacturers. PEO Soldier stated that use of the technique by that body armor manufacturer demonstrates that the use of offset correction factors is an industry standard practice. He added that contrary to what was written in the draft report, the October 25, 2007, first article test conducted on the M4D2 design was a valid first article test and that during a January 6, 2009, meeting, DOT&E concurred that the design passed first article testing. PEO Soldier further stated that the Army has incorporated a laser scanner to measure the BFD, eliminating the requirement for the offset correction technique.

PEO Soldier also disputed our finding of inconsistencies regarding plate size requirements. He stated that for the September 2007 first article test, a wrong size plate was tested and a correct one was substituted in its place. PEO Soldier stated that the test was scored consistent with the ESAPI scoring procedures and that the design passed with 5 points. He further stated that the MP2S2 design passed a subsequent first article test on November 9, 2007, and a February 2008 test conducted by the U.S. Marine Corps. PEO Soldier concluded that the MP2S2 is a qualified design that passed three separate first article tests over a 6-month period. Consequently, the design has no reported quality or performance defects, and the ballistic inserts do not need to be returned.

For the inconsistencies we identified during the scoring process, PEO Soldier acknowledged that some deficiencies existed in documenting testing requirements and practices. He noted that a review was instituted to ensure that improved documentation is incorporated into current and future contracts. However, PEO Soldier stated that common industry standards were used to score the first article tests and that the scoring process used is consistent with body armor testing practices.

Regarding testing overall, PEO Soldier stated that, to gain a complete understanding of the Army's testing strategy, it is important to look at the totality of the testing, not just one level in isolation. First article testing is only one of three levels in the Army's comprehensive, multitiered approach to body armor testing, which also includes lot acceptance and surveillance testing. In addition, the Army's testing protocols have been structured to withstand operational threats greater than those the plates are designed to defeat, providing an increased safety margin in those testing protocols. PEO Soldier added that he recognized that controls needed to be improved to ensure consistent testing and scoring processes and that, in response, many controls have been implemented. Lastly, PEO Soldier stated that the Army continuously reviews and improves its testing processes and procedures to ensure the best products are fielded to soldiers, whose safety is the Army's top priority.

Our Response

We agree that soldier safety should be the top priority and recognize that the Army is taking steps to improve controls over the body armor first article testing and scoring processes. However, we disagree with the Army's position that the first article tests for ballistic insert designs M3D2S2, MP2S2, and M4D2 were valid and scored correctly and that the designs successfully completed first article testing.

In his comments on the draft report, PEO Soldier stated that because an over velocity shot stresses a plate beyond the acceptable V_0 range, a plate can not be awarded points or be penalized for failing a second shot that follows an over velocity first shot. We agree that an over velocity shot could provide additional stress to a plate and that the stress could affect the results of the second shot. However, we are concerned that the second shot was disregarded only when it resulted in a complete penetration, which would have led to more than the allowable number of penalty points. Only during the February 20, 2007, first article test for the M3D2S2 design did the testing facility official conduct a retest when a complete penetration occurred on a second shot that followed an over velocity first shot. In addition, only during scoring for that February 20, 2007, test did the scoring official disregard the initial test results and use the retest results. Had the scoring official used the results of the initial second shot for the plate that withstood the over velocity first shot, the M3D2S2 design would have failed first article testing. PEO Soldier did not explain how these exceptions constitute "consistent scoring practices."

We disagree with PEO Soldier's contention that the offset correction technique is a common industry standard. The documentation provided to support the Army's contention is the e-mail from the COTR to the testing facility, when he instructed the testing facility to use the technique, and another e-mail in which one of the body armor contractors explains the offset correction technique formula and how it is used. We do not consider the two e-mails sufficient to demonstrate that the technique is a common industry standard. As we discuss in finding B, DoD has yet to adopt standards for its V_0 testing. Furthermore, PEO Soldier's change to Contract 0040 instructing testing facility officials to deviate from the COPD and use the offset correction technique to measure BFD was not in accordance with Federal Acquisition Regulation 43.102.

Regarding PEO Soldier's comments concerning plate size, our issue is not whether plates should be scored or retested if the incorrect size plate is shot. Rather, the issue is that the Army was inconsistent in determining which plates should be scored. Incorrect size plates were used during 18 of the 21 first article tests conducted under Contract 0040. Only during the September 12, 2007, first article test for the MP2S2 design did the testing facility official conduct a retest with the correct size plate when he initially tested the incorrect size plate. As with the treatment of second shots after over velocity first shots, the Army made an exception for one of the first article tests by using the score for the retested plate, allowing the design to pass. Had the Army elected to score the original plate, the design would have failed first article testing. PEO Soldier stated that the MP2S2 design passed two additional first article tests, one on November 9, 2007, and the other in February 2008, and that consequently, the design has no reported quality or performance defect, and the inserts do not need to be returned. The first article test data

provided to us by PEO Soldier indicates that the November 9, 2007, first article test was conducted on the MP2S1 design, not the MP2S2 design. In addition, we did not review Marine Corps first article testing; therefore, we did not consider the results of the Marine Corps test in our conclusion. However, we are concerned that PEO Soldier is supporting their statement that the MP2S2 design is a qualified design based the test of a different design and a Marine Corps test that was conducted the same month the Army stopped purchasing the MP2S2 design.

PEO Soldier stated that DOT&E conducted an independent review of the test data for designs M3D2S2, MP2S2, and M4D2 and concluded that the three designs successfully completed first article testing. However, in his comments, DOT&E acknowledged that his review was limited to the first article tests for those three designs and was based on PEO Soldier test protocols and common industry standards. As discussed in our response to DOT&E's comments, DOT&E did not review all 21 first article tests, nor did he provide us evidence of common industry standards. Lacking documentary support for his conclusion, we maintain that these three first article tests were invalid and the designs actually failed.

PEO Soldier also stated that we should have considered the totality of body armor testing and not have focused on one level of that testing. While we agree that lot acceptance and surveillance testing are important, those tests do not determine whether a plate design meets contractual requirements. Lot acceptance testing, conducted after a design passes first article testing, verifies that the manufacturing process is capable of producing a large quantity of plates while still meeting requirements. Additionally, lot acceptance testing for Contract 0040 required only 5 plates to be tested in ambient conditions against threat D whereas first article testing included 25 plates, tested against threats A, B, C, and D, in ambient and 7 environmental conditions. Surveillance testing is conducted on plates when soldiers are on rest and recuperation leave in an effort to determine a service life for the plates. Neither lot acceptance nor surveillance testing should be used as substitutes for a robust, consistent first article testing process.

DOT&E Comments

The DOT&E agreed that significant systemic issues existed regarding body armor first article testing; however, he disagreed with significant portions of finding A. He stated that, at the request of senior Army leadership, DOT&E conducted an independent review of the first article test results for designs M3D2S2, M4D2, and MP2S2. The objective of the review was to determine whether the test facility and scoring official followed PEO Soldier test protocols and established standards for fair shot criteria, BFD, and plate selection.

Regarding fair shot criteria, DOT&E stated that, although the Army's COPD does not clearly articulate the fair hit criteria for a shot that immediately follows an over velocity shot, he believes it is standard and common practice to declare a "no test" if a failing shot occurs following an over velocity first shot. He added that DOT&E approved that process during first article testing conducted under DOT&E oversight at the Army Test and Evaluation Command during 2008. The DOT&E stated that the rationale for the

process is that a plate subjected to an over velocity shot experiences stresses beyond what the plate was designed to experience, regardless of whether the plate defeats the threat. Any subsequent shot that results in a failure may be the result of a generally weakened plate because of the first over velocity shot, and not necessarily the result solely of the second shot. Therefore, DOT&E agrees with the actions taken by the testing facility during the February 20, 2007, first article test for the M3D2S2 design to conduct a retest when a second shot was awarded limited failure points after an over velocity first shot. He also concurs that the design passed first article testing with a score of 5.5 points. The DOT&E also noted that he supports PEO Soldier's intent to review and correct deficiencies in the test process concerning fair shot criteria.

Regarding the offset correction technique when measuring BFD, DOT&E stated that it is his observation that use of the technique is a common test practice when measuring BFD during Army testing. During DOT&E's review of the M4D2 design first article test conducted on October 25, 2007, he stated that in order for the plate in question to reach a catastrophic failure, the BFD would have to be offset 6.4 millimeters. The DOT&E concluded that even if the correction factor had not been used for the plate in question, the design would not have failed the first article test. The DOT&E further stated that the Army Test and Evaluation Command followed this same process during the preliminary design model testing that was conducted under DOT&E oversight. Finally, he stated that current and future testing overseen by DOT&E will use laser scanning technology that is significantly more accurate and will eliminate manual measurement and application of the offset correction technique.

Regarding the plate size requirement, DOT&E reviewed the MP2S2 first article test conducted on September 12, 2007, and confirmed that a correctly sized substitute plate was tested and scored. Therefore, DOT&E concluded that the testing facility officials followed the correct procedure, that the scoring official correctly scored the first article test, and that the design passed. He further stated that DOT&E did not review the other 17 first article tests referenced in the report, but stated that it is PEO Soldier's process to strictly follow plate size test requirements as stated in the first article test protocol. Additionally, he stated that DOT&E ensured that the correctly sized plates were tested during preliminary design model testing in 2008 and that PEO Soldier intends to conduct all future first article tests at the Army Test and Evaluation Command to prevent recurrence of these issues.

Our Response

While we commend the interdepartmental coordination that resulted in DOT&E's review of the Army's first article testing for designs M3D2S2, M4D2, and MP2S2, we do not consider the scope of that review sufficient to support a revision to our findings and recommendations. We reviewed and analyzed the first article test data for all 21 first article tests conducted for Contract 0040. That data analysis provided the basis for our finding that inconsistencies existed in the testing and scoring processes for the 21 first article tests and that because of those inconsistencies, we believe that 3 of the 8 designs that passed first article testing actually failed. The DOT&E did not review the results for all 21 first article tests.

The DOT&E also stated that, for the fair shot determination and BFD issues, the Army used common test practices when testing and scoring the ballistic plates. As we state in our response to PEO Soldier's comments on finding A, we have not been provided adequate documentation to demonstrate that there is an industry-wide standard, and as we state in finding B, DoD body armor testing standards have yet to be adopted. Further, we reviewed whether first article testing criteria were in accordance with the requirements of the COPD and the first article test plan, neither of which cite industry standards.

The DOT&E concluded that for the M4D2 design first article test it was mathematically impossible that the first shot was 48 millimeters; therefore, the design would not have failed had the offset technique not been used. However, because the original measurement was not documented, we used the offset correction technique formula to calculate the possibilities for the original BFD and determined that it was possible for the original BFD to be 48 millimeters. For example, if the deepest point is 25.6 millimeters from the aim point, and the recalculated BFD is 41.6 millimeters, the original BFD measurement would be 48 millimeters.[5] Although this scenario is not probable, it is possible. Therefore, we can not state with absolute assurance that the design would have passed had the offset correction technique not been used.

Recommendations, Client Comments, and Our Response

We expanded Recommendation A.1. to include a request for a plan of action to implement the recommendation within 30 days of the report. Additionally, after the draft report was issued and we considered management comments, we added Recommendation A.2.c. to address our concern that the COTR was able to make a change to the contract without approval from the contracting officer.

A.1. We recommend that the Secretary of the Army direct the Program Executive Officer Soldier to immediately identify and facilitate the return of the 4,151 sets of M3D2S2, 12,037 sets of MP2S2, and 225 sets of M4D2 design ballistic inserts purchased under Army contract number W91CRB-04-D-0040, and remove the ballistic inserts from inventory. The Secretary of the Army should also provide a plan of action within 30 days of this report that implements this recommendation.

Secretary of the Army Comments

The Secretary of the Army agreed to identify and collect the ballistic inserts to ensure that there can be no question concerning the effectiveness of every soldier's body armor until the disagreement between the Army and the DoD IG has been adjudicated by the Deputy Secretary of Defense.

[5] 48-(0.25*25.6)=41.6

Our Response

We commend the Secretary of the Army in that even though he disagreed with finding A, he has agreed to identify and collect the ballistic inserts. We revised Recommendation A.1. after the draft report was issued and requested that the Secretary of the Army provide a plan of action that implements the recommendation within 30 days of this report. Therefore, we request additional comments on this recommendation in response to the final report.

PEO Soldier Comments

Although not required to comment on this recommendation, the Principal Deputy Assistant Secretary of the Army (Acquisition, Logistics, and Technology) endorsed and forwarded comments from PEO Soldier. PEO Soldier disagreed with our recommendation, stating that, regarding the M3D2S2, MP2S2, and M4D2 designs, the successful first article test results were valid, and a return is not required. He further stated that on January 6, 2009, DOT&E reviewed the first article test documentation and concluded that the three designs passed first article testing.

PEO Soldier stated that the Army conducts multiple levels of continuous testing throughout the life cycle of the ballistic plates, including rigorous first article testing, lot acceptance testing, and surveillance testing. The lot acceptance testing is conducted at ambient conditions with the same test and scoring criteria as the first article tests, thereby increasing the statistical confidence that the plates accepted are of the highest quality and will meet the soldiers' needs for protection. PEO Soldier stated that the M3D2S2 design passed 15 of 17 lot acceptance tests, providing the Army high confidence that the plates met the performance requirements. Further, PEO Soldier stated that the plates are also undergoing surveillance testing, which requires the plates to be x-rayed in Kuwait. If cracks are found, the plates are sent to Aberdeen Test Center, Aberdeen Proving Ground for further testing. PEO Soldier stated that, of the 1,750 plates sent to the Aberdeen Test Center, 533 have been live-fire tested. Testing results indicate that when tested against the most prevalent round found in theater and on the most vulnerable part of the plate (location of the crack), the plates have successfully stopped 180 of 180 shots (100 percent). In addition, in testing conducted with ammunition beyond what would be found in theater, the plates successfully stopped 212 of 278 shots (76.3 percent).

PEO Soldier stated that the Army plans to continue live-fire testing of returned plates in an effort to determine a service life for plates. He stated the testing ensures that the Army develops a historical body of knowledge and allows for continuous scrutiny of the plates to ensure they meet the highest standards of plate performance throughout their service life.

Our Response

PEO Soldier stated that the DOT&E review supports his statement that the first article tests were valid. However, he acknowledged in his comments that DOT&E's review was limited to the first article tests conducted for the M3D2S2, MP2S2, and M4D2 designs and was based on PEO Soldier test protocols and common industry standards. Our recommendation was based on a comprehensive review and analysis of all 21 first article

tests conducted for Contract 0040 and whether those tests were conducted in accordance with contractual requirements. The DOT&E's limited scope of review, his acceptance of PEO Soldier's use of common test practices during testing (instead of COPD requirements), and the lack of evidence supporting industry standards do not provide a sufficient basis to alter our conclusions.

PEO Soldier also stated that the Army conducts multiple levels of testing throughout the life cycle of ballistic plates to include first article, lot acceptance, and surveillance testing. We agree that multiple levels of testing are necessary, but do not consider that the results of lot acceptance or surveillance testing compensate for an invalid first article test. The Army conducts first article testing to authorize production of a specific design. First article testing consists of testing 25 plates under ambient and 7 environmental conditions, using 4 different threats. Lot acceptance testing consists of testing three to eight plates, depending on the lot size, under ambient conditions and using only one threat. For Contract 0040, the testing facility officials tested only five plates during lot acceptance testing. PEO Soldier specifically stated that the M3D2S2 design passed 15 of 17 lot acceptance tests, providing the Army high confidence that the plates met performance requirements. However, that argument does not hold true for the M4D2 lot acceptance testing because that design only passed one of four lot acceptance tests.

The Army also provided results concerning surveillance testing conducted in Kuwait and at the Aberdeen Test Center. Although the test results indicate that 100 percent of the plates with identified cracks withstood the most prevalent round in theater, the results can not be extrapolated beyond the plates actually tested because they are not representative of the entire population. The Army must use proper statistical methodology to draw general conclusions concerning the state of the ballistic plates.

DOT&E Comments

Although not required to comment on this recommendation, DOT&E stated that his office reviewed the M3D2S2, MP2S2, and M4D2 design first article tests and concluded that all three were successful. However, DOT&E stated that he deferred to the Secretary of the Army on any decision involving the return of U.S. Army personal protective equipment.

A.2. We recommend that the Program Executive Officer Soldier:

a. Require that a Government representative be present at all first article tests to verify that the testing facility officials follow the test plan and contract requirements.

b. Initiate a review and approval process to verify that the first article test results are scored in accordance with the first article test plan and contract requirements.

c. ***(New)*** **Implement controls to ensure that future changes to the contract are executed by the contracting officer and in accordance with the Federal Acquisition Regulation.**

PEO Soldier Comments

PEO Soldier agreed, stating that since June 2008 there has been a requirement for Government representation during all first article and lot acceptance testing. He also stated that since October 2008, a three-tier scoring methodology was implemented to ensure scoring accuracy. Each test is independently scored by two people, and the results are provided to the PEO Soldier Chief Scientist for adjudication and final approval.

Our Response

PEO Soldier's comments to Recommendations A.2.a. and A.2.b. were fully responsive, and no additional comments are required on those recommendations. Additionally, after the draft report was issued and we considered management comments, we added Recommendation A.2.c. to address our concern that the COTR was able to make a change to the contract without approval from the contracting officer.

DOT&E Comments

Although not required to comment on this recommendation, DOT&E supports PEO Soldier's intent to correct deficiencies in the first article testing process. The DOT&E also supports PEO Soldier's intent to sponsor testing at Government facilities with independent Government oversight when possible and, when not possible, to use independent Government personnel to oversee testing. He stated that conducting first article testing at a Government facility, under Government oversight, and with adequate test processes significantly reduces the risk that the issues discussed in finding A will recur.

Finding B. First Article Testing Criteria for the Army and USSOCOM

The Army and USSOCOM independently developed first article testing criteria for body armor ballistic inserts. Even when testing to the same ballistic threats, the testing criteria differed significantly in the number of plates tested (sample size), the shot pattern, the environmental conditions, the type of tests, and pass/fail guidelines. As a result, DoD does not have assurance that its body armor provides a standard level of protection. To standardize the level of protection, DoD needs to ensure that the Military Services and USSOCOM work with DOT&E to develop a test operation procedure for body armor ballistic inserts. To verify the rigor of the testing, DOT&E should use quantitative methods to develop a test sample size for testing that limits the number of possible failures. The test operation procedure should include, at a minimum, requirements for sample size, shot pattern, types of tests, and pass/fail guidelines.

First Article Testing Criteria

The Army and USSOCOM used different approaches when developing first article testing criteria for body armor ballistic inserts. In 2002, the Army adopted the U.S. Marine Corps SAPI COPD as a baseline to develop first article testing criteria for the Army version of the SAPI COPD. The Marine Corps COPD was based on research conducted at the U.S. Army Natick Soldier Research, Development, and Engineering Center from 1998 through 2000. The initial Army SAPI testing criteria were used to develop the ESAPI testing criteria in 2005 when the Army discontinued the use of the SAPI and began purchasing the ESAPI.

In 1998, USSOCOM adopted testing criteria proposed by one of its body armor contractors. According to the contractor, the criteria were developed based on ballistic behavior, sampling methodology, and confidence levels used to draw inferences from the sample to the population of ballistic inserts being tested. The contractor also stated that the criteria were developed following discussions with ballistics experts.

The different approaches in the development of Army and USSOCOM first article test criteria resulted in significant differences, even when testing to the same ballistic threats. Those results include differences in the number of plates tested (sample size), the type of tests, the environmental conditions, the shot pattern, and the pass/fail guidelines. To make a valid comparison between the different test criteria, we compared the test criteria used for the Army ESAPI and USSOCOM Generation III[6] plates because those plates are required to stop the same ballistic threats (A, B, C, and D).

Number of Plates Tested

The Army and USSOCOM test a different number of plates for each ballistic threat and environmental condition. For the ESAPI, the Army requires the contractor to submit

[6] The Generation III plates are referred to as "baseline configuration plates" in the USSOCOM contract. Once the baseline configuration plates pass testing, they will officially become Generation III plates.

25 plates for first article ballistic testing. For V_0 testing, the COPD requires that one plate be tested against threats A, B, and C in ambient conditions and three plates against threat D in ambient conditions. In addition, the COPD requires that one plate be tested under each of the seven environmental conditions tested by the Army. The remaining 12 plates are used for V_{50} testing.

USSOCOM requires that the contractor submit a minimum of 146 plates for Generation III first article testing. Based on initial results, the number of plates tested can increase to 480 (see Table 1). The test plan requires that 16 plates be tested against threats A, B, C, and D in ambient conditions. The test plan also requires that six plates be tested under each of the eight environmental conditions. During ambient testing, if a complete penetration or BFD greater than 44 millimeters occurs during the second shot with threats A and B or the first shot with threat D, the plan requires the testing facility to test an additional 13 plates in ambient conditions. If the same scenario occurs during environmental testing, the plan requires the testing facility to test an additional 23 plates for the specific condition. In addition to the ambient and environmental testing, USSOCOM requires that 28 plates be tested for shatter gap.[7] The remaining six plates are used for V_{50} testing.

Table 1. Number of Plates Tested

Condition	Threat	ESAPI	Generation III (min)	Generation III (max)
Ambient	A	1	16	29
Ambient	B	1	16	29
Ambient	C	1	16	16
Ambient	D	3	16	29
Environmental(s)	D	7	48	232
Shatter Gap	D	0	28	116
V_{50}	D	12	6	29
Total		25	146	480

According to Army officials, one plate was required for each condition. Because the Army did not test two of the environmental conditions listed in the first article test plan, the two extra plates were tested under ambient conditions against threat D. USSOCOM determined the number of plates required for ballistic testing based on the number of plates necessary to meet its required confidence and probability levels.

Shot Pattern

The Army and USSOCOM use different shot patterns when conducting first article testing (see Figure 5). The Army COPD for ESAPI requires the testing facility official to shoot three shots on each plate against threats A, B, C, and D. The first shot must be 0.75 to 1.25 inches from the edge of the plate, but the COPD does not specify whether that

[7] Shatter gap occurs when a bullet penetrates body armor at a lower velocity than the body armor was designed to defeat. The Army does not test against shatter gap.

shot should be on the left or right edge of the plate. PEO Soldier officials, contractors, and testing facility officials stated that the first shot is always on the left side of the plate, and for the ballistic testing that we observed, we noted no instances in which the right side of the plate was shot. According to the COPD, the second shot is required to be at the weakest point of the plate and within 6 inches of the first shot. PEO Soldier officials consider the weakest point to be the plate's apex,[8] and therefore require the testing facility to fire all second shots at that point. The third shot is required to be 6 inches from the second shot at a 30 degree angle and is for Government reference only against threat D. Therefore, the data from the third shot against threat D are not used when scoring the first article test.

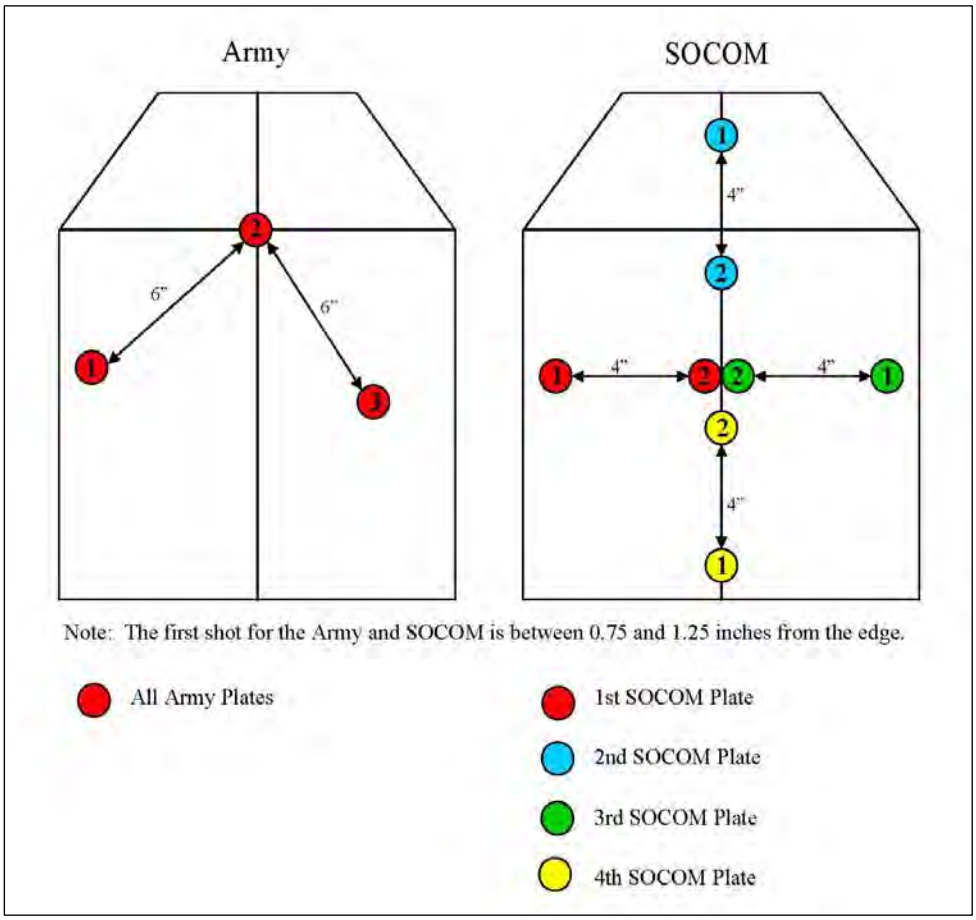

Figure 5. Army and USSOCOM Shot Patterns

The USSOCOM first article test plan requires that the testing facility official shoot each plate two times against threats A, B, C, and D. The first shot is required to be 0.75 to 1.25 inches from the left edge of the plate (9 o'clock). The subsequent first shots are fired in a clockwise pattern at 12 o'clock, 3 o'clock, and 6 o'clock, repeating the shot pattern until the test is complete. The second shot is required to be 4 inches, plus or minus 0.5 inch, from the first shot and toward the center of the plate for each shot.

[8] In Figure 5, the apex is denoted by the number 2 in the Army shot pattern diagram.

USSOCOM officials stated that this shot pattern is used to verify uniform protection across the plate.

Environmental Conditions

The Army and USSOCOM also differ in the types of environmental conditions tested and the conditioning procedures for each of those environmental conditions (see Table 2). The Army tests under seven environmental conditions with 2- or 6-hour conditioning periods, and USSOCOM tests under eight environmental conditions with 8- or 24-hour conditioning periods.

During temperature conditioning, the Army subjects plates to both high and low temperatures for a minimum of 6 hours each before ballistic testing. USSOCOM subjects the plates to the temperature extremes for 24 hours each before testing. The Army also requires temperature shock conditioning, which requires the plate to be at 120 degrees for 2 hours and then at -25 degrees for 2 hours. USSOCOM does not require a temperature shock test.

During liquid conditioning, the Army subjects plates to oil, diesel, and saltwater; USSOCOM subjects its plates to oil, gasoline, weapon lubricant, chlorine water, and sea water. The Army and USSOCOM subject the plates to the various liquids for different periods using different techniques. For example, during oil conditioning, the Army places its plate in half an inch of oil for 2 hours; USSOCOM completely submerges its plates in the oil for 8 hours. Because the plates can be manufactured with material that can absorb and retain a significant amount of liquid, USSOCOM also weighs the plates before and after liquid conditioning to determine whether they absorbed any of the liquid. If there is a difference in weight greater than .25 pounds, the design automatically fails the first article test. The Army does not have a requirement to weigh the plates after liquid conditioning.

For the durability test, the Army and USSOCOM subject their plates to the same type of conditioning. The plates are dropped twice and then x-rayed. If the x-ray shows a crack in the plate, ballistic testing is performed directly on the crack; if no cracks are present, the testing is conducted using the regular shot pattern.

Table 2. Environmental Conditions for ESAPI and Generation III

Environmental Condition	Army Requirement	USSOCOM Requirement
Low Temperature	6 hours	24 hours
High Temperature	6 hours	24 hours
Oil	2 hours	8 hours
Diesel/Gasoline	2 hours	8 hours
Weapon lubricant	N/A	8 hours
Chlorine Water	N/A	24 hours
Sea Water	N/A	24 hours
Saltwater	2 hours	N/A
Temperature Shock	See description in text	N/A
Durability	Dropped twice	Dropped twice

Shatter Gap

USSOCOM tests against shatter gap, and the Army does not. Shatter gap occurs when a bullet hits hard body armor at a velocity significantly less than the armor is designed to defeat. Instead of the bullet "shattering" upon impact, which it would do at a higher velocity, the bullet stays intact. In this state, it could penetrate the hard and soft armor, resulting in a partial or complete penetration. To test shatter gap, USSOCOM tests a minimum of 28 plates against threat D at 4 different velocity ranges. The plates must meet the requirements in the first article test plan.

Pass/Fail Guidelines

The Army and USSOCOM use different criteria when determining whether the contractor's ballistic inserts pass or fail first article testing. For the Army, the contractor fails a first article test if the test results in a catastrophic failure or receives more than six penalty points, as discussed in finding A. For USSOCOM, the contractor fails a first article test if the test does not meet the probability and confidence levels listed in the first article test plan (see Table 3).

As stated in finding A of this report, PEO Soldier officials did not follow the BFD and complete penetration requirements contained in the COPD. PEO Soldier officials developed additional pass/fail guidelines that were based on the concept of catastrophic and limited failures and implemented a point system that was assigned to the limited failures against threat D,[9] as described above.

The COPD states that the BFD can not exceed 43 millimeters, and no complete penetrations can occur on the first, second, or third shot against threats A, B, and C, or on the first or second shot against threat D. However, PEO Soldier officials defined a catastrophic failure as a BFD of 48 millimeters or greater on the first shot or a complete penetration of the hard and soft armor on the first shot. Although PEO Soldier officials did not allow any complete penetrations to occur on the first shot, they did allow the BFD to measure 47 millimeters. PEO Soldier officials stated that they relaxed the COPD requirement of 43 millimeters because industry could not meet that requirement. However, PEO Soldier officials provided 510 BFD data points from ballistic testing results, and only 10 of those 510 data points exceeded the 43 millimeter BFD requirement. We believe that the small number of outliers does not justify allowing the BFD measurement to exceed 43 millimeters.

USSOCOM pass/fail guidelines are based on probability and confidence levels. For example, when testing plates against threat D under ambient conditions, USSOCOM requires the test to have a 90 percent probability with an 80 percent confidence level that the plate will stop the first shot. This would occur if no more than 0 of 16 or 1 of 29 plates results in a failure. A failure occurs if the BFD measurement is greater than 44 millimeters or a complete penetration of the hard and soft armor occurs on the first or second shot. USSOCOM also requires the test to have a 60 percent probability with an 80 percent confidence level that the plate will stop the second shot. This would occur if

[9] As of June 14, 2007, PEO Soldier also assigned limited failure points to threats A, B, and C.

no more than 0 of 6, 1 of 7, 2 of 10, through 8 of 29 plates result in a failure. If the test meets the probability and confidence levels for shots one and two, the contractor passes the first article test. The probability and confidence levels for the additional conditions are listed in Table 3 and discussed below the table.

Table 3. USSOCOM Probability and Confidence Levels

Conditions	Threat	First Shot Probability (Percent)	First Shot Confidence (Percent)	Second Shot Probability (Percent)	Second Shot Confidence (Percent)
Ambient	A	100	100	90	80
Ambient	B	100	100	90	80
Ambient	C	100	100	100	100
Ambient	D	90	80	60	80
Environmental(s)	D	90	80	60*	80*
Shatter Gap	D	100	100	60	80

*Requirement only if the V_{50} test fails.

USSOCOM requires the plate to stop 100 percent of the first shots against threats A, B, and C; 100 percent of the second shots against threat C; and to have a 90 percent probability with an 80 percent confidence level that the plate will stop the second shot against threats A and B. For the environmental tests against threat D, USSOCOM requires the tests to meet the 90 percent probability with an 80 percent confidence level requirement on the first shot and the second shot to pass a V_{50} test. However, if the plate fails the V_{50} test, then a separate environmental test is conducted under the same condition, using the same probability and confidence level requirements as threat D at normal conditions. For the shatter gap test against threat D, USSOCOM requires the test to stop 100 percent of the first shots and meet the 60 percent probability with an 80 percent confidence level requirement on the second shot. If one of the tests discussed above does not meet the required probability and confidence levels, the first article test will fail.

Level of Protection

Because the Army and USSOCOM first article testing criteria differ so significantly, DoD does not have assurance that its body armor provides a standard level of protection. We expected to encounter differences in first article testing based on mission needs; however, the justification for the differences (number of plates tested and pass/fail guidelines) did not specifically relate to the Army and USSOCOM missions.

The differences between the Army and USSOCOM first article testing was difficult to quantify because of the differences in the number of plates tested, the environmental conditions tested under, and the scoring of the first and second shots. However, we were able to calculate and compare the Army and USSOCOM data for the first shot against threat D under ambient conditions using USSOCOM Generation III and Army ESAPI. The simple comparison showed that the USSOCOM sampling plan provided a 27 percent

better chance that defective plates are detected during first article testing (see Appendix B for the calculations).

The Army requires the contractor to submit 25 plates for first article testing and tests 3 of those plates against threat D in ambient conditions. Applying a statistical distribution to the population of 25 plates and assuming 3 plates are each shot once and with zero complete penetrations, we calculated that there is a 20 percent chance that at least 36 percent of the plates will not be detected as failures. For the Generation III criteria, USSOCOM requires the contractor to submit a minimum of 146 plates for first article testing and then tests 16 of those plates against threat D in normal conditions. From a population of 146 plates, assuming 16 plates are each shot once with zero complete penetrations, we calculated that there is a 20 percent chance that at least 9 percent of the plates will not be detected as failures.

Although the USSOCOM and Army require two shots on each plate, these calculations are based only on a first shot comparison. Both USSOCOM and Army plates are two-strike plates and the qualification of their plates requires two-strike qualifications. However, we attribute the 27 percent difference of plates that will not be detected as failures primarily to the total number of plates tested. This significant difference in sample sizes does not verify that USSOCOM and Army body armor provides a standard level of protection.

Standard First Article Testing Criteria

DoD has not instituted standard criteria for body armor first article testing. Although the DoD issued Military Standard 662F, "V_{50} Ballistic Test For Armor," December 18, 1997, and Military Standard 3027, "DoD Test Method Standard for Performance Requirements and Testing of Body Armor," September 30, 2008, they are provided only for body armor testing guidance, and military personnel are not required to follow them.

DoD issued Military Standard 662F to provide V_{50} acceptance criteria for body armor. Specifically, the standard provides guidance for calculating the V_{50} and the ballistic limit of body armor, establishes the V_{50} testing protocol, and provides acceptance and rejection criteria. The Army and USSOCOM follow the standard for V_{50} testing; however, the standard discusses only V_{50} testing procedures, and currently the majority of body armor ballistic testing is V_0 testing.

DoD issued Military Standard 3027 to provide performance requirements and test protocols for developing or qualifying body armor to meet the ballistic threat, environmental conditions, and durability requirements. Army and USSOCOM personnel provided input during the creation of the standard; however, PEO Soldier officials stated that they do not follow the standard because it is too restrictive, and USSOCOM officials are not required to follow the standard.

DoD 4120.24-M, "Defense Standardization Program (DSP)," March 2000, establishes policies and procedures to achieve standardization throughout the Department. This guidance states that standardization improves military operational readiness and reduces

ownership costs and cycle time. Standardization in the body armor program will improve operational readiness by reducing the variety of body armor items in the supply system. Acquisition cycle time would also be reduced by requiring the Services to follow standard body armor requirements. If DoD develops and requires that the Services follow a standard test protocol and standard acceptance criteria for body armor testing, all Service members will receive the same level of body armor protection.

Although we acknowledge the diverse mission requirements across the Services and the combatant commands, the DoD should support the development and use of minimum test protocol and acceptance standards for body armor. During first article testing, body armor products should be tested against all anticipated battlefield threats and accepted under the same criteria. In addition, body armor testing should provide a certain level of confidence that the manufacturing process is capable of producing an armor product that will meet the established requirements. Standardization of body armor testing and acceptance will ensure that Service members receive body armor that has been rigorously tested and will provide uniform protection in the battlefield.

To standardize the level of protection throughout DoD, DoD needs to verify that the Services and USSOCOM work with DOT&E to develop the test operations procedure for body armor ballistic inserts. To verify the rigor of the testing, DOT&E should use quantitative methods to develop a sample size for testing that limits the number of possible failures. In addition, the test operating procedure should include, at a minimum, requirements for sample size, shot pattern, types of testing, and acceptance criteria to verify the rigor of testing.

Client Actions

The "National Defense Authorization Act for FY 2009," Subtitle E, Section 251, gives DOT&E the authority to oversee body armor testing. Specifically, the National Defense Authorization Act states that the Secretary of Defense can authorize DOT&E to perform statutorily mandated monitoring and reporting on defense systems. This gives DOT&E authority to oversee systems that require survivability testing, which include personal protective equipment.

The DOT&E is conducting a comprehensive technical assessment of Army body armor systems in response to a congressional request. A DOT&E official stated that because there is no standard for body armor ballistic testing, his office developed a test plan for hard body armor that was used during the testing of Army ballistic inserts in December 2008. The official stated that he will use the data generated from the December 2008 tests to develop requirements for body armor ballistic testing. The DOT&E will coordinate with the Army Test and Evaluation Command to document the requirements in a test operations procedure for testing hard armor and plans to issue the procedure by the end of FY 2009.

Client Comments on the Finding and Our Response

Army Comments

The Principal Deputy Assistant Secretary of the Army (Acquisition, Logistics, and Technology) endorsed and forwarded comments from PEO Soldier. PEO Soldier agreed that the Army and USSOCOM independently developed first article test criteria for body armor ballistic inserts and said that the test criteria were based on different operational requirements. He stated that the Army will execute its Phase II ballistic testing in coordination with DOT&E and will support the efforts to develop standardized body armor testing procedures and to ensure adequate oversight of those procedures. PEO Soldier stated that the Army will continue to work with DOT&E, the U.S. Army Test and Evaluation Command, USSOCOM, and all Services to improve body armor test procedures.

Regarding the Army's first article testing, PEO Soldier stated that the Army has a thorough and proven testing methodology as substantiated in the GAO report, GAO-07-662R, "Review of Body Armor," April 26, 2007. He also stated the Army has complied with Military Standard 3027 since it was issued on September 30, 2008.

Our Response

We commend the Army's willingness to work with and support DOT&E in the effort to standardize body armor ballistic testing throughout DoD. We believe that standardization will assist the product developers, the testing facilities, and the body armor manufacturers in their efforts to provide the greatest protection to the warfighter.

During our audit, we reviewed a GAO report, GAO-07-662R. Although the report states that "DoD has a standard methodology for ballistic testing of the hard body armor plates," the standard methodology that GAO was referencing was for V_{50} testing, not V_0 testing. As we stated on page 5 of this report, we limited our review to V_0 testing because the V_{50} test results are not always used to determine whether body armor samples pass or fail first article testing.

USSOCOM Comments

Although not required to comment, the Program Executive Officer for Special Operations Forces Warrior Systems suggested editorial changes to the report. We made changes where appropriate. For the specific suggestions and the changes we deemed appropriate, please see the full text of USSOCOM comments in the Client Comments section.

Recommendations, Client Comments, and Our Response

B. We recommend that the Director, Operational Test and Evaluation develop a test operations procedure for body armor ballistic inserts. During the development of the test operations procedure, the Director, Operational Test and Evaluation should:

> **1. Involve the Services and USSOCOM to verify the test operation procedure is implemented DoD-wide.**
>
> **2. Include, at a minimum, requirements for sample size, shot pattern, types of testing, and acceptance criteria to verify the rigor of testing. Specifically, the Director should use quantitative methods to develop a sample size for testing that limits the number of possible failures.**

DOT&E Comments

The DOT&E agreed, stating that DOT&E continues to oversee Army body armor testing and analysis according to congressional direction. Subject matter experts from DOT&E, the Army Test and Evaluation Command, PEO Soldier, and the Army Research Laboratory are working together to develop test protocols that address sample size, plate size, and confidence levels. He stated that the Army Test and Evaluation Command will use those test protocols during upcoming tests, and the test results will shape a future test operations procedure that DOT&E will promulgate across the Department. He further stated that DOT&E's goal is to develop a first article test protocol that requires a 90 percent lower confidence limit on a reliability of 90 percent that the material under test passes the requirement. Lastly, DOT&E stated that the expanded testing, coupled with a comprehensive review of current practices, will address all of the systemic issues identified in this report and will result in standardized test protocols for use across DoD.

Our Response

The DOT&E's comments were fully responsive, and no additional comments are required.

Appendix A. Scope and Methodology

We conducted this audit from August 2008 through January 2009 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Although an announced objective, we did not review first article testing criteria for the other contracts reviewed as part of DoD IG Report No. D-2008-067 "DoD Procurement Policy for Body Armor," March 31, 2008. That objective will be addressed in DoD IG Project No. D2008-D000CD-0256.000 "Research on DoD Body Armor Contracts." In addition, we did not review the safety of the ballistic inserts; therefore, we did not determine whether or not the inserts provide the protection intended.

To accomplish the objectives, we obtained, reviewed, and analyzed the National Defense Authorization Act for FY 2009, military standards; DoD instructions and manuals; Defense Contract Management Agency product inspection reports and corrective action requests; and Army and USSOCOM contracts, first article test plans, scoring criteria, and first article test results. We also observed ballistic testing at H.P. White Laboratory Inc., and toured three contractor sites. Additionally, we interviewed officials from DOT&E, the USSOCOM Special Operations Forces Warrior Systems, U.S. Army Natick Soldier Center, PEO Soldier, the Air Force Research Laboratory, H.P. White Laboratory Inc., and three body armor contractors.

We coordinated with the Government Accountability Office, Army Audit Agency, and DoD IG Audit Acquisition and Contract Management Directorate personnel who were conducting a concurrent review of body armor issues.

Use of Computer-Processed Data

To perform this audit, we used computer-processed data to answer our objectives. We relied on 21 first article test reports and a master lot report. We received the first article test reports from Army officials, a Government contractor, and from H.P. White Laboratory Inc. We compared multiple computer generated first article test reports and we did not find significant discrepancies between those reports. We also used the master lot report provided by Army officials to determine the total cost and amount of ESAPI produced for Contract 0040. We reviewed each of the 21 first article test reports with the Contractor and independently compared each individual first article test to the master lot report. After our extensive review, we believe the computer-processed data was adequate.

Prior Coverage

During the last 5 years, the Government Accountability Office (GAO), the DoD IG, and the Army have issued four reports discussing body armor. Unrestricted GAO reports can be accessed over the Internet at http://www.gao.gov. Unrestricted DoD IG reports can be accessed at http://www.dodig.mil/audit/reports.

GAO

GAO Report No. GAO-05-275, "Defense Logistics: Actions Needed to Improve the Availability of Critical Items during Current and Future Operations," April 8, 2005

DoD IG

DoD IG Report No. D-2008-067, "DoD Procurement Policy for Body Armor," March 31, 2008

DoD IG Report No. D-2007-107, "Procurement Policy for Armored Vehicles," June 27, 2007

Army

Army Audit Agency Report No. A-2004-0202-AMA, "Interceptor Body Armor," March 17, 2004

Appendix B. Use of Technical Assistance

The Quantitative Methods Directorate (QMD) reviewed Army and USSOCOM contract and first article test plans, scoring criteria, and test results. QMD applied appropriate statistical methods to analyze the sampling designs based on the number of plates tested against threat D with the first shot. The main focus was the sample size requirements used in first article testing.

The objective was to quantify the statistical difference between the Army and USSOCOM first article test plans for body armor plates with respect to sample size. The differences between the Army and USSOCOM first article testing was difficult to quantify because of the differences in the number of plates tested, the environmental conditions tested under, and the scoring of the first and second shots. However, QMD analysts were able to compare the Army and USSOCOM data for the first shot against threat D and under ambient conditions using Army ESAPI and USSOCOM Generation III plates. The QMD analysts reviewed relevant documentation provided by the audit team. In addition, the analysts interviewed officials from PEO Soldier, the U.S. Army Natick Soldier Center, and three body armor contractors.

The QMD theoretical analysis is based on a first shot comparison and use of a hypergeometric distribution. The hypergeometric distribution is widely used in quality control studies. It describes an experiment where elements are picked at random without replacement and the probability of success is not constant. The QMD mathematically calculated the lower confidence bound that the Army and USSOCOM first article test could expect to achieve with respect to the first shot. The analysts replicated the analysis performed in 1998[10] by a ballistic expert to validate our statistical model.

The QMD used R statistical software to calculate the lower confidence bound of partial penetration. The lower confidence bound is found by inverting the p-value using the method described by Buonaccorsi, J. (1987).[11]

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[10] November 12, 1998, letter to Ms. Valerie M. Romanchek from John P. Byrd referencing contract USZA22-98-D-0007QMD, citing Dr. Mark Adams, Ballistics Expert, Jet Propulsion Lab, National Aeronautics and Space Administration.

[11] "A Note on Confidence Intervals for Proportions in Finite Populations," *The American Statistician*, 41, 215 - 218.

Information from the first article test was used as arguments in the lower confidence bound function lbhyper(N, n, y, cl). The QMD analysts calculated the number of partial penetrations at the lower bound assuming zero complete penetrations on the first shot and then calculated the lower confidence bound of partial penetration by dividing the number of partial penetrations at the lower bound by population size.

lbhyper(N, n, y, cl)
N = population size
n = sample size
y = number of partial penetration
cl = confidence level

USSOCOM: Threat D:
lbhyper(146, 16, 16, .80)
N = 146
n = 16
y = 16 (complete penetration is zero)
lcb = .91 or 91 percent

From a population of 146 plates, shooting 16 plates with each plate shot once with zero complete penetrations and 16 partial penetrations, the lower confidence bound of partial penetration is .91 or 91 percent at 80 percent confidence; conversely there is a 20 percent chance there will be at least 9 percent failures.

Army: Threat D:
lbhyper (25, 3, 3, .80)
N = 25, (13 shots for testing, 12 for reference, 10 for contractor and Army)
n = 3
y = 3 (complete penetration is zero)
lcb = .64 or 64 percent

From a population of 25 plates, shooting 3 plates with each plate shot once with zero complete penetrations and 3 partial penetrations, the lower confidence bound of partial penetration is .64 or 64 percent at 80 percent confidence; conversely there is a 20 percent chance there will be at least 36 percent failures.

The QMD analysts additionally verified our BFD calculations using the offset correction technique discussed on page 20 of this report.

Appendix C. Analysis of First Article Test Results for Contract 0040

The following summarizes the inconsistencies identified during our analysis of the 21 first article tests conducted for Contract 0040.

The PEO Soldier scoring official determined that the contractor passed the following eight first article tests:

Test Date: 6/21/05
Number of Points: 5
Auditor Note: The testing facility official used the wrong size plate three times during the first article test. Although the wrong size plates were used, the testing facility official did not conduct retests with the correct size plates.

Test Date: 2/08/07
Number of Points: 2.5
Auditor Note: The testing facility official used the wrong size plate three times during the first article test. Although the wrong size plates were used, the testing facility official did not conduct a retest with the correct size plate.

Test Date: 2/20/07
Number of Points: 5.5
Auditor Note: The testing facility official used the wrong size plate four times during the first article test. Although the wrong size plates were used, the testing facility official did not conduct retests with the correct size plates.

In addition to testing the wrong size plates, the testing facility official did not follow the fair shot requirement in the COPD during the hot and saltwater conditions. The velocity for the first shots during those conditions was too high, but there was not a complete penetration or high BFD and according to the COPD, the shots were considered fair. The velocity for the second shots met the requirement in the COPD, but both resulted in a complete penetration; therefore, the plates conditioned in hot temperature and saltwater should have received 1.5 points each. However, a retest was conducted on March 2, 2007, for both conditions. During the hot condition retest, the same scenario occurred, the plate scored 1.5 points, but the official did not conduct a retest. During the saltwater condition retest, the velocity for the first and second shot met the COPD requirement and the plate scored no points. If the PEO Soldier scoring official had followed the fair shot requirement in the COPD, the contractor would have failed with seven points.

Test Date: 7/10/07
Number of Points: 4.5
Auditor Note: The testing facility official used the wrong size plate three times during the first article test and the official did not conduct retests with the correct size plates.

During the first article test, the testing facility official used the offset correction technique to decrease the BFD measurement on three plates. Had the PEO Soldier scoring official used the original BFD measurement, the contractor would have failed the test with a catastrophic failure in addition to accumulating more than 6 points.

Test Date: 9/12/07
Number of Points: 4
Auditor Note: The testing facility official used the wrong size plate four times during the first article test. The official conducted a retest for the incorrect size plate that scored 2.5 points and did not retest the other 3 plates. Had the PEO Soldier scoring official used the original plate, the contractor would have failed the test with 6.5 points. This was the only time the testing facility official conducted a retest with the correct size plate.

Test Date: 9/18/07
Number of Points: 4.5
Auditor Note: The testing facility official used the wrong size plate once during the first article test and the official did not conduct a retest with the correct size plate.

Test Date: 10/25/07
Number of Points: 4
Auditor Note: The testing facility official used the wrong size plate four times during the first article test and the official did not conduct retests with the correct size plates. Additionally, the offset correction technique was used to decrease the BFD on two plates. We are unable to determine whether the contractor would have failed the test if the offset correction technique was not used because the original BFD measurement for one of the plates was not recorded.

Test Date: 11/7/07
Number of Points: 5
Auditor Note: The testing facility official used the wrong size plate once during the first article test and the official did not conduct a retest with the correct size plate. Additionally, the testing facility official did not follow the fair shot requirement in the COPD for one plate that had a high velocity on the second shot and resulted in a complete penetration. According to fair impact criteria in the COPD, the shot would not be considered a fair hit. However, the testing facility official did not retest this plate.

The PEO Soldier scoring official determined that the contractor failed the following 13 first article tests:

Test Date: 4/07/05
Auditor Note: The contractor failed the test because there was a complete penetration on the first shot during the durability test. The testing facility official used the wrong size plate eight times during the first article test. Although the wrong size plates were used, the testing facility official did not conduct retests with the correct size plates.

Test Date: 4/12/05
Auditor Note: The contractor failed the test because there was a complete penetration on the first shot during the durability test. The testing facility official used the wrong size plate eight times during the first article test. Although the wrong size plates were used, the testing facility official did not conduct retests with the correct size plates.

Test Date: 6/1/05
Auditor Note: The contractor failed the test because there was a first shot BFD of 50 millimeters on the plate tested in ambient condition against threat D. The testing facility official used the wrong size plate once during the first article test and the official did not conduct a retest with the correct size plate.

Test Date: 6/16/05
Auditor Note: The contractor failed the test because there was a complete penetration on the first shot during the ambient condition test against threat D. The testing facility official used the wrong size plate three times during the first article test. Although the wrong size plates were used, the testing facility official did not conduct retests with the correct size plates.

Test Date: 6/16/05
Auditor Note: The contractor failed the test because there was a complete penetration on the first shot during the durability test. The testing facility official used the wrong size plates two times during the first article test. Although the wrong size plates were used, the testing facility official did not conduct retests with the correct size plates.

Test Date: 6/21/05
Number of Points: 8
Auditor Note: The contractor failed the test because it received eight points. The testing facility official used the wrong size plate three times during the first article test and the official did not conduct a retest with the correct size plates.

Test Date: 12/29/06
Auditor Note: The contractor failed the test because there was a complete penetration on the first shot during the durability test. The first article test was not complete and we cannot determine if the testing facility official used incorrect plates.

Test Date: 2/7/07
Auditor Note: The contractor failed the test because there was a complete penetration on the first shot during the durability test. This was the only test conducted and the testing facility official used the correct size plate.

Test Date: 5/31/07
Number of Points: 8.5
Auditor Note: The contractor failed the test because it received 8.5 points. The testing facility official used the wrong size plate three times during the first article test. Although the wrong size plates were used, the testing facility official did not conduct retests with the correct size plates.

Test Date: 6/27/07
Auditor Note: The contractor failed the test because there was a first shot BFD of 50 millimeters on the plate tested in the ambient condition against threat D. The testing facility official only used two plates during this test and both plates were the incorrect size. The official used the wrong size plate against threat D in ambient conditions and a catastrophic failure occurred on the first shot.

Test Date: 8/16/07
Auditor Note: The contractor failed the test because there was a complete penetration on the first shot during the durability test. The testing facility official only used one plate during the test and it was the correct size.

Test Date: 8/23/07
Number of Points: 6.5
Auditor Note: The contractor failed the test because it received 6.5 points. The testing facility official used the wrong size plate two times during the first article test. Although the wrong size plates were used, the testing facility official did not conduct retests with the correct size plates.

Test Date: 8/27/07
Auditor Note: The contractor failed the test because there was a complete penetration on the first shot during the durability test. The testing facility official only tested one plate, and it was the correct size.

Department of the Army Comments

SECRETARY OF THE ARMY
WASHINGTON

27 JAN 2009

MEMORANDUM FOR DEPARTMENT OF DEFENSE OFFICE OF THE INSPECTOR GENERAL

SUBJECT: Response to the Department of Defense Inspector General (DoD IG) Draft Report "Department of Defense (DoD) Testing Requirements for Body Armor" (Project No. D2008-D000JA-0263.000), dated: January 9, 2009

I agree with the conclusion of the Director, Operational Test and Evaluation (DOT&E), regarding the three First Article Tests at issue, and non-concur with your finding that the body armor plates failed the FAT tests, with the implication that failed plates were issued to Soldiers.

The Department of Defense's DOT&E is the government's preeminent and *independent* authority on testing of this nature. After a thorough evaluation of the DOD IG's report and the testing conducted by the Army on the armor plates, the Director, OT&E concluded:

> *The DoD Inspector General has identified significant issues with the documentation of the test process and analysis (scoring). However,* ***the three designs meet the performance specification in place at the time of each test.***

In other words, according to the DOT&E, the plates at issue *passed the tests.* Again, that is not only the conclusion of the Army, but of the *Department of Defense experts* in the highly specialized field of ballistic testing.

In order to resolve the disagreement between the Army (based on the DOT&E review) and the DoD IG, I have, pursuant to DoD Directive 7650.3, requested that the Deputy Secretary of Defense adjudicate the opposing positions.

To ensure there can be no question concerning the effectiveness of every Soldier's body armor, I have today ordered that the plates at issue be identified and collected until such time as the matter has been adjudicated by the Deputy Secretary of Defense.

I associate myself with the January 16th memo in response to the DoD IG's report by Dean Popps, the Principal Deputy Assistant Secretary of the Army for Acquisition, Logistics, and Technology. As Mr. Popps' memo explains, the Army, with DOT&E

oversight, commenced comprehensive action to fix its testing system beginning in June 2007.

In conclusion, there is no higher priority for the Army than the safety of our Soldiers. Anything that threatens the safety of our Soldiers or erodes the confidence of Soldiers or the American people in our commitment to their safety is a matter of the utmost importance to Army leadership.

Pete Geren

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY OF THE ARMY
ACQUISITION LOGISTICS AND TECHNOLOGY
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WASHINGTON DC 20310-0103

JAN 16 2009

SAAL-SMS

MEMORANDUM FOR DEPARTMENT OF DEFENSE OFFICE OF THE INSPECTOR GENERAL

SUBJECT: Response to the Department of Defense Inspector General (DoDIG) Draft Report "Department of Defense (DoD) Testing Requirements for Body Armor" (Project No. D2008-D000JA-0263.000), dated January 9, 2009

Enclosed is the Program Executive Officer (PEO) Soldier response to the DoDIG report on DoD Testing Requirements for Body Armor. PEO Soldier does not concur with the DoDIG finding that three designs failed First Article Testing (FAT) and the recommendation to identify and return plates of these designs. An experienced subject matter expert from the Office of the Secretary of Defense, Director for Operational Test and Evaluation reviewed the FAT data for the three designs in question and concluded that the designs passed FAT. This is independent verification of test success.

PEO Soldier concurs with the DoDIG recommendations to require a Government representative to be present at all FATs and to initiate a review and approval process to verify FAT results. PEO Soldier has already implemented these recommendations.

The U.S. Army follows a comprehensive and holistic test strategy that consists of FAT to authorize production, Lot Acceptance Testing to validate fielding, Surveillance Testing to validate long term performance, and both pre-combat and post-combat inspections to ensure serviceability. Recently, the U.S. Army added Non-Destructive Test Equipment (NDTE) to enhance the surveillance testing of body armor. The NDTE detects damage to fielded body armor plates. Those plates are immediately removed from inventory. Samples of all plates are shipped to the Aberdeen Test Center and submitted for ballistic testing according to the test plan developed by the U.S. Army Test and Evaluation Command. This comprehensive multi-level testing methodology ensures that the U.S. Army develops a historical body of knowledge based on accepted test protocols that continuously scrutinize the protective plates to ensure the highest standards of plate performance throughout their service life.

The U.S. Army continuously improves and adapts its test processes to ensure our Soldiers have high confidence that they have the best body armor in the world.

Dean G. Popps
Principal Deputy Assistant Secretary of the Army
(Acquisition, Logistics and Technology)

DEPARTMENT OF THE ARMY
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JAN 16 2009

SFAE-SDR

MEMORANDUM THRU ASSISTANT SECRETARY OF THE ARMY (ACQUISITION, LOGISTICS AND TECHNOLOGY)

FOR DEPARTMENT OF DEFENSE OFFICE OF THE INSPECTOR GENERAL

SUBJECT: Response to the Department of Defense Inspector General (DoD IG) Draft Report "DoD Testing Requirements for Body Armor Project No. D2008-D000JA-0263.000 Dated: January 9, 2009"

The Program Executive Office (PEO) Soldier appreciates the opportunity to comment on the DoD Draft Report on the DoD Testing Requirements for Body Armor. PEO Soldier does not agree with the DoD IG conclusion that three (3) of eight (8) first article tests (FATs) under Contract No. W91CRB-04-D-0040 that were scored as passing should have been scored as failures. These FATs correspond to ballistic insert designs M3D2S2, MH3 and MP2S2. In addition, the DoD IG found that there was insufficient test data to support a passing FAT for design M4D2. The PEO's position is that all FATs were valid and that the FATs in question were scored correctly and supported by sufficient reliable test data. PEO Soldier has provided test data to support this position and has discussed this issue with the DoD IG on several occasions. In addition, an experienced official from the Office of the Director, Operational Test and Evaluation (DOT&E) reviewed the test data and concluded that the designs successfully completed FAT.

In addition, it is important to consider the Army's holistic approach to body armor testing. The FATs discussed in the draft report are one level in a comprehensive, multi-tiered body armor test strategy. The FAT is the first level, the second level is Lot Acceptance Testing (LAT), and the third level is the continuous surveillance testing of plates returned from the field. These three tiers will be discussed in detail further in this memorandum. To gain a complete understanding of the Army's testing strategy it is important to look at the totality of the test strategy, not just one level in isolation.

The PEO has recognized that management controls need to be improved to ensure consistent testing and scoring processes. In response, many controls have been implemented. Once inconsistencies were identified, corrections and improvements to the testing procedures and processes were initiated and institutionalized. The Army continuously reviews and improves its testing processes and procedures to ensure the best products are fielded to Soldiers. The safety of our Soldiers is our top priority.

The following comments are provided in response to the Draft Report:

1. Finding A. First Article Testing for Contract No. W91CRB-04-D-0040.

a. DoD IG draft report Finding A Comment 1: First article testing for contract W91CRB-04-D-0040 was not consistently conducted or scored in accordance with contract terms, conditions, and specifications. Specifically, for the 21 first article tests conducted for contract 0040, testing facility officials did not consistently follow the test plan or COPD requirements for the fair shot determination, measurement of BFD, or plate size.

PEO Soldier Response to Finding A Comment 1 (Page 7): Concur. PEO Soldier agrees that testing facility officials did not follow the test plan or COPD requirements consistently. However, regardless of these inconsistencies, the PEO maintains that **all test results remain valid.** When deviations from the COPD occurred, the Army was consistent and substituted and applied commonly accepted industry standards or practices throughout testing. However, PEO Soldier has revised the written test plan to ensure consistency in testing.

As was discussed with the DoD IG audit team on December 10, 2008, the Army has structured its testing protocols to exceed the characteristics of any operational threat round that the plates are designed to defeat. As such, the ballistic characteristic of the APM2 surrogate round is 9% harder, 7% heavier, and fired 6% faster than the actual operational threat round that ESAPI is designed to defeat. Additionally, all test shots are also done with no deflection angles to the body armor plate. The combination of these surrogate round characteristics exceeds any operational threat round that the plates are designed to defeat and therefore provides an increased safety margin in the testing protocols.

In reference to the DoD IG comment concerning fair shot determination, PEO Soldier recognizes the critical nature of first and second shot selection on ceramic plate testing, and uses commonly accepted industry standards for fair shot scoring. PEO Soldier acknowledges that the purchase description was unclear on second shot scoring. This issue has been addressed with testing officials and manufacturers and future purchase descriptions will clearly describe second shot scoring. As previously discussed with the DoD IG on December 10, 2008, an over velocity first shot stresses the plate beyond the acceptable V_0 range by stressing the adhesive bond between the ceramic tile and backing material beyond the design limits. Therefore, limited failure points cannot be awarded to a plate subsequent to an over velocity first shot. Testing may continue on the plate if it demonstrates performance beyond the requirement. However, a plate will not be penalized for failing following an over velocity first shot. For example, during the FAT on February 20, 2007 for design M3D2S2, the first shot during the salt water subtest was 2,939 fps. This was 39 fps above the maximum allowable velocity. A second shot was taken and if the plate passed that subtest it would have been scored. However, the plate failed. Since the first shot was over velocity and the plate failed, a second plate was tested. Page 10 of the DoD IG report states that the PEO Soldier official "chose" to use the test results for the retested plates when he computed the score. The Contracting Officers Technical Representative (COTR) followed consistent test scoring practices to determine if the shot was scored. Therefore, as required, a second plate was used to determine if the plate passed. During the firing of the second plate, all shots were within velocity acceptable ranges and the plate passed the subtest. By virtue of the plate passing the subtest with zero penalty points, the overall FAT score is 5.5. Therefore, design M3D2S2 conducted on February 20, 2007 passed its FAT. Furthermore, for the November 7, 2007 FAT of the M3D2S2 design, three data sets had first shots with over velocity data. The first data set had no penalty points associated for the second shot. The other two data sets had penalty points associated for the second shots. This FAT when scored using

the penalty points on the over velocity plates still passed. The COTR made the determination that even though these two plates had been overstressed, the design passed FAT. If the plates had been replaced with plates that were fired at velocities within specifications, the results would have improved. Thus, it was not necessary to replace the plates. While this methodology is not specifically documented in the fair shot determination criteria, it is consistent with the application of fair shot criteria by Government ballistic technical experts. It is the PEO's position that a return of plates, as recommended by the DoD IG, is not required. As stated above, the Office of the DOT&E has reviewed the test data and concluded that the passing FATs are valid.

Back Face Deformation (BFD) generally increases as the mass, hardness, and velocity of the round fired at the body armor increases. Because the APM2 test round is heavier, harder, and flies faster than the actual operational threat round ESAPI was designed to defeat, the allowable BFD criteria was increased from 43 mm to 47 mm. ESAPI plates that pass testing using this BFD criterion generally perform with BFD of 26-40 mm when tested using the actual operational threat round. The purchase description requires BFD be measured using the deepest point of penetration. The offset correction technique is a common accepted industry standard used to measure BFD when the aim point of the projectile is different than the deepest point of penetration. As an example, during the December 10, 2008 meeting with the DoD IG, PEO Soldier provided the DoD IG documentation from Ceradyne Inc., a current body armor manufacturer, showing their use of the offset correction technique. This demonstrates that the use of offset correction factors is an industry standard practice. The COTR clarified the application of the offset correction technique for the personnel at the test facility to ensure that they had a thorough understanding of its application for FAT and LAT, and to ensure that this standard procedure is used for all vendors. Additionally, the report states the original measurement was not documented. The COTR only requires that the test lab documents the corrected value after the offset correction technique is used, and notes that the offset correction was used. Contrary to what is written in the draft report on the M4D2 FAT conducted on October 25, 2007, this was a valid, passing FAT. During the meeting on January 6, 2009, the DOT&E concurred that the FAT passed.

The DoD IG draft report illustrates the Army's appropriate use of the offset correction technique. Specifically, during the FAT dated June 1, 2005 and June 27, 2007, respectively, both show BFD offset correction was not used because the deepest point of penetration was not offset from the aim point. Currently, the Army in conjunction with DOT&E has incorporated the laser scanning device into the DoD test standard. The laser scanner eliminates the requirement to use the offset correction technique and is an example of the Army continually improving our testing procedures.

For FAT design MP2S2 conducted in September 2007, the test shows the wrong size plate tested and a corrected one substituted in its place. The ESAPI FAT allows for 6.0 penalty points. The MP2S2 FAT was scored by the COTR in accordance with the annotations on the data sheet and the scores reported were consistent with ESAPI scoring procedures resulting in a score of 5.0 penalty points which means this design passed FAT. The Army conducted another FAT on the MP2S2 design in November 2007. The November 2007 FAT was required due to a change in the oxidation process on the production line, not in the technical characteristics of the plate. The design passed FAT on November 9, 2007. This design successfully passed a FAT conducted by the USMC in February 2008. The MP2S2 was a qualified design, tested to Government Quality Assurance requirements that successfully passed three separate FATs over

a six month time period. There are no reported quality or performance issues for this design. For these reasons, it is the PEO's position that the plates do not need to be returned.

b. DoD IG draft report Finding A Comment 2 (Page 7): The PEO Soldier scoring official could not provide adequate documentation that explained why certain plates were selected for scoring and others were disregarded during the scoring process.

PEO Soldier Response to Finding A Comment 2: Non-Concur. PEO Soldier has provided a detailed response to this comment in its response to DoD IG Comment 1. PEO Soldier has adopted common industry standards for scoring; for example, the selection of plates for scoring is based on fair shot determination, which recognizes the performance dependencies of first and second shots on ceramic plates. An over velocity first shot stresses the plate beyond the acceptable V_0 range by stressing the adhesive bond between the ceramic tile and backing material beyond the design limits. Therefore, limited failure points cannot be awarded to a plate subsequent to an over velocity first shot. Testing may continue on the plate if it continues to demonstrate performance beyond the requirement. However, a plate will not be penalized for failing to meet the requirement following an over velocity first shot. This scoring relationship between an over velocity first shot and standard second shot has been a consistent practice in body armor testing. All available documentation in support of this contract such as test data sheets, emails, contractual documents, and documents provided by body armor vendors have been provided to the DoDIG. PEO Soldier does acknowledge that some deficiencies exist in terms of documentation of testing requirements and standard testing practices. In response, PEO Soldier has instituted a thorough review to ensure improved documentation of testing standards and practices are incorporated in current and future contracts.

c. Recommendation to Secretary of the Army: The DoD IG recommends that the Secretary of the Army direct Program Executive Soldier to identify and return the 4,151 sets of M3D2S2, 12,037 sets of MP2S2, and 225 sets of M4D2 design ballistic inserts purchased under Army contract W91CRB-04-D-0040.

PEO Soldier Response to Recommendation: Non-concur. As previously stated, with regard to M3D2S2, MP2S2, and M4D2, the successful FAT results are valid and a return is not required. On January 6, 2009 the DOT&E reviewed the FAT documentation and concluded that these designs passed FAT. Further, the Army conducts multiple levels of continuous testing throughout the production cycle of ballistic plates. The first level of testing is the rigorous FAT. The second level of testing is the Lot Acceptance Test (LAT). LATs are conducted at ambient temperature conditions with the same ballistic test procedures and shot scoring criteria as the FATs and therefore increase the statistical confidence that the plates accepted are of the highest quality and will meet the Soldiers' needs for protection. As an example, for ArmorWorks design M3D2S2, 17 separate lots were tested. The 17 ArmorWorks lots passed 15 LATs successfully and experienced 2 failures. On average each ArmorWorks lot was comprised of 534 plates. Using the Army sampling protocol from the ANSI/ASQ Z1.4 standard, the Army tested a total of 85 ArmorWorks M3D2S2 plates during LAT in addition to the 25 plates from the initial FAT. Therefore the Army live fire tested 110 plates from the M3D2S2 design. The successful

test results achieved by live fire testing of these plates in FAT and LAT provide high confidence that the plates meet the performance requirement.

The third level of testing is the continuous surveillance testing of plates. The Army has a Non-Destructive Test Equipment facility to scan plates in Theater and return plates for additional testing. For example, as of December 16, 2008, the Army has X-rayed over 55,000 plates in Theater. Plates identified by the NDTE as cracked, are labeled for additional testing, segregated, and sent to Aberdeen Test Center (ATC), Aberdeen Proving Ground, for further testing. To date, 533 plates of the 1,750 returned from Kuwait have been live fire tested based on a testing plan developed and executed by the Army Test and Evaluation Command.

The Army is testing the plates from vendors under two conditions: (1) with the most penetration capable ammunition on the most vulnerable part of the plate and using the drop test subtest criterion from the FAT; and (2) testing with the operationally prevalent threat in Theater using the same two tests as above. To date, using the ammunition beyond what Soldiers would see in Theater, the plates successfully stopped the round 212 of 278 shots (76.3%) on the crack and using the drop test protocol. Also, using the most prevalent round in Theater, the plates successfully stopped 180 of 180 shots (100%). By using the NDTE which is capable of identifying any design from any vendor, the Army can specifically monitor the ballistic performance of the designs discussed in the DoD IG report by segregating scanned plates of these designs from Army inventory and conducting live fire testing at ATC. The Army will continue live-fire testing of returned plates in an effort to determine a service life for the plates. This comprehensive multi-level testing methodology ensures the Army develops a historical body of knowledge and continuously scrutinizes the protective plates to ensure they meet the highest standards of plate performance throughout their service life.

d. Recommendations to Program Executive Officer Soldier: The DoD IG recommends that the Program Executive Officer Soldier:

(1). Require that a Government representative be present at all first article tests to verify that testing officials follow the test plan and contractual requirements.

PEO Soldier Response: Concur. PEO Soldier recognized the requirement for an on site Government representative during testing and since June 2008, there has been a requirement for Government representation at all first article and lot acceptance testing.

(2). Initiate a review and approval process to verify that the first article test results are scored with the first article test plan and contractual requirements.

PEO Soldier Response: Concur. Since October 2008, PEO Soldier put in place a three tier scoring methodology to ensure scoring accuracy. Two testers independently score a FAT and provide the results to the Chief Scientist for adjudication and final approval.

2. Finding B. First Article Testing Criteria for the Army and SOCOM.

PEO Soldier Response to Finding B: Concur. The Army and SOCOM independently developed first article test criteria for body armor ballistic inserts, based on different operational requirements. The Army will support the Director of Operational Test and Evaluation (DOT&E) in developing standardized body armor testing procedures and ensuring adequate oversight in accordance with the requirements of the Duncan Hunter National Defense Authorization Act for Fiscal Year 2009, Pub. L. 110-417, Section 251, Modification of Systems Subject to Survivability Testing Oversight by the Director of Operational Test and Evaluation. The Army has assisted the DOT&E in the performance of required oversight over the live fire, survivability, and lethality testing of critical defense systems, including personnel protective equipment such as body armor and helmets. The Army, in conjunction with DOT&E, will execute Phase II ballistic testing at ATC in January 2009. One of the purposes of Phase II testing is to provide data for possible future changes to ballistic insert first article testing. The Army will continue to work with DOT&E, the U.S. Army Test and Evaluation Command, the Special Operations Command and all services to continue to improve body armor test procedures.

Page 21 of the DoD IG draft report states that DoD issued Military Standard (MILSTD) 3027 to provide performance requirements and test protocols for developing and/or qualifying body armor to meet the ballistic threat, environmental, and durability requirements delivered. The last lot under Contract No. W91CRB-04-D-0040 was delivered in February 2008 and all testing was completed prior to the September 30, 2008, the effective date of MILSTD 3027. All testing since September 30, 2008 has been in compliance with MILSTD 3027.

The Army has a thorough and proven testing methodology as substantiated in GAO report, "GAO-07-662R", Review of Body Armor, dated April 26, 2007. The Army applies three levels of testing to ensure the body armor issued to Soldiers is safe. This comprehensive multi-level testing methodology ensures the Army develops a historical body of knowledge based on accepted test protocols that continuously scrutinize the protective plates to ensure they meet the highest standards of plate performance throughout their service life.

My point of contact is Project Manager Soldier Equipment, COL John McGuiness, e-mail: john.mcguiness@us.army.mil, (703) 704-3322.

PETER N. FULLER
Brigadier General, USA
Program Executive Officer Soldier and Commanding General, Natick Soldier Systems Center

Director, Operational Test and Evaluation

OPERATIONAL TEST AND EVALUATION

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JAN 16 2009

MEMORANDUM FOR DEPARTMENT OF DEFENSE (DoD) INSPECTOR GENERAL (IG)

SUBJECT: Director, Operational Test and Evaluation Comments to DoD IG Report: DoD Testing Requirements for Body Armor

Reference: DoD Testing Requirements for Body Armor; DoD IG Project No. D2008-D000JA-0263.000

I have reviewed the referenced report. Per your request, I am providing comments to Recommendations B.1. and B.2. Additionally, I am providing information I believe relevant and important for your consideration on Recommendations A.1. and A.2.

Recommendation A.1.: Recommendation that the Secretary of the Army direct the Program Executive Officer Soldier (PEO Soldier) to identify and facilitate the return of 4,151 sets of M3D2S2, 12,037 sets of MP2S2, and 225 sets of M4D2 design ballistic inserts purchased under Army contract number W91CRB-04-D-0040, and remove the ballistic inserts from their inventory.

DOT&E Comment: DOT&E defers to the Secretary of the Army on any decision involving return of U.S. Army personal protective equipment. Although Finding A reveals significant systemic issues in need of correction, on which we agree, we disagree with significant portions of Finding A. Upon request of senior Army leadership, DOT&E conducted a technical, independent review of the results of the First Article Tests (FAT) for designs M3D2S2, M4D2, and MP2S2. The objective of our review was to determine if the test facility followed PEO Soldier test protocols and established standards, and that the scoring official assessed the tests in accordance with PEO Soldier criteria. Below we discuss each FAT and the respective issues of fair hit criteria, back face deformation (BFD) measurement, and plate selection:

Design M3D2S2: The principal issue raised is that of fair hit criteria. Your report states that the PEO Soldier scoring official did not follow the fair hit criteria pertaining to an over velocity shot when scoring the February 20, 2007, FAT for the M3D2S2 design. Although the PEO Soldier's contract purchase description does not clearly articulate the fair hit criteria for a shot that immediately follows an over velocity shot, it is DOT&E's judgment that it is standard and common practice to declare a no test if a failing shot occurs following an otherwise fair-hit, over velocity first shot. We approved this process during the conduct of preliminary design model testing and FAT conducted at the Army Test and Evaluation Command (ATEC) during 2008, a test under DOT&E oversight. The rationale for this process is that a plate subjected to an over velocity shot experiences stresses and strains beyond what it was designed to experience, whether or not the plate initially successfully defeats the threat. A subsequent shot on

that plate that results in a failure may be the result of a generally weakened plate as a result of the first over velocity shot, and not necessarily the result solely of the second shot. DOT&E confirmed that during the M3D2S2 FAT, an over velocity first shot was followed by a second shot that resulted in the awarding of limited failure points. Per the standard test process, the test facility disregarded that plate, substituted another, and re-fired that subtest. In review of the accumulation of limited failure points, DOT&E concurs with the scoring official's result of 5.5 points. Thus, the FAT was successful. DOT&E notes that the fair hit criteria in the ESAPI purchase description does not adequately describe this process and supports the PEO Soldier's intent to review and correct deficiencies in test process and analysis documentation. The Army will shortly conduct an expanded, rigorous evaluation of the ESAPI and XSAPI plates qualified under the recent FAT testing. The test will be conducted under my office's oversight and I will approve the test plan. These test plans will clearly articulate fair shot criteria.

M4D2: The principal issue raised is back face deformation measurement. Your report indicates that PEO Soldier, in an email dated April 25, 2005, instructed testers to apply a curvature correction factor for BFD measurements when the deepest point of clay deformation was not behind the bullet's point of impact. You also note that this technique is not within PEO Soldier's contract purchase description. Your report states that for the October 25, 2007, FAT for design M4D2, the test facility did not document the uncorrected BFD measurement and that therefore you could not determine whether the test would have passed or failed if the curvature correction factor technique was not used. It is DOT&E's observation that it is a common test practice to correct for plate curvature when measuring BFD during Army plate testing. Although an approximation, this technique does increase the accuracy of BFD measurements. This process is applicable when the deepest point of clay deformation is off-axis from the impact point. When this occurs, there is a lateral offset between the impact point and the deepest deformation. Given that the plate is curved, the curvature between the lateral offset should be accounted for when making the BFD measurement. The above referenced email that PEO Soldier provided to the test facility described the process to account for the curvature. ATEC followed this same process during preliminary design model testing that was conducted under DOT&E oversight. That process utilizes a nominal correction factor for all plates of 1 mm of correction for every 4 mm of lateral offset (this is based upon the nominal radii of ESAPI plates). DOT&E reviewed the M4D2 FAT and observes that the test facility reported only the corrected BFD measurement for one shot as cited in your report. The corrected value for the referenced shot is 41.6 mm. In order for this plate to reach a catastrophic failure the BFD must be 48 mm, and, therefore, a correction factor of 6.4 mm would be required. Following review of that particular shot and given the necessary lateral offset to reach a correction factor of 6.4 mm, DOT&E concludes that even if the correction factor were not used for this shot, the result would not cause this FAT to fail. Current and future testing overseen by DOT&E will utilize a laser scanning technology to measure BFD in accordance with MIL-STD 3027. This technology is significantly more accurate and alleviates the need for a manual measurement and the need for application of a curvature correction factor.

MP2S2: The principal issue raised is that of plate size test requirements. Your report indicates the PEO Soldier scoring official should have scored a plate that was disregarded during scoring of the MP2S2 FAT. DOT&E reviewed the MP2S2 FAT and

confirmed that a substitute correct-sized plate was tested and scored. DOT&E therefore concludes that the test facility followed the correct procedure, the scoring official correctly scored this FAT, and the design passed. As you did not cite the other 17 referenced FATs for action, DOT&E did not review those tests and provides no comment on them. DOT&E confirms that although formal documentation is lacking, it is PEO's process to strictly follow plate size test requirements as stated in their FAT protocol. DOT&E ensured that ATEC followed this process during conduct of the preliminary design model testing conducted in 2008. Additionally, ATEC has redundant procedures in place (multiple individuals observing test preparations and the use of checklists) to mitigate the risk of an incorrect sized plate being tested. PEO Soldier intends to conduct all future FATs at ATEC and their procedures will prevent a recurrence of these issues. As noted previously, the Army will conduct additional testing in 2009. Test plans for that effort will ensure that procedures are developed to address the issue that an incorrect plate size is tested.

Recommendation A.2.: Recommendation that PEO Soldier a) requires that a government representative be present at all first article tests to verify that the testing officials follow the test plan and contract requirements; and, b) initiates a review and approval process to verify that the FAT results are scored in accordance with the FAT plan and contract requirements.

DOT&E Comment: DOT&E supports PEO Soldier's intent to correct any deficiencies in test process and analysis documentation. DOT&E also supports PEO Soldier's intent to sponsor testing at government facilities with independent government oversight (ATEC, DOT&E, for example) when possible, and when not possible, to utilize independent government personnel (ATEC for example) to oversee such testing. It is DOT&E's judgment that conducting FATs at a government facility, under government oversight, and with adequate test process and analysis documentation, significantly reduces the risk of the issues discussed above (fair hit, BFD measurement, and plate size) reoccurring. DOT&E also supports PEO Soldier's intent to make the FAT testing and analysis process as transparent as practicable, to include permitting vendors to witness testing of their material.

The DoD Inspector General has identified significant systemic issues with the documentation of the test process and analysis (scoring). However, the three designs meet the performance specification in place at the time of each test.

Recommendation B: Recommendation that DOT&E develop a test operations procedure for body armor ballistic inserts. During development of the test operations procedure, DOT&E: 1) involve the Services and the Special Operations Command to verify the test operating procedure is implemented DoD-wide; and, 2) include, at a minimum, requirements for sample size, shot pattern, types of testing, and acceptance criteria to verify the rigor of testing. Specifically, the Director should use quantitative methods to develop a testing sample size that limits the number of possible failures.

DOT&E Comment: Concur. DOT&E continues to oversee, per congressional direction, ongoing Army body armor testing and analysis. Subject matter experts from DOT&E,

ATEC, PEO Soldier, and the Army Research Laboratory are working together to develop test protocols that ATEC will use during an upcoming test to address specific issues regarding sample size, plate size, and confidence levels (2-4QFY09). That test, which includes continuous review by an integrated product team of people representing multiple agencies, will shape a future test operating procedure that DOT&E will promulgate across the Department (2/3QFY10). It is DOT&E's goal to develop a FAT-like protocol that requires a 90 percent lower confidence limit on a reliability of 90 percent that the material under test passes the requirement (a "90/90"). DOT&E will also work with the Services to investigate the appropriate test scope for lot acceptance tests, recognizing that lot acceptance tests will by necessity be less rigorous than the FAT protocol. The parallel approach of expanded testing coupled with a comprehensive review of current practices will address all of the systemic issues identified by the IG and will result in documented standardized test protocols for use across the DoD.

DOT&E will also encourage the Services to engage with their combat developers to produce valid combat requirements in accordance with the Department's CJCSM 3170.01 (the Joint Capabilities Integration Development System).

Editorial Recommendation: Page 22, 5th paragraph, second sentence: Change to read: "…because there is no Department standard used by all the Services for body armor …".

Rationale: There exist several test standards within the Department for body armor testing (MIL-STD-662, MIL-STD 3027, etc). The issue is that there is not a single testing standard and that existing standards are not required to be followed.

I appreciate the opportunity to review and provide comment on your draft report. I will continue to make my staff available to you as your office prepares its final report.

Charles E. McQueary
Director

U.S. Special Operations Command Comments

Final Report Reference

UNITED STATES SPECIAL OPERATIONS COMMAND
7701 TAMPA POINT BLVD.
MACDILL AIR FORCE BASE, FLORIDA 33621-5323

SOAL-SW JAN 16 2009

MEMORANDUM FOR INSPECTOR GENERAL, DEPARTMENT OF DEFENSE, 400 ARMY NAVY DRIVE, ARLINGTON, VIRGINIA 22202-4704

SUBJECT: Department of Defense Testing Requirements for Body Armor (Project No. D2008-D000JA- 263.000)

1. REFERENCE: Draft Report, Subject as above.

The following comments relate to the reference document. Each proposed change is identified by line and page and followed by a summary of rationale supporting the change. In all cases the change is underlined.

a. Throughout the document, the abbreviation USSOCOM should be used for the U. S. Special Operations Command instead of "SOCOM." — Revised

Rationale: Accuracy.

b. The phrase "…standard level of protection" occurs twice on page i, once in the third paragraph on p. 20, and once in the third paragraph on p. 21. In each instance, change to read, "…required minimum level of protection."

Rationale: Testing normally evaluates an item for its ability to meet an established threshold. The item being tested need only meet or exceed the required minimum. The level of performance for Special Operations Forces Equipment Advanced Requirements (SPEAR) body armor is based on an established performance specification that cannot be waivered and that may exceed a future Department of Defense (DoD) standard. Describing the threshold as a "required minimum" rather than "standard" will allow the United States Special Operations Command (USSOCOM) to pursue the level of performance established for SPEAR body armor.

c. p. 3, line 7: change to read, "…within the parameters established in the Contract Purchase Description (COPD) or performance specification." — Revised

Rationale: The COPD applies only to U.S. Army and USMC contracts. USSOCOM relies on performance specifications to support contracting.

SUBJECT: Department of Defense Testing Requirements for Body Armor (Project No. D2008-D000JA- 263.000)

d. p. 22, first paragraph, last line: change to read, "…members are given the required level of body armor protection."

Rationale: As stated in b. above.

e. p. 22, third paragraph, first line: change to read, "To establish a minimum level of protection throughout DoD, DoD needs to verify that the…"

Rationale: As stated in b. above.

f. p.27, second paragraph, first sentence: change to read, "The objective was to quantify the statistical differences between the Army first article testing plan and the USSOCOM first article testing plan for body armor plates with respect to sample size."

Revised, Page 37

Rationale: The action described was a comparison of two plans rather than actual testing by each organization.

2. My point of contact for this action is Mr. James Pettigrew, Assistant Program Executive Officer for Individual Equipment, 813-826-9436, DSN 299

(FOR)

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