Audit Report

OFFICE OF THE INSPECTOR GENERAL

CONTRACT QUALITY ASSURANCE AND PRICING PRACTICES FOR PATRIOT MISSILE PROCUREMENTS

Report No. 95-252 June 26, 1995

Department of Defense

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Acronyms

MICOM	Missile Command
DPRO	Defense Plant Representative Office

INSPECTOR GENERAL
DEPARTMENT OF DEFENSE
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ARLINGTON, VIRGINIA 22202-2884

Report No. 95-252

June 26, 1995

MEMORANDUM FOR DIRECTOR, DEFENSE CONTRACT AUDIT AGENCY
DIRECTOR, DEFENSE LOGISTICS AGENCY
AUDITOR GENERAL, DEPARTMENT OF THE ARMY

SUBJECT: Audit of Contract Quality Assurance and Pricing Practices for Patriot Missile Procurements (Project No. 4CF-8020)

Introduction

We are providing this report for your information and use. The audit was conducted in response to allegations to the Defense Hotline concerning improper quality assurance and pricing practices relating to the manufacture of the Patriot Missile System (Patriot).

The complainant alleged that in manufacturing Patriots, the Raytheon Company, Andover, Massachusetts (Raytheon):

- did not completely solder electrical connections to the top side of multilayer printed circuit boards as required by contract No. DAAH01-87-C-A025;

- did not perform quality assurance inspections to ensure that the topside soldering was complete and should reimburse the Government for the cost of those inspections; and

- was paid more than $800,000 for completely soldering similar connections to the top side of multilayer printed circuit boards on follow-on contract No. DAAH01-92-C-0251. Further, the payment amount was overstated because it was based on more missiles than were required by the contract.

Audit Results

The allegations were partially substantiated. Raytheon:

- did not completely solder the electrical connections according to contract requirements. However, the Army Missile Command (MICOM), Redstone Arsenal, Alabama, waived those requirements.

- did not perform inspections to ensure that soldering met requirements. Raytheon believed that the waiver of soldering requirements obviated inspection requirements. The allegation concerning inspection costs billed to the Government could not be substantiated.

• was not paid more than $800,000 for complete soldering of electrical connections to the top side of circuit boards. However, Raytheon was paid about $813,000 to **inspect** for the presence of topside solder on follow-on contract No. DAAH01-92-C-0251. Further, Raytheon was overpaid $198,000 for the inspection. The overpayment occurred because of incorrect bases for calculating the payment.

MICOM and Raytheon promptly corrected the overpayment by reducing the price of contract No. DAAH01-92-C-0251 by $198,000. Those actions are commendable, and DoD funds totaling about $198,000 were put to better use during FY 1995 as a result of the audit.

Audit Objectives

The audit objectives were to evaluate DoD and Raytheon quality assurance and pricing practices for Patriot missile circuit boards. We also evaluated the management control program as it applied to the audit objectives.

Scope and Methodology

We reviewed MICOM and Raytheon documents on quality assurance inspections and pricing for contract Nos. DAAH01-87-C-A025 and DAAH01-92-C-0251 from July 1986 through December 1994. We also reviewed Defense Plant Representative Office (DPRO)-Raytheon records relating to the administration of those contracts. We interviewed cognizant DPRO, MICOM, and Raytheon officials. We did not use computer-processed data or statistical sampling procedures to perform the audit.

The Audit Planning and Technical Support Directorate, Technical Assessment Division, Office of the Assistant Inspector General for Auditing, DoD, assisted on the technical aspects of the allegations. The Office of the Deputy General Counsel (Inspector General), DoD, assisted on legal issues for contract No. DAAH01-87-C-A025.

This economy and efficiency audit was made from August 1994 through April 1995. The audit was made in accordance with auditing standards issued by the Comptroller General of the United States as implemented by the Inspector General, DoD. We included tests of management controls considered necessary. Enclosure 1 lists the organizations visited or contacted.

Management Control Program

Because of the nature and scope of the audit, we limited the evaluation of management controls to the controls over quality assurance and procurement functions that impacted contract Nos. DAAH01-87-C-A025 and DAAH01-92-C-0251. Those management controls were deemed to be effective in that the

audit disclosed no material weaknesses as defined by DoD Directive 5010.38, "Internal Management Control Program," April 14, 1987. We found no evidence that quality assurance and procurement officials circumvented management controls. Therefore, we had no reason to assess the self-evaluation aspect of the management control program.

Prior Audits and Other Reviews

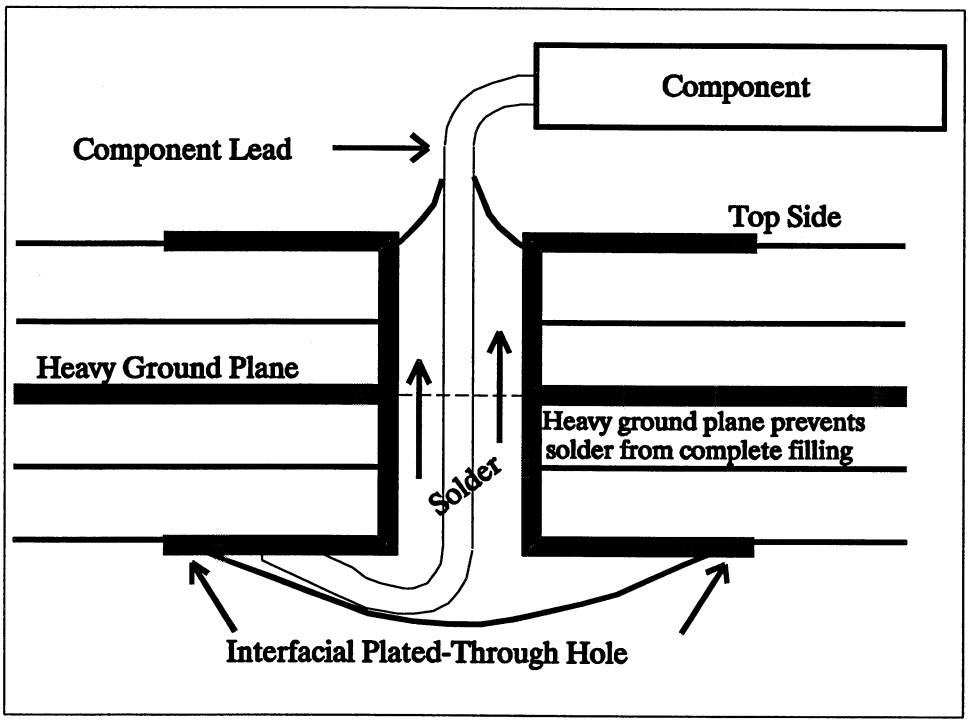
No prior audits or other reviews during the past 5 years related to issues discussed in this report.

Background

The Patriot is a mobile air defense system that employs electronic radar scanning for target detection and tracking. Raytheon began manufacturing the Patriot in 1980. Since that time, Raytheon sold 6,918 Patriots and 111 related ground units to the DoD.

Contracts for Patriots. In March 1987, Raytheon began manufacturing Patriots on contract No. DAAH01-87-C-A025, totaling about $3.6 billion, and is currently manufacturing Patriots on contract No. DAAH01-92-C-0251, totaling about $1.1 billion.

Multilayer Circuit Boards. Patriot guidance systems contained 39 multilayer circuit boards and the related ground units contained 1,760 similar boards. Those multilayer circuit boards were formed by compressing from 2 to 16 single-layer circuit boards into one unit. They were further formed by connecting the interfacial plated through-holes of a single-layer circuit board to through-holes of the other single-layer circuit boards in the multilayer unit. As depicted on page 4 of this report, electronic components are inserted in the plated through-holes and connected by osmotically flowing the solder from the bottom toward the top of the multilayer circuit boards.



Cross Section View of Upward Solder Flow Through a Multilayer Circuit Board

Discussion

Inspection Requirements. During April 1993, a DPRO Quality Assurance Specialist questioned Raytheon's practices related to soldering electrical connections to the topside of multilayer circuit boards for the Patriot. As a result of that inquiry, DPRO, MICOM, and Raytheon officials differed on requirements for topside soldering and related inspections in contract No. DAAH01-87-C-A025.

MICOM and Raytheon officials resolved the issue by agreeing that Raytheon would inspect for the presence of visible rather than for complete solder when viewed from the topside of multilayer circuit boards. Raytheon agreed to the inspection for the remaining term of the contract at no cost to the Government but indicated that a cost impact would be on the follow-on contract.

Contract Waiver. To avoid delays in delivering the Patriots, MICOM issued a waiver to contract No. DAAH01-87-C-A025 to relieve Raytheon from the requirement for completely soldering electrical components to the topside of the multilayer circuit boards. That waiver resulted in further differences of opinion among MICOM and Raytheon officials. MICOM stated that the waiver did not relieve Raytheon of inspection requirements and that inspections should be for the presence of topside solder. Raytheon believed that the waiver also

relieved it from the requirement to perform the related inspection. Allegations resulting from those differences were referred to the Defense Hotline. The allegations were partially substantiated.

Allegation 1. Raytheon did not completely solder electrical connections to the top side of multilayer printed circuit boards as required by contract No. DAAH01-87-C-A025.

Audit Results. The allegation was substantiated. Raytheon did not completely solder the electrical connections to the top side of those circuit boards according to contract requirements. However, no adverse impact was determined. When MICOM determined that the contract requirements were not met, it issued a contract waiver relieving Raytheon from that requirement to avoid delays in the delivery of the Patriots.

Allegation 2. Raytheon did not perform quality assurance inspections to ensure that the topside soldering was complete and should reimburse the Government for the cost of those inspections.

Audit Results. The allegation was partially substantiated. Raytheon did not perform the required inspection. However, the audit did not substantiate the allegation that Raytheon should reimburse the Government for inspection costs.

Inspections, Quality, and Reliability. MICOM issued a contract waiver that canceled the requirement for achieving topside solder. That waiver made the related inspection requirement uncertain. We found no evidence that quality or reliability problems occurred because of the lack of the inspections. The multilayer circuit boards were routinely subjected to environmental, shock, vibration, and final acceptance tests before Government acceptance. No faults were found during those tests that could be attributed to the lack of complete topside solder.

Patriots were randomly selected from deployed units and returned for testing and replacement of limited life parts and parts that failed. From November 1989 through October 1994, 1,528 Patriots were tested. No faults were detected in the topside solder of multilayer circuit boards.

We selected 42 Patriot multilayer boards and requested that Raytheon identify the number of failures during the past 5 years for each board. Raytheon attributed four failures to a solder fault, but none were attributed to topside solder. The contractually required mean time before failure for Patriot ground units was 42 hours. The actual mean time before failure for ground units procured on Buy 12 of contract No. DAAH01-87-C-A025 was 190 hours.

Inspection Payments. Raytheon claimed that it had never received payments for inspections of topside solder. Historically, bids for inspections were based on the number of hours incurred for inspections on prior contracts. Because topside solder inspections were not made on the prior contracts, such inspections were not in the bid for contract No. DAAH01-87-C-A025.

Raytheon's cost accounting system did not collect costs or labor hours at a level of detail so that inspections for topside solder could be differentiated from other quality assurance inspections of the circuit boards. Further, Raytheon's inspection documentation did not provide sufficient details for such determination.

Allegation 3. Raytheon was paid more than $800,000 for completely soldering electrical connections to the top side of multilayer printed circuit boards for follow-on contract No. DAAH01-92-C-0251. Further, the payment amount was overstated because it was based on more missiles than were required by the contract.

Audit Results. The allegation was partially substantiated. Raytheon was not paid more than $800,000 for such soldering tasks on that contract. However, Raytheon was paid about $813,000, excluding cost of money and profit, to **inspect** for the presence of topside solder. That amount included a $198,000 overpayment. The overpayment was based on faulty bases for cost calculations. The calculations reflected 1,151 Patriots, rather than the 1,020 Patriots required by the contract. Also, the data base used to calculate the opportunities for inspection was incorrect. Further, the calculations did not recognize that inspection of some topside solder connections was impossible because the connections were completely covered by electrical components.

MICOM and Raytheon took prompt actions to reduce the cost of contract No. DAAH01-92-C-0251 by $198,000. Those actions are commendable, and DoD funds totaling about $198,000 were put to better use during FY 1995 as a result of the audit.

We referred information on the pricing of contract No. DAAH01-92-C-0251 to the Defense Contract Audit Agency, Raytheon Resident Office, on February 7, 1995. That information is for inclusion in its current defective pricing review of the Buy 13 proposal for that contract.

Management Comments

We provided a draft of this report to you on May 12, 1995. Because the report contains no findings or recommendations, no comments were required, and none were received. Therefore, we are publishing this memorandum report in final form.

We appreciate the cooperation and courtesies extended to the audit staff. If you have questions about this audit, please contact Mr. Joseph P. Doyle, Audit Program Director, at (703) 604-9348 (DSN 664-9348), or Mr. Charles M. Hanshaw, Audit Project Manager, at (703) 604-9294 (DSN 664-9294). The planned distribution of this report is listed in Enclosure 2. Audit team members are listed inside the back cover.

Robert J. Lieberman
Assistant Inspector General
for Auditing

Enclosures

Organizations Visited or Contacted

Department of the Army

Army Materiel Command, Alexandria, VA
  Army Missile Command, Redstone Arsenal, AL
Army Patriot Project Office, Huntsville, AL

Defense Organizations

Defense Contract Audit Agency, Alexandria, VA
  Raytheon Resident Office, Andover, MA
Defense Logistics Agency, Alexandria, VA
  Defense Contract Management Command, Alexandria, VA
    Defense Contract Management District-Northeast, Boston, MA
      Defense Plant Representative Office Raytheon, Andover, MA
      Defense Plant Representative Office Raytheon, Burlington, MA

Non-Government Organizations

Raytheon Company, Andover, MA
Raytheon Company, Burlington, MA

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Senate Subcommittee on Defense, Committee on Appropriations
Senate Committee on Armed Services
Senate Committee on Governmental Affairs
House Committee on Appropriations
House Subcommittee on Defense, Committee on Appropriations
House Committee on Government Reform and Oversight
House Subcommittee on National Security, International Affairs, and Criminal Justice, Committee on Government Reform and Oversight
House Committee on National Security

Audit Team Members

This report was prepared by the Contract Management Directorate, Office of the Assistant Inspector General for Auditing, DoD.

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