

AUDIT REPORT

FOLLOWUP AUDIT ON ORBITER MAINTENANCE DOWN PERIODS AT KSC

June 12, 1998

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Acronyms

BNA	Boeing North American
DoD	Department of Defense
FY	Fiscal Year
ISS	International Space Station
JSC	Johnson Space Center
KSC	Kennedy Space Center
NASA	National Aeronautics and Space Administration
NPV	Net Present Value
NSLD	NASA Shuttle Logistics Depot
OIG	Office of Inspector General
OMDP	Orbiter Maintenance Down Period
OPF	Orbiter Processing Facility
SFOC	Space Flight Operations Contract
STS	Space Transportation System
USA	United Space Alliance

W

June 12, 1998

TO: M/Associate Administrator for Space Flight
J/Associate Administrator for Management Systems and Facilities

FROM: W/Assistant Inspector General for Auditing

SUBJECT: Final Report on the Followup Audit on Orbiter Maintenance Down Periods at KSC
Assignment Number A-HA-97-043
Report Number IG-98-016

The subject final report is provided for your use. Your comments on a draft of this report were responsive to our recommendation. The report provides our evaluation of your response. We consider the recommendation to be closed for reporting purposes.

If you have any questions concerning the report, please call Mr. Lee Ball, Acting Program Director for Human Exploration and Development of Space, at 757-864-8500. We appreciate the courtesies extended to the audit staff. See Appendix 6 for the report distribution.

Russell A. Rau

Enclosure

cc:

JSC/Manager, Space Shuttle Program
/Deputy Manager, Space Shuttle Vehicle Engineering Office
KSC/Director of Shuttle Processing

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FOLLOWUP AUDIT ON ORBITER MAINTENANCE DOWN PERIODS AT KSC

EXECUTIVE SUMMARY

INTRODUCTION

We performed our audit as a followup to the National Aeronautics and Space Administration (NASA) Office of Inspector General (OIG) Rapid Action Report KE-96-001, "Impacts of Performing Orbiter Maintenance Down Periods (OMDP's) at KSC versus Palmdale," October 24, 1995. An OMDP is a period of time when one of NASA's four orbiters¹ is taken out of service for structural inspections and modifications.² The Rapid Action Report stated that \$30 million annually, or \$400 million to \$500 million, could be saved over the life (projected to the year 2012) of the Shuttle Program by scheduling OMDP's at the Kennedy Space Center (KSC) rather than at Palmdale, California.

NASA management agreed with the prior audit findings. However, after issuance of Report KE-06-001, management conducted further studies. Due to the complexity of planned modification work and scheduling conflicts, NASA management determined the next two OMDP's should be at Palmdale. (A list of OMDP-related reports is in Appendix 4.)

The purpose of the followup audit³ was to evaluate NASA's decisions to continue using the Palmdale facility for OMDP's and to determine whether the award of the single prime contract affects future decisions about OMDP location. We evaluated cost factors and programmatic impacts at the following OMDP locations:

- Palmdale, California,
- existing KSC facilities, and
- a new KSC modification facility.

RESULTS OF AUDIT

The most appropriate location for OMDP's is Palmdale, based on the current manifest⁴ and projected Shuttle life. Scheduling

¹ The four orbiters are: OV-102 (Columbia), OV-103 (Discovery), OV-104 (Atlantis), and OV-105 (Endeavour).

² Background information on OMDP's is in Appendix 3.

³ Objectives, scope, and methodology are in Appendix 1.

⁴ The manifest summarizes the missions planned by NASA for the Space Shuttle vehicles as of the date of publication. Launch dates are shown by month and represent reasonable expectations as to when the launch will occur. The manifest reflects NASA's commitments to its external customers and the established priorities among its internal programs.

OMDP's at KSC would introduce substantial risk to the International Space Station (ISS). The complexity and time-critical schedule of ISS assembly would tax the existing KSC infrastructure if OMDP's were performed at KSC, and construction of a new facility would not provide sufficient payback.

Palmdale. NASA would pay more by scheduling OMDP's at Palmdale rather than at KSC, but risk would be greatly reduced compared to using existing KSC facilities. Locating OMDP's at Palmdale, at least until deployment of critical ISS components, would provide KSC with more flexibility to address and correct anomalies while processing the vehicles for ISS launches. Further, scheduling OMDP's at Palmdale takes advantage of the organizational structure and workforce that are in place for orbiter inspections and major modifications. The Palmdale facility can also support large-scale orbiter restorations or re-manufacture of an orbiter that may be required as scheduled service life proceeds beyond 2012 to 2030. Loss of such capability introduces risk by reducing options available to NASA management in Shuttle operations.

Existing KSC Facilities. NASA could save \$7.6 million per OMDP (or \$5.7 million annually) if OMDP's were scheduled in existing KSC facilities rather than at Palmdale. Existing facilities and infrastructure would support a KSC OMDP. However, significant risk is associated with performing OMDP and orbiter processing⁵ in the existing three orbiter processing facilities (OPF's). Major modifications have not been performed in the KSC facilities, and significant difficulties could arise in doing so in support of the more aggressive manifest schedule warranted by ISS. Delays in the ISS resulting from Shuttle nonavailability would have a significant cost and schedule impact on the ISS program because the Shuttle is the primary means to deploy space station components. We believe this risk outweighs the potential cost savings.

A New KSC Modification Facility. NASA could save \$3.9 million per OMDP (or \$2.9 million annually) if a new facility is built. A new facility would reduce risk to the current manifest, but the cost recovery period does not warrant its construction. The total investment would cost NASA about \$49.7 million.

⁵ Orbiter processing consists of removing payloads from returned flights, servicing hazardous propellants, and performing interval inspection tests and check-out requirements to assure the space vehicle is flight-ready. Minor modifications may also be performed.

The savings identified in Report KE-96-001 were based primarily on eliminating duplicate facility and infrastructure costs. The prior audit concluded that KSC could perform OMDP's based on the assumption that Palmdale would close. Also, the prior audit compared incremental costs at KSC with the full-cost for OMDP's at Palmdale. Since Report KE-96-001 was issued, conditions have changed:

- The KSC workforce has been significantly reduced.
- Boeing North American (BNA) transferred its manufacturing operations to Palmdale. The Palmdale facility is unlikely to close if OMDP's are at KSC because other contract work is completed in the facility.

The single prime contract for Shuttle operations contains the OMDP requirement but is not specific as to location. Therefore, there is no contractual requirement governing the location of OMDP performance. When OMDP's are at Palmdale, United Space Alliance (USA) subcontracts the work to BNA. If OMDP's are located at KSC, USA would perform the work.

The Shuttle Program operates in a very dynamic environment. The manifest and other program elements change frequently. When conditions change significantly, NASA management should reevaluate the OMDP location.

RECOMMENDATION

The Associate Administrator for Space Flight should reevaluate OMDP location when significant changes occur to the Shuttle Program, such as major changes in the flight manifest. The evaluation should consider the need to perform orbiter upgrades or major repairs beyond the present capability at KSC.

Management's Response

Concur. Management fully supports the recommendation and will continue to evaluate upcoming OMDP locations. However, as management's study and the audit report indicate, for now the most appropriate location for the bulk of OMDP work is Palmdale. The full text of management's response is in Appendix 5.

Evaluation of Management's Response

We consider management's planned action responsive to the recommendation.

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OBSERVATIONS AND RECOMMENDATION

COST IMPACT

Based on current conditions, NASA could save \$7.6 million per OMDP by scheduling OMDP's in existing facilities at KSC. From 1999 to 2030, net savings would be about \$125.3 million after deducting the \$6.4 million investment from total savings (see Exhibit 2, Figure 1). However, USA cannot process Shuttle operations **and** perform OMDP work in existing facilities without significant additional risk to the Shuttle Program.

The savings per OMDP total \$3.9 million if a new facility is constructed. Total savings would be about \$67.6 million through 2030 (see Exhibit 2, Figure 2). A new facility would eliminate the additional risk, but it would take about 20 years to recover the \$49.7 million capital investment. Further, deducting the investment from total savings would result in a net savings of \$17.9 million. (See Appendix 2 for details on KSC infrastructure.)

Under either scenario, the savings are not significant compared to NASA's funding under SFOC. Under SFOC, USA's annual costs are about \$1 billion.

See Exhibits 1 and 2, which present our analyses using existing facilities and constructing a new facility at KSC.

PROGRAMMATIC IMPACTS

The Shuttle Program goals are to fly safely, meet the manifest, improve mission support, and reduce costs. USA and BNA employees and management have comparable abilities with regard to performing orbiter modifications and conducting work to assure a high degree of safety. However, the Shuttle manifest may be threatened if orbiter processing and OMDP activities are at the same location, absent the construction of an additional facility at KSC. The KSC mission is to process the Space Shuttle vehicles for launch. KSC has three OPF's to perform these tasks. If one were used primarily for OMDP's, processing flexibility would be reduced because the remaining two OPF's would support a higher workload.

The Palmdale facility is dedicated to orbiter maintenance and modification and allows OMDP's to be conducted without impact on KSC launch processing. USA can recover from schedule and program deviations and anomalies more easily if OMDP's are at Palmdale. This recovery capability is essential during the time-critical ISS assembly launches.

Further, NASA's goals are to increase the flight rate and upgrade the Shuttle. Reductions in OPF cycle time are necessary before higher flight rates can be achieved. By scheduling OMDP's at KSC, NASA could lose the capability to accomplish some of the proposed upgrades or to perform major repairs.

***Changing Conditions
Make Manifest at Risk***

Changing conditions require frequent update of the manifest. NASA and USA officials continually evaluate and address the Shuttle launch schedule. Their reviews include impacts to ISS launch dates and assembly sequence. As a result of the reviews, launch dates and payloads are changed; payloads are moved to different orbiters; and flights are added, deleted, or renumbered. Below are examples of changes that occurred during our followup audit.

- Space Transportation System (STS)-86 was scheduled to fly on OV-105 but was changed to fly on OV-104. This change delayed the start of the OV-104 OMDP until November 1997, and the OV-105 had to be stored in the vehicle assembly building to accomplish the reflight processing.
- STS-83 returned early from its planned orbit. The payload was reflown on STS-94, which was added to the manifest in Fiscal Year (FY) 1997.
- Because of problems encountered on STS-87, the payload will be reflown on STS-95 scheduled for October 1998.
- The payload for STS-93 will be delayed several months. The delay has required a major reassessment of Shuttle flights. The originally scheduled launch in August may be rescheduled to December 1998. However, this date coincides closely with an ISS launch.

With OMDP's at KSC, problems may be encountered that could impact meeting scheduled launch dates. There is little latitude to deal with unexpected changes if the three OPF's are used to process and modify the Shuttle vehicles. Situations such as a main engine shutdown at the launch pad, a delayed roll out of the orbiter from an OPF, or hurricane could cause facility scheduling problems. If an OPF is used for OMDP's, the time between orbiters leaving an OPF and entry of the next vehicle would often be less than 2 weeks. The availability of an OPF between orbiters could be more than 4 weeks if OMDP's are at Palmdale.

Program deviations or major slips in such tightly constrained facilities could jeopardize the ISS assembly flights. Three to five ISS launches are scheduled during or within 2 weeks of the next five OMDP's. The ISS flights must occur in sequence within specified time parameters. The risk would be minimized if an additional processing facility were available. Consequently, the flexibility afforded by three OPF's dedicated to flight processing is essential, given the projected ISS flight rate and timing.

***Long-term Goals
are Vulnerable***

NASA's long-term goals to increase the flight rate and upgrade the Shuttle may not be achievable if OMDP's are performed in existing facilities at KSC. NASA currently has planned an average Shuttle flight rate of eight or nine per year from 1999 to 2004, but the manifest is under review. Because of ISS delays, NASA may launch only four or five flights during 1998. NASA anticipates increasing the rate to 10 per year by 2002 and 15 per year by 2007.⁶ With the current length of orbiter cycle time, only eight or nine flights a year are feasible with OMDP's scheduled in existing facilities at KSC; but the manifest would be at risk because this schedule leaves minimal (less than 2 weeks) margin for unforeseen maintenance, payload, or other delays.

To increase the flight rate, USA must reduce OPF turnaround processing as well as address limitations in other facilities. Efforts are under way to identify efficiencies that will shorten the cycle time. However, until such reductions are achieved, the flight rate cannot increase.

NASA is also planning major upgrades to the Space Shuttle system to provide safe, continuous, and affordable operations through the year 2030. The upgrades are categorized into four phases. Designs in the fourth phase would significantly change orbiter configuration. These upgrade plans and contingency plans for major repairs of a damaged vehicle or to manufacture a new orbiter also impact OMDP location. KSC's facilities are not sized to support large-scale restorations or build a new orbiter. Locating OMDP's at Palmdale maintains a facility large enough to handle these activities.

⁶ The increased flights will accommodate commercial customers. Current regulations prohibit carrying most commercial payloads, such as private communications satellites. Consequently, NASA is in the process of requesting legislative approval to fly commercial payloads. The change, if approved, may take several years to implement.

**CHANGED CONDITIONS
AFFECT OMDP
LOCATION**

Many factors can impact the location decision, such as:

- *Delays in ISS.* Minimal delays in ISS payload availability could extend the turnaround time required in OPF's and negatively impact the overall manifest schedule.
- *Flight rate.* Higher flight rates increase the risk associated with locating OMDP's at KSC, whereas lower rates reduce the risk.
- *OPF cycle time.* Reductions in cycle time allow greater scheduling flexibility.
- *Reusable Launch Vehicle Program.* This program will affect how long the Shuttle will be needed.
- *Commercial payloads.* Permission to fly commercial payloads may result in a larger number of payloads with decreased scheduling flexibility.

Management should be cognizant of program changes that may affect OMDP location and, as appropriate, reevaluate the location decision.

RECOMMENDATION

The Associate Administrator for Space Flight should reevaluate OMDP location when significant changes occur to the Shuttle Program, such as major changes in the flight manifest. The evaluation should consider the need to perform orbiter upgrades or major repairs beyond the present capability at KSC.

Management's Response

Concur. Management fully supports the recommendation and will continue to evaluate upcoming OMDP locations. However, as management's study and the audit report indicate, for now the most appropriate location for the bulk of OMDP work is Palmdale. Management also suggested two minor editorial changes and suggested a clarification of USA's fee for the BNA subcontract work. The full text of management's response is in Appendix 5.

***Evaluation of
Management's Response***

We consider management's planned action responsive to the recommendation. We made management's two suggested editorial changes. Regarding USA's fee, we used a fee rate of 7.5 percent for our cost comparison, which was the rate USA

proposed for the OV-104 OMDP. However, management stated the rate will most likely be reduced to 1 percent and suggested adding sentences to clarify the fee for the subcontract work. The fee change would lower the cost of OMDP's at Palmdale by about \$1.8 million. We did not revise our cost analyses to reflect the lower fee rate but included appropriate comments in our report. Our conclusion to schedule OMDP's at Palmdale is not altered, unless a significant change in the Shuttle Program occurs.

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RECURRING INCREMENTAL OMDP COSTS

OMDP'S AT PALMDALE AS COMPARED TO OMDP'S AT KSC

(Dollars in Millions)

Cost and Fee Elements	Palmdale	KSC (Existing Facilities)	KSC (New Facility)	Difference		Note
				Existing Facilities	New Facility	
Labor and Employee Benefits	\$19.80	\$17.31	\$18.72	(\$2.49)	(\$1.08)	1
Indirect Costs	4.16	0.63	0.68	(3.53)	(3.48)	2
Computers and Telecommunications	1.04			(1.04)	(1.04)	3
Orbiter Transport	1.67			(1.67)	(1.67)	4
Civil Service Support	0.25			(0.25)	(0.25)	5
Recertifications/Training		1.16	1.29	1.16	1.29	6
"Excess Capacity"		1.16	1.29	1.16	1.29	7
Warehouse Consolidation		(0.60)	(0.60)	(0.60)	(0.60)	8
Design Engineers		1.71	1.71	1.71	1.71	9
Material and Equipment Shipments	0.10	0.14	0.14	0.04	0.04	10
Building Operation and Maintenance			1.59		1.59	11
Subtotal	\$27.02	\$21.51	\$24.82	(\$5.51)	(\$2.20)	
Boeing North American Fee	2.65			(2.65)	(2.65)	12
United Space Alliance Fee	2.03	2.58	2.98	0.55	0.95	12
Total Recurring Costs/(Savings)	\$31.70	\$24.09	\$27.80	(\$7.61)	(\$3.90)	

NOTES:

1 - LABOR AND EMPLOYEE BENEFITS

We evaluated labor hours, skills, efficiencies, and costs to perform structural inspections and modifications to the OV-102 OMDP at Palmdale and KSC. The OV-102 is scheduled for OMDP in October 1998 but may change based on an ongoing review.

Palmdale Staffing and Hours

Because of its experience with OMDP's and access to engineering drawings, BNA estimated labor hours by task for the planned structural inspections and modifications to the OV-102 at Palmdale. The hours were estimated by labor discipline and include manufacturing, product assurance, engineering, logistics, and other support areas. Approximately 265 BNA employees would be involved with the OMDP.

KSC Staffing and Hours

USA used BNA's estimated labor hours to derive the number of employees and hours required to complete the work at KSC. USA's labor categories include manufacturing technicians, quality, engineers, and planners and schedulers. USA must hire, train, and certify about 225 employees to perform the maintenance and modification tasks in existing facilities at KSC. If a new facility is built at KSC, about 30 additional employees would be needed.

Exhibit 1
Recurring Incremental OMDP Costs

USA's labor includes purchased support for cleaning, calibration, and nondestructive testing, which are included in BNA's indirect costs. Some of this work is now being done by USA employees. Labor costs also include manufacturing support from the NASA Shuttle Logistics Depot (NSLD), a USA organization. Further, USA would require assistance from BNA design engineers who support OMDP's by authorizing all changes to the orbiters. Labor-related costs include design support. Also refer to note 9.

USA Labor Skills

Based on several discussions with USA and NASA officials at KSC, we believe the employees at KSC have the necessary skills and capabilities to perform the work during an OMDP. USA has extensive experience processing orbiters to meet scheduled launches. During flight processing, USA employees may perform structural inspections and minor modifications. Thus, they are familiar with the orbiter structure. This experience provides the employees with the skills to perform the generally more complex modifications required during OMDP's.

Learning Efficiencies

BNA's estimated hours for the OV-102 OMDP were lower for certain tasks than the hours employees had charged for similar tasks during previous OMDP's. The lower number of hours resulted from BNA applying its learning experience on completed OMDP's to the OV-102 requirements. USA's use of BNA's hours has limitations. USA's experience with normal processing and familiarity with the orbiters provide equivalent capabilities, but the required number of hours for USA's employees may differ from BNA's. USA has no specific experience with performing major modifications. USA may not be as proficient initially as the Palmdale workers, but there was no relevant historical data to support greater hours for USA for the OV-102 OMDP or in the long term.

Labor Costs

BNA's labor and employee benefits rates are approximately \$5.00 and \$3.50, respectively, higher than USA's. Although BNA's labor rate includes an overtime premium, the difference is also due to employees' experience. USA's workforce had 12.7 years of experience versus 23.5 years for BNA employees. The pay differential may erode as the Palmdale workforce ages and retires and as USA employees gain more experience. But the average could reverse during the life of the Shuttle Program. We made no adjustment in our analyses to account

Exhibit 1
Recurring Incremental OMDP Costs

for these changing demographics because of the inherent uncertainty in projecting costs many years into the future. Also refer to Exhibit 2.

BNA would incur about \$19.80 million for labor and employee benefit costs. If USA performs the OMDP work, labor and employee benefits would be about \$17.31 million if existing facilities were used at KSC. These costs would be about \$18.72 million if a new facility is constructed because of the need for 30 additional employees.

2 - INDIRECT COSTS

We computed the incremental indirect costs associated with performing the OV-102 structural inspections and modifications. Incremental indirect costs represent the variable costs associated with the change in labor costs.

BNA's Indirect Costs

BNA's \$4.16 million indirect costs include salaries and wages, supplies and expenses, computer and telecommunication costs, and some accounting and human resources costs. Incremental costs equal the difference between total indirect costs if BNA performs the OMDP work and if BNA does not perform the work.

USA's Indirect Costs

USA's indirect costs are much less than BNA's, primarily because of the difference in the company's accounting practices. USA classifies most labor costs as direct, and many services (for example, cleaning and calibration) that BNA charges as indirect are provided by non-USA contracts. We adjusted the costs elsewhere to equalize the differences. For example, USA's purchased support is included with labor and employee benefits. Adding these costs to USA's indirect costs would approximate BNA's indirect costs.

USA's indirect costs would be \$0.63 million if existing KSC facilities are used and \$0.68 million if a new facility is constructed. The indirect costs are due to the increased staffing and include computers, miscellaneous supplies, accounting and payroll staff, corporate business taxes, and additional allocations of corporate office expenses.

Fixed Indirect Costs

We considered the impact to all Government contracts in our analyses. We did **not** include fixed indirect costs because the Government would pay for them regardless of OMDP location.

Exhibit 1
Recurring Incremental OMDP Costs

Fixed indirect costs include depreciation, taxes, insurance, and general and administrative expenses. We based our analysis on BNA's continued use of its facilities to perform work for NASA and other customers, primarily the Department of Defense (DoD).

If OMDP's are at Palmdale, NASA would pay approximately \$15.57 million of BNA's fixed indirect costs for the OMDP-related work. If OMDP's are at KSC, the \$15.57 million would be redistributed to the remaining NASA and DoD contracts. NASA would pay about \$11.22 million, or \$4.35 million less, but DoD's contract costs would increase by \$4.35 million.

**3 - COMPUTERS AND
TELECOMMUNICATIONS**

BNA accumulates personal computer, telephone, and telecommunications costs in a pool and allocates the costs based on "productive" labor. Productive labor can be direct or indirect. It does not include vacation, holiday, or sick leave. About \$1.04 million would be allocated directly to the OV-102 OMDP for computer and telecommunications costs.

4 - ORBITER TRANSPORT

NASA spends about \$1.67 million to ferry the orbiter to California when OMDP's are at Palmdale. These costs, which can be avoided if OMDP's are at KSC, are for technician and support labor to prepare the orbiter for transport, tail cone assembly/disassembly, a C-141 pathfinder aircraft, mating/demating the orbiter to the Shuttle carrier aircraft, fuel, and related travel costs.

**5 - CIVIL SERVICE
SUPPORT**

Shuttle processing and quality control employees at KSC travel to California when the OMDP is at Palmdale. NASA's FY 1997 budget included \$252,000 for this travel in FY 1999.

**6 - RECERTIFICATIONS/
TRAINING**

The new hires at KSC will require about 1 month for training and recertifications. These salary and employee benefit costs are \$1.16 million for 228 employees and \$1.29 million for 255 employees. Although additional employees must be hired to complete OMDP requirements, these employees would **not** perform the work, at least initially, during the OMDP. USA would use its more experienced employees for the OMDP-related work, supplemented with the new hires.

7 - "EXCESS CAPACITY"

Excess capacity results from USA's continued retention of the new hires for OMDP's at KSC. BNA has either laid off

Exhibit 1
Recurring Incremental OMDP Costs

employees or assigned them to other contracts when an orbiter was not at Palmdale for an OMDP.

Because three OMDP's are scheduled every 4 years, an OMDP averages about 16 months. The period begins when the orbiter lands and ends when it is launched after the OMDP and includes post- and pre-flight processing. Of the 16-month period, about 10 months would be required for structural inspections and modifications; 1 month, for vacations and holidays; 1 month, for recertifications and training (see note 6); and about 4 months would be "excess capacity" (or downtime).

NASA and USA officials stated the new employees would not be idle but would be used productively during the 4 months. They would assist the existing workforce performing post- and pre-flight processing of the OMDP orbiter. This effort could shorten the OMDP by 30 to 45 days. In addition, ferry preparation time would not be required if OMDP's were at KSC, and overtime could be reduced. We estimated the costs for excess capacity to be the equivalent of 1 month's labor and employee benefit costs for the new employees—\$1.16 million if existing KSC facilities are used and \$1.29 million if an additional facility is used.

**8 - WAREHOUSE
CONSOLIDATION**

BNA would incur one-time costs of \$300,000 to eliminate and consolidate some warehouse space at Palmdale if OMDP's are at KSC. This action would generate annual "savings" of \$600,000 by eliminating the \$400,000 lease and \$100,000 security costs and by decreasing utilities by \$100,000. See also Exhibit 2, Note 1.

9 - DESIGN ENGINEERS

About 15 BNA design engineers would travel to KSC during the OMDP. BNA has a staff of about 100 operational engineers at KSC; but the design engineers in Downey, California, authorize all changes to the orbiters. The distance from the orbiter and time zone difference would cause delays in completing required work. Collocating design engineers with the orbiter at KSC during an OMDP or transfer of design authority to KSC would expedite the process. We estimated travel and indirect costs for these engineers to be \$1.71 million.

**10 - MATERIAL AND
EQUIPMENT SHIPMENTS**

When OMDP's are at Palmdale, ground support equipment must be transferred from the Dryden Flight Research Center and KSC

Exhibit 1
Recurring Incremental OMDP Costs

to Palmdale; spare parts are shipped from the NSLD in Cape Canaveral, Florida, to Palmdale; and repaired parts are returned from NSLD to Palmdale. The cost for these shipments is estimated at \$100,000.

Because BNA would continue to manufacture Shuttle mission and modification kits, the kits must be shipped to KSC if OMDP's are at KSC. The cost for these shipments is estimated at \$135,000.

**11 - BUILDING OPERATION
AND MAINTENANCE**

About \$1.59 million would be required for janitorial services, maintenance, utilities, and security in the new facility at KSC. Refer to Exhibit 2 for facility construction costs.

12 - FEES

We computed fees on the total costs for the OV-102 OMDP; however, some of the work content, such as structural inspections, may be included in the SFOC contract with no additional fee. For USA's fee on the BNA subcontract effort, we used a fee rate of 7.5 percent, which was submitted by USA for the OV-104 proposal. At the time of our field work, OV-104 negotiations had not been finalized. The fee rate will mostly likely be reduced to 1 percent. The revised fee rate would lower the cost of OMDP's at Palmdale by about \$1.76 million, but our conclusion to perform OMDP's at Palmdale remains unchanged. Consequently, we did not adjust our cost summary to reflect the lower fee rate.

BNA Fee

If OMDP's are at Palmdale, BNA could be awarded a fee of \$2.65 million (9.8 percent of costs). USA could also get \$2.03 million (7.5 percent of BNA's costs) for managing the subcontractor. Total fee for the OV-102 OMDP could be \$4.68 million.

USA Fee

If OMDP's are at KSC, USA's fee, at 12 percent of total costs, would be \$2.58 million if existing facilities are used and \$2.98 million if a new facility is built. The savings to NASA would be \$2.10 million and \$1.70 million, respectively, per OMDP.

FIXED INVESTMENT COSTS AND RECOVERY PERIOD

FIXED INVESTMENT COSTS

NASA would have initial investments to complete OMDP requirements at KSC. If existing facilities are used, an investment of \$6.47 million would be necessary. Performing structural inspections and major modifications during OMDP's **and** processing orbiters to meet scheduled launches would be much riskier unless a new facility is constructed. The total investment for a new facility is \$49.71 million, but the investment is not financially justified.

Table 1: Nonrecurring Costs for KSC OMDP's

(Dollars in Millions)			
Cost Elements	Existing Facilities	New Facility	Note
Warehouse Consolidation	\$0.30	\$0.30	1
Layoff	0.15	0.15	2
Training	5.27	5.52	3
Relocation	0.75	0.75	4
New Facility and Training		42.99	5
Total Investment	\$6.47	\$49.71	

NOTES:

- 1 - **WAREHOUSE CONSOLIDATION:** If the OMDP location is not at Palmdale, BNA would eliminate and consolidate some warehouse space. To achieve these changes, BNA would incur one-time costs of \$300,000. However, this action would result in annual savings of \$600,000. A \$400,000 warehouse lease and \$100,000 for security would be eliminated, and utilities would decrease by \$100,000 (see also Exhibit 1, Note 8).
- 2 - **LAYOFF:** If the OMDP location is at KSC, BNA would lay off employees, primarily from the manufacturing department. BNA estimated layoff costs to be \$150,000.
- 3 - **TRAINING:** USA must train and certify the new hires before an OMDP begins at KSC. These costs are based on the salaries of the required labor disciplines and training time. The estimated costs are about \$5.27 million if existing facilities are used and \$5.52 million if a new facility is constructed. About 30 additional people would be required for the new facility.

Exhibit 2
Fixed Investment Costs and Recovery Period

4 - **RELOCATION:** USA officials estimated it would pay relocation costs for 15 professional employees if the OMDP location is at KSC. We estimated the cost per person to be \$50,000 based on our audit of aircraft consolidation (Audit Report HA-96-007, "Aircraft Consolidation at the Dryden Flight Research Center," August 12, 1996). Total relocation costs are estimated at \$750,000.

5 - **NEW FACILITY AND TOOLING.** Another facility would provide more flexibility to meet a manifest that is often revised to meet launch slips and anomalies. Total investment costs for the new facility are \$42.99 million:

- The cost to construct a new building is approximately \$42.26 million. Construction would require 2 years.
- About \$530,000 would be required to outfit the building. Outfitting includes costs for communications equipment and furniture.
- About \$200,000 would be required for tooling. The tools investment would not be necessary if existing facilities are used. The three OPF's contain sufficient tools for OMDP's.

RECOVERY PERIOD

We computed the recovery periods for both investment scenarios at KSC. The recovery, or payback, period is the length of time required for the net savings by locating OMDP's at KSC to return the cost of the investment.

We converted the OMDP savings to an annual basis, escalated them, and computed their present value. We escalated the annual savings because OMDP costs for each company will increase each year due to inflation. Consequently, annual savings will also increase. We used the projected 3.9 percent rate forecast by Data Resources, Inc., for the aerospace industry. Finally, we discounted the escalated annual savings to the present value using the U.S. Treasury rate. We used the 6.25 percent rate effective January 1 through June 30, 1998.

There is inherent uncertainty in estimating future costs through the expected life of the Shuttle Program. We used the savings

Exhibit 2
Fixed Investment Costs and Recovery Period

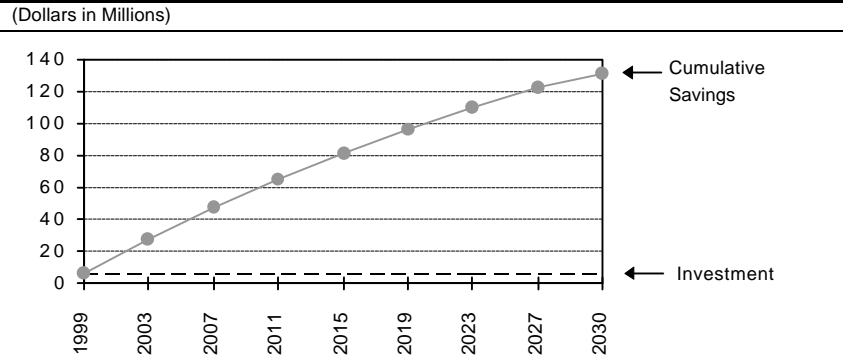
for the OV-102 OMDP to compute the payback period although we recognize that labor costs, in particular, may change because of the difference in experience levels at each location. However, we had no basis for determining realistic labor adjustments. We also did not make adjustments for work content, which will change during subsequent OMDP's.

**Existing KSC Facilities
Used for OMDP's**

Figure 1 shows NASA would recover the one-time \$6.47 million investment with the \$7.60 million savings from the first OMDP at KSC. The cumulative present value of the annual savings is \$131.73 million. Deducting the \$6.47 million investment results in a net present value (NPV) of \$125.26 million. Present value is the value in 1999 of the future escalated cost savings, discounted at the appropriate interest rate. NPV is the present value minus the cost of the investment.

We used the year 2030 as the end of the Shuttle Program. Although uncertain at this time, NASA is evaluating upgrades to extend the life of the program to 2030. The Shuttle could be replaced by another reusable launch vehicle prior to that time.

Figure 1: Present Value of Cumulative Savings and Investment Without a New Facility (1999 to 2030)



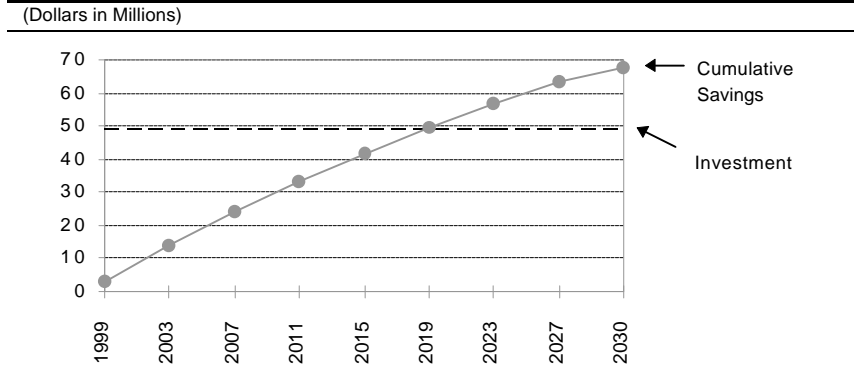
Note: The savings are plotted after every three OMDP's, or every 4 years.

Exhibit 2
Fixed Investment Costs and Recovery Period

*New Facility at KSC
for OMDP's*

KSC requires a modification facility to minimize risk if OMDP's are at that location. The economic advantage with another facility is speculative. Considering the time value of money, NASA would not recover the \$49.71 million investment shown in Figure 2 until 2020, well beyond the deployment schedule of the ISS slated for completion in FY 2004. If the Shuttle is replaced with the next-generation reusable launch vehicle, there may not be an alternative use for the facility constructed for OMDP's. If another use is not identified, NASA could spend its limited funds to construct and maintain a building that may not be utilized.

Figure 2: Present Value of Cumulative Savings and Investment With a New Facility (1999 to 2030)



Note: The savings are plotted after every three OMDP's, or every 4 years.

OBJECTIVES, SCOPE, AND METHODOLOGY

OBJECTIVES

The purpose of the audit was to evaluate NASA's decisions to continue using the Palmdale facility for OMDP's. Specifically, we wanted to answer the following questions:

1. What is the most appropriate location for orbiter maintenance and modification work based on cost factors and programmatic impacts?
2. How does the award of a single prime contract affect future decisions about OMDP location?
3. Are facilities, infrastructure, and workforce adequate at KSC for performing future orbiter maintenance and modification work?

SCOPE AND METHODOLOGY

The Associate Administrator for Space Flight and the Space Shuttle Program Manager directed a NASA Shuttle Program/USA team to study the "best value" location for OMDP's. The team was tasked to analyze the cost, operational, and programmatic implications of performing OMDP's at KSC and Palmdale. NASA officials at Johnson Space Center (JSC) and KSC and representatives from USA and BNA participated in the team review. The team performed its review concurrent with our audit work. We attended the team's meetings and participated in weekly telephone conferences. We validated information provided by the team or made adjustments, as appropriate. We shared cost data and other information with the team to minimize duplication.

We evaluated the most appropriate location for OMDP's based on the Shuttle Program goals to fly safely, meet the manifest, improve mission support, and reduce costs. We established the following criteria:

- We would perform an incremental cost analysis. Incremental costs are those costs that change depending on OMDP location. The incremental cost comparison was based on planned work for the OV-102 OMDP scheduled to begin in the first quarter of FY 1999. We recognize that considerable variability in work content may occur and that duration may vary during subsequent OMDP's, but we considered the cost differential to be representative and adequate for evaluating location based on costs.

Appendix 1
Objectives, Scope, and Methodology

- USA would need additional employees to perform OMDP work. USA's existing workforce at KSC must perform Shuttle processing operations.
- BNA would continue to use its Palmdale facility to manufacture orbiter parts, such as external tank disconnects and mission/modification kits, and to perform other NASA contracts. We did not assess whether further cost savings and efficiencies could result from the consolidation of all manufacturing activities at KSC.
- The OMDP could be scheduled at either Palmdale or KSC. We evaluated two facility options for the KSC location.

***Cost and
Programmatic Areas***

To calculate incremental costs, we identified areas where costs would change depending on OMDP location. We evaluated BNA's forward pricing rate model to compute incremental indirect costs and to assist in determining USA's incremental indirect costs. We also used USA's forward pricing rate information to compute its incremental indirect costs. We used forward pricing or escalated actual rates to compute indirect and labor costs. We used rates in effect as of May 1997.

We assessed the conversion of BNA labor hours to required KSC staffing and hours. We evaluated the detailed construction estimates for a new modification facility. We discussed costing methodology with cognizant officials for areas such as "excess capacity," ferry flights, training, travel, and shipping cost.

To determine safety processes and procedures, we consulted with safety and reliability officials at Palmdale and KSC and reviewed BNA and USA safety assessments.

To assess manifest impact and long-term support, we reviewed flight rate goals and Shuttle upgrade plans and interviewed program officials about long-term program goals. We reviewed "as-run" schedules for historical flight rates. We compared the ISS flights in the November 20, 1997, manifest to the planned OMDP's as of October 13, 1997.

Appendix 1
Objectives, Scope, and Methodology

Single Prime Contract

To determine the effect of the award of a single prime contract on OMDP location, we reviewed contract, program, and joint venture documents. We also consulted with program officials and the OIG attorney advisor.

KSC Infrastructure

To evaluate the adequacy of KSC's facilities, we reviewed manifest and facility studies prepared by NASA and USA officials and evaluated USA's study for a new facility. To evaluate employee skills, we discussed the capabilities of the KSC workforce with several officials and assessed training and certification requirements. We also toured USA and NASA facilities at KSC.

NASA and USA completed manifest and facility studies to determine the impact on meeting the manifest by scheduling OMDP's in KSC facilities. USA considered 13 options in its facility study, including:

- Modifying the operations and checkout facility
- Modifying the space station processing facility if it becomes available
- Modifying the McDonnell Douglas facility in Titusville, Florida
- Building a new facility on Launch Complex 39 at KSC

AUDIT FIELD WORK

We conducted our audit from April 1997 to February 1998 in accordance with generally accepted government auditing standards. We did our field work at NASA Headquarters, KSC, JSC, and Downey and Palmdale, California.

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KSC INFRASTRUCTURE

INFRASTRUCTURE NEEDS CHANGED

Infrastructure—the underlying foundation for operation—includes people, facilities, and business practices. The existing infrastructure at KSC needs to be changed to accomplish OMDP requirements and meet the goals of timely launches at an increased flight rate.

- A new modification facility is required.
- Additional employees are needed.
- Organizational structure must change.

Facility Needed

A new facility or significantly reduced processing time is required to accomplish OMDP requirements and meet the goals of timely launches at increased flight rates. With only three OPF's, the impact of processing disruptions significantly increases with four vehicles at KSC for all activities. One of the OPF's would be used almost exclusively for OMDP's. A new modification facility would allow for reduced schedule risk, increased processing efficiency, and increased flight rate.

Managers currently plan about 80 calendar days to process an orbiter. In addition to normal inspections and tests, such things as in-flight anomalies and hardware failures may occur and must be corrected, if necessary, during flight processing. Other OPF activities include removal of hazardous materials and orbiter preparation for the ferry flight to California.

With current capabilities, KSC facilities can support both OMDP operations and orbiter processing with a flight rate of eight or nine per year. Reducing processing time allows KSC facilities to accommodate OMDP work with higher flight rates. However, the OPF's would be almost fully utilized. There would often be less than 2 weeks from the time a vehicle leaves an OPF and another is rolled in after landing at KSC. The impact of anomalies, such as roll-out slip, weather-related launch slip, hurricane rollback, or main engine problems, could be severe. An orbiter may have to be moved (bumped) to temporary storage in the vehicle assembly building, potentially delaying launch dates because of additional processing times. This situation could jeopardize ISS assembly launches.

At the time of our review, the most viable and cost-effective option for a new facility was constructing a building on Launch

Appendix 2
KSC Infrastructure

Complex 39. To keep costs to a minimum, the new facility would not have the capability to service hazardous propellants. However, the costs to construct the new facility would not be recovered until the year 2020. The alternative to increasing facility capacity at KSC would be to schedule OMDP's at Palmdale. See Exhibit 2 for construction costs.

***Increased
Staffing Needed***

USA employees are competent to complete maintenance and modification tasks during an OMDP. Labor skills are adequate to assure no increased risk to the Shuttle Program. The qualifications to process orbiters for flight are similar to the experience needed to complete work during an OMDP. USA employees also routinely implement orbiter modifications, albeit minor, during flight processing. However, additional employees are needed to staff OMDP operations—about 225 in existing KSC facilities and 255 in a new facility. These employees will require training and relevant certification. Refer to Exhibit 1, Notes 1 and 6, for more information on labor costs and hours.

***Organizational
Changes Needed***

Organizational changes will be required if OMDP's are located at KSC. USA's environment does not provide the separation of normal processing from required work during OMDP's. USA concentrates its efforts on ensuring the Shuttle is processed to meet the launch manifest. The highest priority is the next orbiter to be launched. An orbiter in OMDP is not critical to meeting near-term launches.

The separation of flight hardware processing from flight hardware modification currently exists with OMDP's at Palmdale. If OMDP's are at KSC, organizational changes may be required to accommodate the new requirements. Although efficiencies may be attainable with a shared workforce, procedures must be in place to ensure that sufficient attention is given to an orbiter in OMDP. USA management recognizes that these changes will be needed.

BACKGROUND

ORBITER MAINTENANCE DOWN PERIODS

NASA maintains a fleet of four orbiters⁷ in its space transportation system. The vehicles are taken out of service for an OMDP about every 3 years or after no more than eight flights. Structural inspections and modifications are performed during an OMDP.

Six OMDP's have occurred since 1991. The orbiter design contractor, BNA, or its predecessor, completed work for five OMDP's at its Palmdale, California, facility. One OMDP was located at KSC. The OMDP at KSC consisted of structural inspections and *minor* modifications. Since that time, OMDP's have included *major* modifications—alterations to improve the Shuttle's safety, operational quality, and long-term support and to extend its life. For example, recent OMDP's have included installation of external airlocks for docking capability to the Russian Mir and ISS and thermal tile weight reductions.

In 1996, NASA consolidated 12 separate flight operations contracts into the Space Flight Operations Contract (SFOC). The award of SFOC to USA was the first step to effect efficiencies in and privatization of the Shuttle Program. If OMDP's are located at KSC, USA would perform the work. If OMDP's are at Palmdale, USA would subcontract with BNA.

There are approximately three OMDP's in a 4-year period. With NASA's plans to upgrade the Space Shuttle system for use through the year 2030, about 24 OMDP's may be scheduled during the remaining life of the Shuttle Program. Table 2 shows the near-term OMDP schedule.

Table 2: OMDP Schedule
(1998 to 2004)

Orbiter	Begin Date	End Date
OV-102	October 1998	June 1999
OV-103	March 2000	November 2000
OV-105	May 2001	January 2002
OV-104	July 2002	March 2003
OV-102	August 2003	April 2004

Source: KSC Manifest Assessment dated October 13, 1997

⁷ The four orbiters are: OV-102 (Columbia), OV-103 (Discovery), OV-104 (Atlantis), and OV-105 (Endeavor).

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PRIOR REPORTS

NASA/USA Team	“Orbiter Maintenance Down Period (OMDP) Analysis,” January 13, 1998, issued by the Director, Johnson Space Center, to the NASA Associate Administrator for Space Flight.
NASA Office of Inspector General	“Impacts of Performing Orbiter Maintenance Down Periods at KSC versus Palmdale,” Report No. KE-96-001, October 24, 1995.
NASA Office of Space Flight	“Final Report on Comparing Orbiter Maintenance Down Period (OMDP) Cost at KSC and Palmdale,” November 12, 1993, issued by the Director of Space Shuttle Operations to the Director of Space Shuttle Program.

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MANAGEMENT'S RESPONSE

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001



APR 20 1998

Reply to Airtel of M-7

TO: W/Assistant Inspector General for Auditing
FROM: M-7/Deputy Associate Administrator for Space Shuttle
SUBJECT: Response to Draft Report on Follow-up Audit on
Orbiter Maintenance Down Periods at KSC
(Assignment Number A-HA-97-043)

We have reviewed the referenced draft report and concur with your findings and recommendation. We have three minor comments to the draft report, none of which impact the findings or recommendation. Two of these comments are editorial in nature and one is a clarification on USA fee calculation. These comments are contained in enclosure 1.

We fully support your recommendation, "...to reevaluate OMDP location when significant changes occur to the Shuttle program...". We will continue to evaluate upcoming OMDP locations as part of our normal process. However, as our study and your report states, for now the most appropriate location for the bulk of OMDP work is Palmdale. We appreciate the opportunity to work with you and your staff on this subject.

A handwritten signature in black ink, appearing to read "Stephen S. Oswald".

Stephen S. Oswald

Enclosure

cc:
JM/J. Werner
M-7/L. Cywanowicz
MX/G. Gabourel
JSC/BD-5/P. Ritterhouse
MA/T. Holloway
MV/W. Gerstenmaier
KSC/PH/R. Sieck
HM-CIC/J. Nary

Appendix 5
Management's Response

Response to Draft Report on Follow-up Audit on
Orbiter Maintenance Down Periods at KSC
(Assignment Number A-HA-97-043)

1. On Page 3 in the next to the last paragraph of the Results of the Audit section a sentence is duplicated. We suggest the following correction:

Draft report: "When OMDP's are at Palmdale, USA subcontracts the work to BNA. When OMDP's are at Palmdale, USA subcontracts the work to BNA."

Suggestion: "When OMDP's are at KSC, USA performs the work. When OMDP's are at Palmdale, USA subcontracts the work to BNA."

See p. 3

2. On page 29, we suggest the following correction as a clarification:

Draft report: " To keep costs to a minimum, the new facility would not have the capability for removal of hazardous waste."

Suggestion: " To keep costs to a minimum, the new facility would not have the capability for the servicing of hazardous propellants."

Now on p. 26

3. On page 15, item 12 Fee, An additional sentence should be added to clarify the USA fee for USA subcontracted work. The paragraph uses the word "could" for the fee discussion, but the implications of the more likely actual fee should be addressed by the addition of several sentences to paragraph two.

Suggestion(new sentences): "The USA fee on BNA subcontracted work used in this report of 7.5% represents the fee rate submitted by USA in the OV-104 proposal. Final negotiations with USA on this proposal will most likely reduce the USA fee on BNA subcontracted work to 1%. The 1% fee is consistent with the current contract. This fee change will not effect any of the final conclusions of this report. This fee change would lower the cost of OMDP's at Palmdale by ~1.8M\$. Thus the savings for OMDP's at KSC would be reduced by this amount. The conclusion to perform OMDP's at Palmdale stands."

See p. 8 and
comments now
on p. 16

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Major Contributors to the Report

Lee T. Ball

Sandra L. Laccheo

Timothy L. Bailey

Teresa S. Danne

Acting Program Director for Human Exploration and Development of Space

Auditor-in-Charge

Staff Auditor

Staff Auditor