IG-00-011

AUDIT REPORT

SPARE PARTS QUALITY ASSURANCE FOR THE SPACE SHUTTLE

March 8, 2000

National Aeronautics and
Space Administration

OFFICE OF INSPECTOR GENERAL

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Acronyms

BAR	Broad Area Review
DCMC	Defense Contract Management Command
FAR	Federal Acquisition Regulation
NSTS	National Space Transportation System
OMB	Office of Management and Budget
SFOC	Space Flight Operations Contract
SMA	Safety and Mission Assurance
SSP	Space Shuttle Program
USA	United Space Alliance
USBI	United States Booster, Inc.

W March 8, 2000

TO: A/Administrator

FROM: W/Inspector General

SUBJECT: INFORMATION: Spare Parts Quality Assurance
for the Space Shuttle
Report Number IG-00-011

The NASA Office of Inspector General has completed an audit of Spare Parts Quality Assurance for the Space Shuttle. We found that quality assurance processes for the orbiter vehicles were effective but not always efficient and that the United Space Alliance appropriately considered quality assurance requirements in the selection of orbiter vehicle flight hardware suppliers. However, the Space Shuttle Program (SSP) Manager has not updated or streamlined criteria for eliminating unnecessary inspection points at spare parts suppliers and has not consolidated quality assurance requirements using a program-level approach. As a result, at some locations, NASA has redundant Government quality assurance resources that could be used more efficiently to perform other quality assurance functions.

Background

The Office of Management and Budget directs Federal agencies to develop and use quality assurance surveillance plans in contract administration. The Federal Acquisition Regulation, Part 46, "Quality Assurance," requires that NASA perform Government quality assurance functions for all Space Shuttle flight hardware to ensure compliance with contract requirements. Government agency and program downsizing have required agencies to focus greater attention on total program costs, including delegated functions, and to establish more effective and efficient methods for assuring product quality. The SSP Manager is responsible for quality assurance of the SSP and relies on NASA quality assurance personnel and the Defense Contract Management Command (DCMC) to perform this function.

Recommendations

NASA management should establish policies and procedures to improve the efficiency of quality assurance at the supplier level. In particular, management should establish inspection point criteria at the supplier level consistent with streamlined criteria established for Shuttle processing and vehicle manufacturing. Also, management should ensure efficient quality assurance processes at supplier sites by consolidating use of Government quality personnel including DCMC personnel for the SSP.

Management Response and OIG Evaluation

Management concurred with our conclusion that Government quality assurance resources and processes are effective. However, management stated that it would perform assessments based on the Institute of Defense Analyses November 1999 report on Space Launch Vehicles Broad Area Review (BAR)[*] and on the John F. Kennedy Space Center processing criteria to determine whether a change in flight hardware supplier criteria is advisable. The SSP will also assess opportunities for utilization of quality assurance personnel using a program-level approach based on existing multiple contracts, multiple space flight centers, and increased hardware development activities in support of shuttle upgrades. These assessments will be completed by October 2000.

We believe that NASA's assessment of the BAR Report may be warranted to determine which criteria to establish for flight hardware suppliers. However, performing an assessment to determine whether criteria should be changed is not possible since the SSP does not currently have standardized written criteria for flight hardware suppliers. Similar to our recommended action, the BAR Report also recommended formalizing systems engineering and quality policies, practices, and procedures. Further, waiting until October 2000 to determine whether to establish criteria only prolongs the risk to safety and does not ensure that corrective action will be taken. NASA should commit to establishing the criteria now and provide a date for completing that action.

The SSP has multiple contracts, space flight centers, and common suppliers; therefore, we believe that a program-level approach to quality assurance is cost beneficial and warranted. We believe the SSP can consolidate quality assurance resources without reducing the level of surveillance at supplier sites. We, therefore, consider management's proposed corrective actions to be not fully

[*]In May 1999, the Chief of Staff of the Air Force directed that a team be established to examine recent expendable launch vehicle failures and provide a report that identifies causes of the failures and recommendations for changes in practices, procedures, and operations to prevent future failures. Members of the team included senior active or retired Government officials with a wide range of expertise in space launch planning and operations representing national security, civil, and commercial sectors of the space community. The BAR Report was issued in November 1999.

responsive because performing assessments does not ensure that the SSP will establish criteria or use a program-level approach to consolidate quality assurance resources. We have requested that management provide additional comments.

We consider the two recommendations unresolved and open for reporting purposes.

[original signed by]
Roberta L. Gross

Enclosure
Final Report on Audit of Spare Parts Quality Assurance
for the Space Shuttle

FINAL REPORT
AUDIT OF SPARE PARTS QUALITY ASSURANCE FOR THE SPACE SHUTTLE

W March 8, 2000

TO: M/Associate Administrator for Space Flight
AA/Director, Lyndon B. Johnson Space Center

FROM: W/Assistant Inspector General for Auditing

SUBJECT: Final Report on the Audit of Spare Parts Quality Assurance for the Space Shuttle
Assignment Number A9900700
Report Number IG-00-011

The subject final report is provided for your use and comments. Please refer to the Executive Summary for the overall audit results. Our evaluation of your response is incorporated into the body of the report. We consider management's proposed, corrective actions nonresponsive. We request that management provide additional comments by April 7, 2000. The recommendations will remain open for reporting purposes.

If you have questions concerning the report, please contact Mr. Dennis E. Coldren, Program Director, Human Exploration and Development of Space Audits, at (281) 483-4773, or Ms. Sandra A. Massey, Auditor-in-Charge, at (321) 867-4057. We appreciate the courtesies extended to the audit staff. The final report distribution is in Appendix E.

[original signed by]
Russell A. Rau

Enclosure

cc:
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G/General Counsel
Q/Associate Administrator for Safety and Mission Assurance
JM/Director, Management Assessment Division
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NASA Office of Inspector General

IG-00-011 **March 8, 2000**
A9900700

Spare Parts Quality Assurance for the Space Shuttle

Executive Summary

Background. The Space Shuttle Program (SSP) Manager, located at the Lyndon B. Johnson Space Center (Johnson), is responsible for quality assurance of the Space Shuttle Program. The Shuttle is composed of five elements: orbiter vehicles, main engines, solid rocket boosters and motors, and external tanks. NASA has awarded contracts for each of the five Shuttle elements. For example, on September 26, 1996, NASA entered into the Space Flight Operations Contract (SFOC) with the United Space Alliance (USA)[1] for Shuttle operations including acquiring, building, and repairing spare parts for the orbiter vehicle. Johnson administers the SFOC, however, USA's procurement and logistics responsibilities are carried out primarily by personnel at the John F. Kennedy Space Center (Kennedy) or the NASA Shuttle Logistics Depot at Cape Canaveral, Florida. USA maintains about 200,000 spare parts for the orbiter fleet at the Depot. From October 1998 through June 1999, NASA paid USA about $36 million for procured or built spare parts and $48 million for repaired spare parts.

The Office of Management and Budget (OMB) directs Federal agencies to develop and use quality assurance surveillance plans in contract administration. The Federal Acquisition Regulation (FAR), Part 46, "Quality Assurance," requires that NASA perform Government quality assurance functions for all Space Shuttle flight hardware to ensure compliance with contract requirements. The SSP Manager relies on NASA quality assurance personnel and the Defense Contract Management Command (DCMC)[2] to perform this function.

Objectives. Our overall objective was to determine whether the quality assurance processes for Space Shuttle spare parts were effective and efficient. Specifically, we determined whether NASA had:

- utilized quality assurance information in the acquisition of spare parts,
- established and implemented adequate policies for quality assurance of spare parts, and

[1]USA, headquartered in Houston, Texas, is a Boeing/Lockheed Martin joint venture formed to conduct space flight operations for NASA.

[2]NASA relies on DCMC, a division of the Defense Logistics Agency, Department of Defense, to provide Government contract administration services.

- ensured effective performance of acceptance testing.

We limited our review of the Space Shuttle to orbiter vehicle spare parts due to the complexity and size of the five Space Shuttle elements. We will address whether NASA has taken appropriate actions with regard to quality deficiencies under a separate audit.

Details on the objectives, scope, and methodology for this audit are in Appendix A.

Results of Audit. Quality assurance processes for the orbiter vehicles were effective but not always efficient. USA appropriately considered quality assurance requirements in the selection of orbiter vehicle flight hardware suppliers. In keeping with Government downsizing and the advent of the performance-based[3] SFOC, the SSP Manager and NASA safety and mission assurance officials reduced Government Mandatory Inspection Points (inspection points)[4] for Shuttle processing and vehicle manufacturing and took significant steps to ensure the safety of Shuttle operations. (Appendix B provides details on those steps.) However, the SSP Manager has not updated or streamlined criteria for eliminating unnecessary inspection points at spare parts suppliers and has not consolidated quality assurance requirements using a program-level approach. As a result, NASA has redundant Government quality assurance resources at some locations that could be used more efficiently to perform other quality assurance functions.

Recommendations. NASA management should establish policies and procedures to improve the efficiency of quality assurance at the supplier level. In particular, management should:

- Establish inspection point criteria at the supplier level consistent with streamlined criteria established for Shuttle processing and vehicle manufacturing to ensure efficient quality assurance processes at supplier sites.

- Consolidate use of Government quality personnel for the Space Shuttle Program.

Management's Response. Management concurred with the finding that Government quality assurance resources were effective. However, the SSP plans to assess the Broad Area Review (BAR)[5] findings and the applicability of the Kennedy processing criteria by October 2000 to determine whether a change in Government surveillance is advisable at this time. Further, by

[3]Performance-based contracting means structuring all aspects of an acquisition around the purpose of the work to be performed as opposed to either the manner by which the work is to be performed or broad and imprecise statements of work.

[4]An inspection point is the point at which a Government representative has required an inspection to ensure that products and services meet quality and contract specification as required by FAR, Part 46, Quality Assurance.

[5]In May 1999, the Chief of Staff of the Air Force directed that a team be established to examine recent expendable launch vehicle failures and provide a report that identifies causes of the failures and recommendations for changes in practices, procedures, and operations to prevent future failures. Members of the team included senior active or retired Government officials with a wide range of expertise in space launch planning and operations representing national security, civil, and commercial sectors of the space community. The BAR Report was issued in November 1999.

October 2000, the SSP plans to review the utilization of quality assurance personnel on a program-level approach based on multiple contracts and space flight centers. The complete text of the response is in Appendix D.

Evaluation of Response. Management's planned actions are nonresponsive to the recommendations. Specifically, management did not state whether it concurred with the recommendations or indicate whether the recommended, corrective actions would be taken. We agree that an assessment of the BAR findings may be warranted to determine which criteria are appropriate. However, management should establish formal, written criteria for flight hardware suppliers regardless of whether Government surveillance is changed. Further, because the SSP has multiple contracts and space flight centers, we maintain that a consolidation of Government quality assurance resources is cost beneficial and warranted. Therefore, we request that management further review its position on these matters and provide additional comments.

Introduction

Government agency and program downsizing have required agencies to focus greater attention on total program costs, including delegated functions, and to establish more effective and efficient methods for assuring product quality. In fiscal year 1997, NASA advocated performance-based contracting as one method to promote quality performance. This contracting method gives greater incentives to contractors to deliver quality products and services, allowing the procuring agency to be more selective about how it applies its resources to oversee supplier activities.

The SFOC, a performance-based contract, requires that USA develop and implement a plan to ensure that all safety and mission assurance functions, such as safety, reliability, maintainability, and quality effectively mitigate risk for the SSP. SSP management elected to transition responsibility for supplier quality to USA, while performing Government contract quality assurance through surveillance.

Four space flight Centers perform Government quality assurance for the SSP: Johnson, Kennedy, George C. Marshall Space Flight Center (Marshall), and John C. Stennis Space Center (Stennis). Johnson officials are responsible for Government quality assurance functions for orbiter modifications and upgrades, which Boeing North America performs for USA. Kennedy officials carry out Government quality assurance functions for orbiter flight hardware, which USA procures. Marshall officials implement the Government quality assurance functions for all Shuttle propulsion systems; that is, the Space Shuttle main engines, solid rocket motors and boosters, and external tank. Stennis supports the Marshall project office by performing Government quality assurance testing activities for the Space Shuttle main engines.

NASA's contracting officers may delegate contract administration or specialized support services either through interagency agreements or by direct request to the DCMC pursuant to the FAR, Part 42.2, Contract Administration Services. NASA issues to the DCMC a Letter of Delegation that delineates responsibilities to ensure contractor compliance with contractual quality assurance requirements as defined in FAR, Part 46, Quality Assurance. The DCMC supports the SSP and augments NASA quality assurance resources by performing quality assurance services at flight hardware supplier sites.

Finding and Recommendations

Efficiency of Quality Assurance at Supplier Sites

NASA did not provide efficient Government quality assurance for flight hardware suppliers. Specifically, the SSP Manager did not streamline quality assurance criteria for inspection points at supplier sites consistent with the streamlined criteria for Shuttle processing and vehicle manufacturing. In addition, the SSP Manager used redundant quality assurance resources at some supplier sites. These conditions existed because SSP management relied on outdated quality assurance criteria. Also, the SSP Manager relied on the space flight Centers to perform Government quality assurance at the supplier sites rather than taking a consolidated program-level approach. As a result, NASA has inefficiently used Agency quality assurance personnel and has incurred increased DCMC costs.

Government Quality Assurance Through Surveillance

On March 15, 1991, the OMB issued the Memorandum for Agency Senior Procurement Executives, Subject: "Government-wide Guidance on Contract Administration," to advise Federal agencies of the need for both procurement and program officials to place greater emphasis on contract management and administration. The memorandum states that contract management and administration includes ensuring that the contractor fulfill its contractual obligations and that the cognizant agency meet its responsibilities under the contract and manage its programs in a manner that does not inhibit contractor performance.

OMB's memorandum directs that Federal agencies place greater emphasis on the development and use of a quality assurance surveillance plan (surveillance plan) when the contract requires administration by Government personnel:

> A well-developed surveillance plan provides a systematic method to evaluate services the contractor is required to furnish rather than the details of how the contractor accomplishes the work. A surveillance plan is based on the premise that the contractor, and not the government, is responsible for the management and quality control actions necessary to meet the terms of the contract. Effective use of the surveillance plan is essential.

FAR, Part 46, "Quality Assurance," states that "government contract quality assurance shall be performed at such times (including any stage of manufacture or performance of services) and places (including subcontractors' plants) as may be necessary to determine that the supplies or services conform to contract requirements."

Streamlining Government Quality Assurance at Supplier Sites

The SSP Manager has not established inspection criteria at supplier sites to focus more on quality assurance through surveillance[6] to be consistent with the criteria recently updated for Shuttle processing and vehicle manufacturing (see Appendix B).[7] The SSP Manager planned to review and streamline inspection criteria at supplier sites but has not scheduled such a review in the near term. In the interim, Kennedy quality assurance representatives have not established streamlined inspection points for orbiter vehicle flight hardware in a manner consistent with Shuttle processing and vehicle manufacturing.

Kennedy's Supplier Quality Division performs Government quality assurance functions for orbiter flight hardware. Twelve quality assurance representatives are assigned to various orbiter flight hardware suppliers across the United States. The quality assurance representatives informed us that as of June 1999, they performed 1,251[8] inspection points at 94 USA orbiter flight hardware suppliers (prime and subcontractor suppliers). The representatives also reported to us that they issued 64 delegations for quality assurance services to DCMC because travel requirements made it infeasible for Kennedy representatives to perform the necessary inspections.

Kennedy quality assurance representatives have reduced inspection points for spare parts by focusing primarily on criticality-1 hardware[9] and any functional component thereof. However, quality assurance representatives may also use their discretion in establishing inspection points for hardware at supplier sites. For example, representatives may require inspection points during in-process manufacturing or acceptance testing or simply at final inspection without determining whether the inspection point is the last test of a critical system or the last assembly task in the manufacturing process. Two of the Kennedy quality assurance representatives we visited had reduced inspection points using their discretion only. At one site, the Kennedy representative reduced inspection points from 350 to 7, maintaining only those mandated by the design contractor. At a second site, the representative eliminated 10 inspection points because (1) the flight hardware not considered criticality-1 hardware and (2) in the representative's judgment, the inspection points were no longer necessary based on the supplier's performance. The reduction in inspection points was not based on whether the inspections were the last test of a critical system or the last assembly task in the hardware manufacturing process.

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[6]Surveillance is a systematic method to evaluate performance using measures and standards. For example, some surveillance methods include inspections, sampling, audits, and metrics.

[7]The SSP Manager updated inspection criteria for Shuttle processing and vehicle manufacturing in fiscal years 1998 and 1999, respectively.

[8]The number of inspection points varies based on purchasing activity. This figure represents inspection points in existence based on active purchase orders as of June 1999. The figure is conservative based on the low Shuttle flight rate at the time of our review.

[9]The SSP categorizes flight hardware as criticality-1, -2, or -3. Failure of criticality-1 hardware would result in loss of human life or the orbiter vehicle. Failure of criticality-2 hardware would result in loss of a mission. All other hardware is considered criticality-3 hardware. Kennedy quality assurance representatives may also elect to inspect items when parts have failed to perform as required or when parts are procured from a new source or a source that has a poor quality history.

Redundant Government Quality Resources at Supplier Sites

NASA has redundant Government quality assurance resources at some hardware supplier sites. The three Centers independently delegated the Government quality assurance function; consequently, the SSP Manager funded multiple Government quality representatives. Johnson, Marshall, and Stennis relied on DCMC for quality assurance support, while Kennedy relied primarily on civil service quality assurance personnel. From October 1998 through June 1999, the SSP received DCMC monthly billing reports totaling about $6.3 million for services provided to the space flight centers. In addition, the SSP Manager incurred costs for Kennedy personnel to support quality assurance at supplier sites.

The Safety and Mission Assurance (SMA) Manager for the SSP is responsible for ensuring quality assurance for all the Space Shuttle elements. The SMA Manager's duties include:

- providing SMA requirements, tasks, and resource integration for NASA and contract support, and

- ensuring establishment of contractor SMA processes to assure that the Shuttle and its related systems are designed, constructed, tested, and operated satisfactorily to meet their intended purposes.

However, the SMA Manager has not established an effective program-level approach to identify and consolidate quality assurance resources. The SMA Manager has been unable to establish a program-level approach because the SSP Manager has not established surveillance plans or inspection criteria for the supplier sites, but rather, relied on each space flight Center to carry out the quality assurance functions. As a result, Johnson, Kennedy, and Marshall SMA organizations have independently managed the quality assurance delegations to DCMC for their respective Shuttle elements.

Consolidating Delegations is Cost-Effective

Marshall procurement officials delegated to DCMC the responsibility for reviewing United States Boosters, Inc.[10] (USBI) activities. Monthly billing reports indicated that DCMC charged 836 hours for those activities during the 9-month period ended June 30, 1999. Effective October 1, 1999, USBI became part of USA under the SFOC. The SMA Manager for the SSP delegated quality assurance responsibilities for USA procurement activities to the Kennedy quality assurance representatives. Since USBI is now part of USA, Kennedy quality assurance representatives should have responsibility for quality assurance of the solid rocket booster. Reassigning the quality assurance responsibility from DCMC to Kennedy would improve efficiencies by giving the resident Kennedy personnel visibility of the procurement and quality

[10]USBI is the design contractor for the Shuttle solid rocket boosters.

assurance functions. By using existing Kennedy personnel, there would be no additional cost to the SSP for USBI quality assurance functions, and the SSP could eliminate about $56,000 annually[11] in DCMC costs.

The SSP Manager could use resident Kennedy quality assurance personnel for some USBI suppliers. For example, as of June 30, 1999, DCMC charged 165 hours for quality assurance services at Honeywell, Incorporated, an orbiter vehicle flight hardware supplier to USBI. Since Kennedy has a quality representative on-site at Honeywell, the SSP Manager could reassign the work to the Kennedy representative, thereby eliminating about $11,000 annually[12] in DCMC costs. We concluded that Kennedy quality assurance personnel could perform the USBI-related quality assurance functions for the solid rocket booster at Honeywell and without the need for increased staffing through integration of these activities with present responsibilities at their locations. The potential exists for other USBI suppliers to be covered by Kennedy quality assurance personnel.

At some spare parts supplier sites, it may be more cost-effective to use resident DCMC rather than Kennedy representatives. At OEA Aerospace in Fairfield, California, DCMC provides some quality assurance support for Marshall for solid rocket booster hardware. A Kennedy quality assurance representative travels between the OEA Aerospace in California and Honeywell in Phoenix, Arizona, to support orbiter flight hardware. A resident DCMC quality assurance representative could provide functions for both the solid rocket booster and orbiter flight hardware more cost-effectively by eliminating unnecessary travel expenses for the Kennedy representative. In addition, using DCMC would release the NASA quality assurance representative to support other SSP needs. See Appendix C for additional suppliers with redundant Government quality assurance resources.

Surveillance Plans Can Reduce Government Mandatory Inspections

Although there is a need for on-sight inspections by Government quality assurance representatives, Kennedy could use a surveillance plan to reduce Government mandatory inspections. Many of the inspections performed at both the prime and subcontractor suppliers were not necessary when compared to the inspections required under the updated criteria for Shuttle processing and vehicle manufacturing. For example, some quality assurance representatives established inspection points to verify that the flight hardware supplier met delivery packaging and shipping requirements. When USA performs receiving inspections at Kennedy, USA is responsible for verifying that the flight hardware supplier met packaging and

[11]The SSP Program Office provided us DCMC monthly billing reports for services performed at USBI which showed that DCMC billed an average of 93 hours a month for a 12-month period at a rate of $50.15 per hour (93 X 12 X $50.15 = $55,967.40).

[12]The SSP Program Office provided us DCMC monthly billing reports for services performed at Honeywell which showed that DCMC billed an average of 18 hours a month for a 12-month period at a rate of $50.15 per hour (18 X 12 X $50.15 = $10,832.40).

shipping requirements. Therefore, Kennedy quality assurance representatives should not perform Government mandatory inspections on packaging and shipping because they are not then warranted.

Kennedy's inspections at the orbiter flight hardware suppliers has provided the SSP Manager additional assurance. However, the combined effects of surveillance and the SFOC implementation should allow the SSP Manager to limit Government mandatory inspections to those deemed most critical to hardware acceptance and overall Program safety. By evaluating the need for inspection points and eliminating inspections that do not compromise safety, the SSP will benefit from efficiencies such as those gained in the streamlined Shuttle processing and vehicle manufacturing areas.

Conclusion

Improved and better-controlled processes assure that products are manufactured to meet established standards resulting in less need for product inspections. Achieving consistent processes can improve quality programs and decrease cost. The key is to establish an effective Government surveillance program that provides adequate confidence in the contractor's performance.

The SSP Manager's requirement to update specific criteria for inspection points for both Shuttle processing and vehicle manufacturing contributed to work force efficiencies and better uses of Government quality assurance personnel. The SSP Manager could save about $67,000 annually[13] by eliminating redundancies in Government quality assurance personnel discussed in this report. By reviewing inspection points at the supplier sites and consolidating Government quality assurance personnel for the entire Shuttle Program, the SSP Manager can make better use of Agency quality assurance personnel and further reduce DCMC costs.

Recommendations, Management's Response, and Evaluation of Response

The Director, Lyndon B. Johnson Space Center, should:

1. **Establish criteria for the minimum number of inspection points and other Government surveillance activities at the supplier level to ensure Program safety. The criteria should be similar to the criteria established for Space Shuttle processing and vehicle manufacturing to eliminate redundant quality assurance activities and to make efficient use of DCMC support.**

2. **Establish a program-level approach to identify and consolidate quality assurance requirements to ensure the most efficient and cost-effective use of Government quality assurance personnel for the Shuttle Program.**

[13]This figure is the sum of the annual cost for DCMC reviews of USBI activities ($55,967) and the annual cost for DCMC services at Honeywell ($10,832) ($55,967 + $10,832 = $66,799)

Management's Response

Management concurred that the existing Government quality assurance resources and processes are effective in assuring orbiter vehicle spare parts quality. The SSP recognizes that there are opportunities to consolidate surveillance activities and potentially realize a more efficient quality assurance process. However, changes in the surveillance of these critical processes must be carefully reviewed, and the potential efficiencies must be weighed against the impact of change. The SSP does not have the same level of Government involvement at the flight hardware suppliers as that available for Shuttle processing. Therefore, there is a greater reliance on DCMC for Government surveillance at supplier sites.

Management stated that the November 1999 BAR Report must be reviewed and assessed for applicability to the SSP. The BAR, conducted as a result of recent expendable launch vehicle failures, concluded that an increase in DCMC in-plant technical support was required to improve the safety and reliability of the expendable launch vehicle programs. The SSP will assess by October 2000 the BAR findings and the applicability of the Kennedy processing criteria to determine whether a change in the flight hardware supplier criteria is advisable at this time.

Management also agreed that a program-level approach might increase efficiency in the utilization of quality assurance personnel. Before October 2000, the SSP Management Team will assess these opportunities and identify the advantages/disadvantages of a program-level approach considering existing multiple contracts, multiple space flight centers, and increased hardware development activities in support of Space Shuttle upgrades activities.

Evaluation of Response

Management's comments are nonresponsive because they do not directly address the recommendations. While we agree that surveillance of critical processes must be weighed against potential efficiencies, the SSP is already at risk because it does not have standardized criteria for Government surveillance at the supplier sites. Management's decision to perform an assessment of the BAR Report should not affect establishment of standardized criteria. In fact, one of the BAR recommendations to the space launch industry was that formalizing systems engineering and quality policies, practices, and procedures is needed.

We also agree that the SSP does not have the same level of Government involvement at flight hardware suppliers as that available for Shuttle processing at Kennedy. The SSP has established and streamlined Shuttle processing criteria at Kennedy to efficiently use Government quality resources. However, at supplier sites, the SSP has not established standardized criteria for Government surveillance activities. Delaying a decision on establishing criteria prolongs the risk to safety and does not indicate that corrective action will be taken. The SSP should establish formal criteria for flight hardware suppliers whether or not Government surveillance is changed upon completion of the BAR assessment.

We recognize that the SSP consists of multiple contracts and multiple space flight centers. However, it is for those reasons that we believe the consolidation of quality assurance resources

is cost beneficial and justified. We maintain that reassigning the DCMC quality delegations to the Kennedy quality assurance representatives at some locations and, conversely, reassigning the Kennedy delegations to DCMC at other locations would provide for increased efficiency in the utilization of quality assurance personnel. As discussed in our report, the SSP has resident quality representatives at some supplier sites. It may be more cost-effective to use the resident quality assurance representatives for all Shuttle elements rather than supporting multiple quality resources. Therefore, the SSP could consolidate quality assurance resources without reducing the level of surveillance by taking a program-level approach to quality assurance of spare parts. The SSP's stated action to perform a review does not indicate that corrective action will be taken.

We maintain our position on these issues and, therefore, request that management reconsider its position and provide additional comments.

Appendix A. Objectives, Scope, and Methodology

Objectives

The overall objective was to evaluate the effectiveness of the spare parts quality assurance process for the Space Shuttle Program. Our specific objectives were to determine whether NASA had:

- utilized quality assurance information in the acquisition of spare parts,
- established and implemented adequate policies for quality assurance of spare parts, and
- ensured effective performance of acceptance testing.

We will address whether NASA has taken appropriate actions with regard to quality deficiencies in a separate audit.

Scope and Methodology

We limited our review to the quality assurance of spare parts for the orbiter vehicle for the Shuttle due to the complexity and size of the five Shuttle elements.

We relied on DCMC monthly billing reports to determine costs incurred for services provided to the SSP. We did not validate the data because DCMC billing reports were not the subject of our review. We determined that in the actual assessment of quality performance, our reliance on the computer-generated spare parts inventory database was not critical to meeting our objectives; therefore, we did not test the contractor inventory system.

We interviewed cognizant NASA and contractor personnel at NASA Headquarters, Johnson, Kennedy, Marshall, and orbiter flight hardware supplier sites. In June 1999, we surveyed the Kennedy quality assurance representatives regarding their responsibilities at the orbiter hardware supplier sites. We received responses from all 12 representatives surveyed. We visited the following supplier sites from March through June 1999: OEA Aerospace, Fairfield, California; Hamilton-Sunstrand, Hartford, Connecticut; International Fuel Cells, Windsor Locks, Connecticut; Michelin Aircraft Tire Corporation, Norwood, North Carolina; and Accurate Metal, Rockledge, Florida. During the site visits, we observed audits and inspections performed by the Kennedy quality assurance representatives and USA product quality assurance representatives.

Additionally, we attended:

- The Conference on Quality in the Space and Defense Industries on March 1 and 2, 1999, at Cape Canaveral, Florida, sponsored by the American Society for Quality.

- The Space Shuttle Program's Flight Readiness Review on May 5, 1999, at Kennedy for the STS-96 launched on May 20, 1999.

Appendix A

Management Controls Reviewed

We reviewed the following Federal, NASA, and contractor documents related to contract administration and quality assurance:

- OMB Memorandum for Agency Senior Procurement Executives, Subject: "Government-wide Guidance on Contract Administration," dated March 15, 1991, which provides guidance on placing greater emphasis on quality assurance surveillance plans as part of contract management and administration.

- National Space Transportation System (NSTS) 07700, Volume X, which references NSTS 5300.4(1D-2), "Safety, Reliability, Maintainability, and Quality Provisions for the Space Shuttle Program." Chapter 3 of this section addresses quality assurance to include management and planning; testing, inspections, and evaluations; nonconforming articles; and procurement.

- Space Shuttle Program Directive 55F, Subject: "Safety, Reliability, and Quality Assurance Audits," dated January 22, 1997, which provides that the Johnson Space Shuttle Safety, Reliability, and Quality Assurance Office will perform and monitor the progress and reporting on internal audits and self-assessments performed by the quality assurance organizations at Johnson, Kennedy, and Marshall to verify that requirements are adequately documented and implemented.

- FAR Part 46, Quality Assurance, provides the following:

    - Paragraph 46.301 states that the contractor is responsible for performing or having performed all inspections and tests necessary to substantiate that the supplies or services furnished under a contract conform to contract requirements. This clause takes precedence over any Government inspection and testing required in the contract's specifications, except for specialized inspections or tests specified to be performed solely by the Government.

    - Paragraph 46.303 states that the contractor is to maintain an internal inspection system acceptable to the Government and to keep records of any inspection performed on supplier contracts. The system maintained should provide reasonable assurance that the supplies will conform to contract requirements. Contractors may also be required to establish an acceptable quality control system, that is, a system of in-process checks on manufacturing operations to eliminate defects prior to incorporation into the end item.

- Paragraph 46.401 provides the guidance for deciding how inspections, *including* quality assurance, will be performed.

- FAR Part 42.302 (a)(38), "Assignment of Contract Administration," states that contracting officers may delegate contract administration for support services, such as ensuring contractor compliance with contractual requirements.

- USA Specification, MTO802-101, revision C, D01, "Quality Requirements for Suppliers and Subcontractors for the Shuttle Program," dated January 28, 1997, mirrors NSTS 5300.4(1D-2) and defines the basic requirements for quality assurance activity in support of the Space Shuttle Program.

We considered management controls for quality assurance of spare parts to be adequate except as discussed in the finding.

Performance Measures

The Safety and Mission Assurance Office has complied with the requirements of the Government Performance and Results Act of 1993. The Act requires that agencies establish strategic plans that define goals and report on their progress through collecting and assessing performance measures. In March 1998, the Office of Safety and Mission Assurance issued revisions to its April 1996 Safety and Mission Assurance Strategic Plan, which presented the vision, mission, and goals to be accomplished by Center organizations. Center quality organizations use a management communication tool called the Annual Operating Agreement to annually report their integrated approach to planning, developing, and evaluating products and services delivered to their Center customers.

Audit Field Work

We conducted field work from December 1998 through August 1999, at NASA Headquarters, Johnson, Kennedy, USA-Florida, and the supplier sites listed in the Scope and Methodology section of this appendix. We performed the audit in accordance with generally accepted government auditing standards.

Appendix B. Streamlining Government Quality Assurance in Shuttle Processing and Vehicle Manufacturing

Streamlining Quality Assurance in Processing the Shuttle for Launch

The SSP management, in conjunction with Agency safety and mission assurance officials at Johnson and Kennedy, determined in the early 1990's that by using surveillance,[14] management could reduce inspection points without compromising program safety. The SSP Manager reviewed inspection points and reduced them by performing surveillance rather than inspections on criticality-2 and -3 hardware.[15] In fact, the SSP Manager reduced inspection points from more than 40,000 to about 22,000 during Shuttle processing for launch.

In 1998, based on experiences gained and lessons learned using surveillance, the SSP Manager initiated another review focused on the remaining criticality-1 inspections. To perform this review, SSP officials developed criteria for identifying true safety-related inspections, that is, those that affect loss of the crew or vehicle. The SSP requires a Government mandatory inspection if either of the following criteria is met:

> The last test of a critical system which provides confidence that the system is operating as designed.
>
> The last criticality-1 hardware assembly task, for which there is no subsequent functional or nondestructive test, which provides confidence that the assembly is proper.

By approving the transition to surveillance and establishing the criticality-1 inspection criteria, SSP management reduced inspection points from about 22,000 to 8,500 during Shuttle processing for launch. The safety and mission assurance workforce at Kennedy also decreased from about 350 to 225, or about 35 percent. Kennedy safety and mission assurance officials stated that the inspection point reduction was one of many factors that resulted in workload efficiencies in Shuttle processing.[16]

Streamlining Quality Assurance in Vehicle Manufacturing

Subsequent to the review of inspection points for Shuttle processing, the SSP Manager directed a similar review of manufacturing operations at Palmdale, California. As a result of the

[14]Surveillance is a systematic method to evaluate performance using measures and standards. For example, some surveillance methods include inspections, sampling, audits, and metrics.

[15]The SSP categorizes flight hardware as criticality-1, -2, or -3. Failure of criticality-1 hardware would result in loss of human life or the orbiter vehicle. Failure of criticality-2 hardware would result in loss of a mission. All other hardware is considered criticality-3 hardware.

[16]A number of factors contributed to workforce reductions from 1996 to present. Some of the factors include Agency downsizing, reassignment of duties to USA, phase-out of the Spacelab program, assumption of the safety and mission assurance responsibilities by the employees, use of contract labor for independent assessments, and a reduced flight rate.

manufacturing review, the NASA quality assurance representatives no longer perform Government mandatory inspections, but ensure quality through surveillance. Besides reducing inspection points from 420[17] to 0, the number of Government quality assurance representatives assigned to the manufacturing effort was reduced from 14 to 6. As a result, eight Kennedy quality assurance representatives were able to perform other quality assurance functions, resulting in greater efficiencies for the Shuttle Program.

[17]Government quality assurance representatives conducted an average of 420 inspection points per month prior to the manufacturing review.

Appendix C. Shuttle Supplier Sites with Redundant Government Quality Assurance Resources

Although several prime contractors support the five Shuttle elements, some suppliers provide component parts for multiple Shuttle elements. For example, Honeywell, Incorporated, manufactures flight hardware for the orbiter vehicles and the solid rocket boosters. The table below shows the 26 suppliers that produce flight hardware in support of multiple Shuttle elements and that are supported by multiple Government quality assurance representatives.

Redundant Quality Assurance Resources at Supplier Sites

Supplier	Type of Quality Assurance		
	Johnson	Kennedy	Marshall
Abex/NWL Aerospace	DCMC	NASA	DCMC
Aerospace Avionics, Inc.	DCMC	NASA	N/A*
AIL Systems, Inc.	DCMC	NASA	N/A
Allied Signal, Inc. (AZ)	DCMC	NASA	N/A
Allied Signal, Inc. (WA)	DCMC	NASA	N/A
Aydin Vector Division	DCMC	DCMC	N/A
BF Goodrich Rosemount	DCMC	DCMC	N/A
Carlton Technologies	DCMC	DCMC	N/A
Circle Seal Controls, Inc.	N/A	NASA	DCMC
Eaton Corporation (CA)	DCMC	NASA	DCMC
EG&G Engineered Products (formerly Wright Components)	DCMC	DCMC	N/A
Gardner Bellows Corp.	N/A	DCMC	DCMC
Hamilton Sunstrand (IL)	DCMC	NASA	DCMC
Honeywell, Incorporated (AZ)	DCMC	NASA	DCMC
Langley A Fleet Aerospace	DCMC	NASA	DCMC
Lockheed Martin Vought (formerly LTV Aerospace)	DCMC	NASA	N/A
Moog, Inc.	DCMC	DCMC	DCMC
OEA Aerospace, Inc.	N/A	NASA	DCMC
Parker Symetrics	DCMC	DCMC	N/A
Parker Hannifin (CA)	N/A	NASA	DCMC
Primex Aerospace, Inc.	N/A	DCMC	DCMC
SPS Technologies/Aerospace Products	N/A	DCMC	DCMC
Senior Flexonics, Inc. (CA)	DCMC	NASA	N/A
Senior Flexonics, Inc. (CT)	N/A	DCMC	DCMC
Sierrancin/Harrison	DCMC	NASA	N/A
Vacco Industries	DCMC	NASA	N/A

***N/A** = Government quality assurance support is not applicable at this supplier for this Center.

Appendix D. Management's Response

National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center
2101 NASA Road 1
Houston, Texas 77058-3696

Reply to Attn of: BD5

JAN 19 2000

TO: NASA Headquarters
Attn: W/Assistant Inspector General for Auditing

FROM: AA/Director

SUBJECT: Management Response to OIG's Draft Report on the Audit of Spare Parts Quality Assurance for the Space Shuttle, Assignment Number A990700

We have reviewed the subject draft report, and thank you for the opportunity to provide comments. This response has been coordinated with the Office of Space Flight. We are pleased to see that your review found the quality assurance processes for the orbiter vehicles to be effective. The professionalism and thoroughness of the audit team was outstanding. Quality assurance of spare parts is a very important aspect of Space Flight success and was difficult to review in the allotted time. We appreciate your involvement in this review.

Government surveillance and involvement at the supplier level continues to be in the Government's best interest. The quality of flight hardware spare parts and resultant impact to the safety of the vehicle are the most important factors to consider and preserve, even at the expense of potential efficiencies in quality assurance resources. We have reviewed the recommendations and identified actions necessary to provide program management evaluation of the supplier surveillance policies as discussed in the enclosure.

If you have any questions regarding this response please contact Mr. William J. Harris at 281-483-0480 for technical content or Ms. Pat Ritterhouse, Audit Liaison Representative for any other questions.

George W. S. Abbey

George W. S. Abbey

Enclosure

cc:
MA/R. D. Dittemore
MA/W. J. Harris
HQ/JM/H. Robbins
HQ/M/J. Rothenberg
HQ/MX/G. Gabourel
KSC/HM-E/J. Nary
MSFC/RS40/A. McMillan

Appendix D

Management Response to OIG's Draft Report on the Audit of Spare Parts Quality Assurance for the Space Shuttle, Assignment Number A990700

Auditor's Findings

In keeping with Government downsizing and the advent of the performance-based Space Flight Operations Contract (SFOC), the Space Shuttle Program (SSP) Manager and NASA safety and mission assurance officials reduced Government Mandatory Inspection Points for Shuttle processing and vehicle manufacturing and took significant steps to ensure the safety of Shuttle operations. However, the SSP Manager has not updated or streamlined criteria for eliminating unnecessary inspection points at spare parts suppliers and has no consolidated quality assurance requirements using a program-level approach. As a result, NASA has redundant Government quality assurance resources at some locations that could be used more efficiently to perform other quality assurance functions.

Recommendations for Corrective Actions

The Center Director, Lyndon B. Johnson Space Center, should:

1. Establish criteria for the minimum number of inspection points and other Government surveillance activities at the supplier level to ensure Program safety. The criteria should be similar to the criteria established for Space Shuttle processing and vehicle manufacturing to eliminate redundant quality assurance activities and to make efficient use of DCMC support.

2. Establish a program-level approach to identify and consolidate quality assurance requirements to ensure the most efficient and cost-effective use of Government quality assurance personnel for the Shuttle program.

JSC Comments

We concur with the report finding that the existing Government quality assurance resources and processes are effective in assuring orbiter vehicle spare parts quality. We recognize that the Prime Contractor is responsible for supplier quality assurance and that consolidation of various contracts under the Space Flight Operations Contract (SFOC) provides an opportunity for the government to consolidate surveillance activities and potentially realize a more efficient quality assurance process. However, changes in the surveillance of these critical processes that have been so effective for the life of the Space Shuttle Program must be carefully reviewed and the possibility of potential efficiencies weighed against the impact of change.

As a first step in utilizing the potential of the consolidated SFOC, government quality assurance processes were evaluated and modified at the Kennedy Space Center. The level of government involvement in the processing oversight and insight surveillance activities at the KSC made it possible to establish criteria where mandatory government inspections could be reduced. The same level of government involvement is not available at flight hardware suppliers and a greater reliance on the Defense Contract Management Command (DCMC) for government surveillance of suppliers at the supplier level is required.

Enclosure

Government surveillance and involvement at the supplier level continues to be in the Government's best interest. The quality of flight hardware spare parts and resultant impact to the safety of the vehicle are the most important factors to consider and preserve, even at the expense of potential efficiencies in quality assurance resources. NASA has utilized the quality assurance services of the DCMC as an effective and economical method of implementing government surveillance. There may be opportunities for reduced government surveillance at the supplier level. However, it should be noted that the recent Broad Area Review (BAR) conducted as a result of recent Expendable Launch Vehicle (ELV) failures concluded that an increase in DCMC in-plant technical support was required to improve the safety and reliability of the ELV programs. We believe that the BAR findings must be reviewed and assessed for applicability to the Space Shuttle Program, and that any action to redefine the criteria for government assurance at flight hardware suppliers be contingent upon that assessment. The Space Shuttle Program will assess the BAR findings and applicability of the KSC processing criteria to the flight hardware suppliers to determine if a change in the flight hardware supplier criteria is advisable at this time. This activity will be completed by October 1, 2000.

As indicated in your report, there may exist opportunities for increased efficiency in the utilization of quality assurance personnel through implementation of a program-level approach versus individual space flight centers. The Space Shuttle Program will assess these opportunities, identify the advantages/disadvantages of a program-level approach considering existing multiple contracts, multiple space flight centers, and increased hardware development activities in support of Space Shuttle Upgrades activities. A review with the Shuttle Program Management Team will be conducted prior to October 1, 2000.

Appendix E. Report Distribution

National Aeronautics and Space Administration (NASA) Headquarters

A/Administrator
AI/Associate Deputy Administrator
AO/Chief Information Officer
B/Chief Financial Officer
B/Comptroller
BF/Director, Financial Management Division
G/General Counsel
J/Associate Administrator for Management Systems
JM/Director, Management Assessment Division
L/Associate Administrator for Legislative Affairs
M/Associate Administrator for Space Flight
M-4/Chief Engineer (Space Station)
P/Associate Administrator for Public Affairs
Q/Associate Administrator for Safety and Mission Assurance
R/Associate Administrator for Aero-Space Technology
S/Associate Administrator for Space Science
U/Associate Administrator for Life and Microgravity Sciences and Applications
Y/Associate Administrator for Earth Science
Z/Associate Administrator for Policy and Plans

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Chairman, Advisory Committee on the International Space Station

NASA Centers

Director, Lyndon B. Johnson Space Center
  JSC/BD5/Audit Liaison Representative
Director, John F. Kennedy Space Center
  KSC/HM-E/Audit Liaison Representative
Director, George C. Marshall Space Flight Center
  MSFC/RS40/Audit Liaison Representative
Director, John C. Stennis Space Center
  SSC/EA00/Audit Liaison Representative

Non-NASA Federal Organizations and Individuals

Assistant to the President for Science and Technology Policy
Deputy Associate Director, Energy and Science Division, Office of Management and Budget
Branch Chief, Science and Space Programs Branch, Energy and Science Division, Office of Management and Budget
Associate Director, National Security and International Affairs Division, Defense Acquisition Issues, General Accounting Office
Professional Assistant, Senate Subcommittee on Science, Technology, and Space

Chairman and Ranking Minority Member - Congressional Committees and Subcommittees

Senate Committee on Appropriations
Senate Subcommittee on VA, HUD, and Independent Agencies
Senate Committee on Commerce, Science, and Transportation
Senate Subcommittee on Science, Technology, and Space
Senate Committee on Governmental Affairs
House Committee on Appropriations
House Subcommittee on VA, HUD, and Independent Agencies
House Committee on Government Reform and Oversight
House Subcommittee on Government Management, Information, and Technology
House Subcommittee on National Security, Veterans Affairs, and International Relations
House Committee on Science
House Subcommittee on Space and Aeronautics

Congressional Member

Honorable Pete Sessions, U.S. House of Representatives

NASA Assistant Inspector General for Auditing
Reader Survey

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Report Title: Spare Parts Quality Assurance for the Space Shuttle

Report Number:_____ **Report Date:** _____

Circle the appropriate rating for the following statements.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
1. The report was clear, readable, and logically organized.	5	4	3	2	1	N/A
2. The report was concise and to the point.	5	4	3	2	1	N/A
3. We effectively communicated the audit objectives, scope, and methodology.	5	4	3	2	1	N/A
4. The report contained sufficient information to support the finding(s) in a balanced and objective manner.	5	4	3	2	1	N/A

Overall, how would you rate the report?

Excellent Fair
Very Good Poor
Good

If you have any additional comments or wish to elaborate on any of the above responses, please write them here. Use additional paper if necessary. _____

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How did you use the report? _____

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How could we improve our report? _____

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How would you identify yourself? (Select one)

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May we contact you about your comments?

Yes:_____ **No:_____**

Name:

_____

Telephone: _____

Thank you for your cooperation in completing this survey.

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