

GAO

Briefing Report to the Ranking Minority
Member, Subcommittee on Space and
Aeronautics, Committee on Science,
House of Representatives

May 1995

CASSINI MISSION

Estimated Launch Costs for NASA's Mission to Saturn





United States
General Accounting Office
Washington, D.C. 20548

National Security and
International Affairs Division

B-260888

May 8, 1995

The Honorable Ralph M. Hall
Ranking Minority Member
Subcommittee on Space and Aeronautics
Committee on Science
House of Representatives

Dear Mr. Hall:

In April 1994, the National Aeronautics and Space Administration (NASA) estimated that it would cost about \$475 million for a Titan IV-Centaur launch of its Cassini spacecraft. Concerned about the cost, as the Chairman of the former Subcommittee on Space, House Committee on Science, Space, and Technology, you requested that we provide information about the current estimated cost for the Cassini launch and determine the extent to which cost saving opportunities exist. On April 11, 1995, we briefed your staff on the results of our work. This report contains the information presented at that briefing.

Background

NASA plans to launch its Cassini spacecraft to Saturn in October 1997. Following a voyage of more than 6 years, the spacecraft will orbit Saturn for 4 years. Cassini will provide intensive, long-term observations of Saturn's atmosphere, rings, magnetic fields, and moons. Cassini's probe will be used to analyze the atmosphere of Saturn's largest moon, Titan.

Cassini, a joint U.S.-European mission, was originally paired with a project to explore comets and asteroids, the Comet Rendezvous Asteroid Flyby (CRAF). Cassini was first funded by Congress in fiscal year 1990. Since then, CRAF was canceled, and Cassini's original scientific capabilities have been reduced and its launch schedule extended.¹

NASA is responsible for the overall success of the Cassini mission, including integrating the spacecraft with the launch vehicle and approving the final launch. Under an agreement with NASA,² the Air Force will provide a

¹Changes to CRAF/Cassini projects are described in *Space Science: Causes and Impacts of Cutbacks to NASA's Outer Solar System Exploration Missions* (GAO/NSIAD-94-24, Dec. 29, 1993).

²"Memorandum of Agreement between the National Aeronautics and Space Administration and United States Air Force on Titan IV-Centaur Launch Support for the Cassini Mission," Aug. 11, 1994.

Titan IV expendable launch vehicle³ with a Centaur upper stage⁴ and launch service from Cape Canaveral Air Force Station in Florida.

Results in Brief

NASA's most recent estimate for the Titan IV-Centaur launch of its Cassini spacecraft is about \$452 million, approximately \$23 million less than its \$475-million estimate in April 1994. The decrease occurred principally because NASA reduced its earlier estimate of mission integration costs. The \$452-million estimate includes about \$253 million paid to the Air Force for a Titan IV-Centaur launch vehicle and launch services. The remaining Cassini launch costs are NASA funding to pay for potential future cost increases, mission integration, prior-year studies, support by two NASA field centers, and miscellaneous costs. The Air Force estimates that its cost for launch vehicle and services is about \$98 million more than the \$253 million NASA will pay. Air Force officials believe there are benefits to providing a launch vehicle for Cassini. For example, the Air Force will avoid an estimated \$11.5 million to \$13.8 million in storage charges and will reduce mission reliability risk due to the aging of components.

Reductions in the cost of the Cassini launch may be possible because NASA recently completed its negotiation of the mission integration contract for \$15 million less than estimated. However, cost savings in other areas of the Cassini launch are unlikely, and some of NASA's costs could increase. Also, NASA missed a potential cost-saving opportunity because its agreement with the Air Force does not require the Air Force to refund NASA payments in excess of cost. Consequently, the Air Force is not required to refund to NASA fees that the Air Force does not pay to the Titan IV contractor. These fees include \$2 million in award fees and a \$9-million incentive fee. In addition, NASA's mission integration contract does not fully comply with the agency's revised policy for cost-plus-award-fee contracts, which was implemented to encourage contractors to deliver quality products at reasonable costs.

Scope and Methodology

We obtained and analyzed NASA and Air Force documents, including memoranda of agreement, estimated and negotiated costs, funding and budget data, the mission integration contract, and launch and production schedules. We interviewed personnel in NASA's Office of Space Science and in the Office of the Assistant Secretary of the Air Force (Acquisition) in Washington, D.C. We also obtained information from officials at the

³An expendable launch vehicle is a disposable, unpowered launcher.

⁴An upper stage provides propulsion to carry a payload from a lower to a higher orbit around earth.

Titan IV Systems Program Office, Space Systems Division, Air Force Systems Command, Los Angeles, California, and the Launch Vehicles Project Office, Lewis Research Center, Cleveland, Ohio.

We performed our work from August 1994 to March 1995 in accordance with generally accepted government auditing standards. As agreed with your office, we did not obtain written agency comments on this report. However, we discussed the information in a draft of this report with officials from NASA and the Air Force and incorporated their comments where appropriate.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 10 days from its issue date. At that time, we will send copies of this report to the NASA Administrator, the Secretaries of Defense and the Air Force, the Director of the Office of Management and Budget, appropriate congressional committees, and other interested parties upon request.

If you or your staff have any questions concerning this report, please contact me on (202) 512-8412. The major contributors to this report were Frank Degnan, Raymond H. Denmark, and Sandra D. Gove.

Sincerely yours,

A handwritten signature in black ink that reads "David R. Warren". The signature is written in a cursive style with a long horizontal flourish at the end.

David R. Warren, Director
Defense Management and NASA Issues

Cassini Launch Costs

GAO Estimated Cassini Launch Costs

Dollars in millions

Item	Amount
Vehicle and launch services	\$253.4
Reserved funding	38.0
Integration contract	104.7
Other integration	5.0
Prior-year studies	25.7
Lewis support	15.6
Kennedy support	5.5
Miscellaneous	3.8
Total	\$451.7

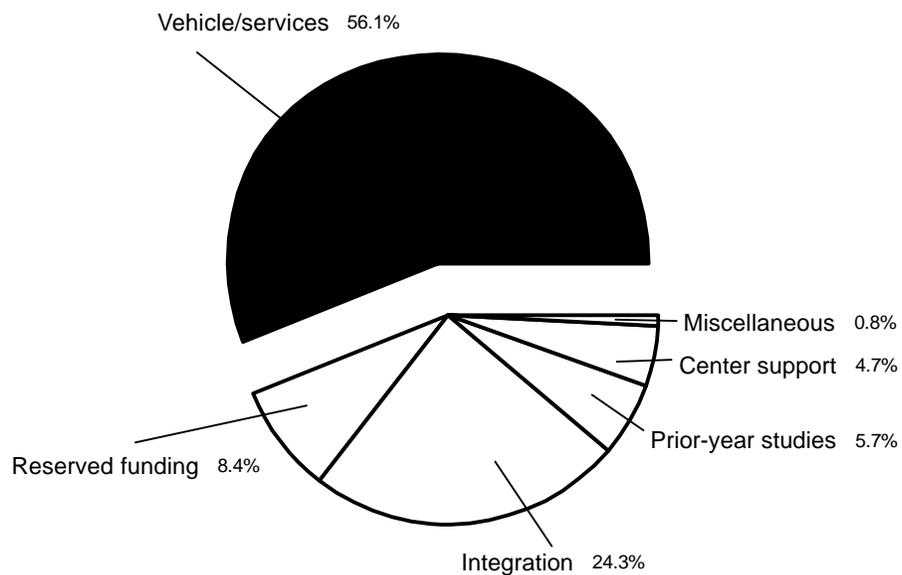
Source: NASA's fiscal year 1996 budget and data provided by NASA.

The National Aeronautics and Space Administration (NASA) estimates the Titan IV-Centaur launch of the Cassini spacecraft will cost \$451.7 million, or about 17 percent of NASA's total estimated cost of \$2.7 billion for the mission. NASA's current estimate is about \$23 million less than its \$475-million estimate in April 1994. The decrease occurred principally because NASA reduced its earlier estimate of mission integration costs.

NASA will pay the Air Force \$253.4 million for a Titan IV-Centaur launch vehicle and launch services for Cassini. Other estimated launch costs in NASA's fiscal year 1996 budget include \$38 million in funding reserves to be held by NASA to pay for future modifications to the launch vehicle and other unanticipated cost increases; \$104.7 million for an integration contract; and \$55.6 million for other integration, prior-year studies, support provided at two NASA field centers, and miscellaneous items.

GAO Cassini Launch Costs

Percentage of dollars



Source: GAO analysis of data provided by NASA.

Briefing Section I
Cassini Launch Costs

About 56 percent of the total estimated launch cost is for the vehicle and launch services provided by the Air Force. The mission integration contract and other integration costs account for about 24 percent of estimated launch costs; reserved funding, prior-year studies, center support, and miscellaneous items account for the remaining 20 percent.

GAO Costs for Launch Vehicle & Launch Support Services

Dollars in millions

Category	NASA cost
Titan core booster	\$109.2
Centaur upper stage	70.9
Mission-unique hardware	25.3
Range support	10.6
Miscellaneous	9.7
Mission success incentive	9.1
Propellant	7.0
Technical support	5.1
Generic integration	4.5
Award fee	2.0
Launch operations	0.0
Total	\$253.4

Source: Memorandum of agreement between NASA and the Air Force, Aug. 11, 1994.

According to an August 1994 memorandum of agreement (MOA), which was established under the authority of the Economy Act (31 U.S.C. 1535), NASA will pay the Air Force \$253.4 million for a Titan IV-Centaur vehicle and launch support services. Under its agreement with the Air Force, NASA was also to retain \$45 million to pay for future cost increases or unanticipated future changes to hardware. This reserved funding is discussed later.

Over \$205 million, or about 80 percent of the \$253.4 million in charges for launch service under the agreement, is for launch vehicle hardware—the Titan IV core booster with a solid rocket motor upgrade, Centaur upper stage, and mission-unique hardware.⁵ Almost \$37 million is for a variety of items, including range support, miscellaneous costs (including storage), propellant, technical support, and integration tasks that are not unique to the Cassini mission, which are being performed under an Air Force contract. The remaining charges of about \$11 million cover award fees and a mission success incentive to be paid to the launch vehicle contractor for a successful launch.

⁵About half of the cost of mission-unique hardware, or \$12 million, is for a Space Vehicle Destruct System. This system is required because the Cassini spacecraft will use plutonium-powered Radioisotope Thermoelectric Generators.

GAO NASA's Cost Compared With Air Force Estimate

Dollars in millions

Category	NASA cost	Air Force estimate	Difference
Titan core booster	\$109.2	\$133.2	\$24.0
Centaur upper stage	70.9	79.0	8.1
Mission-unique hardware	25.3	25.3	0.0
Range support	10.6	15.3	4.7
Miscellaneous	9.7	9.7	0.0
Mission success incentive	9.1	9.1	0.0
Propellant	7.0	5.7 ^a	-1.3
Technical support	5.1	5.1	0.0
Generic integration	4.5	4.5	0.0
Award fee	2.0	2.0	0.0
Launch operations	0.0	62.5	62.5
Total	\$253.4	\$351.4	\$98.0

^aA more recent Air Force estimate of propellant cost is discussed later.

Source: NASA cost based on memorandum of agreement, Aug. 11, 1994; Air Force estimate as of September 1994.

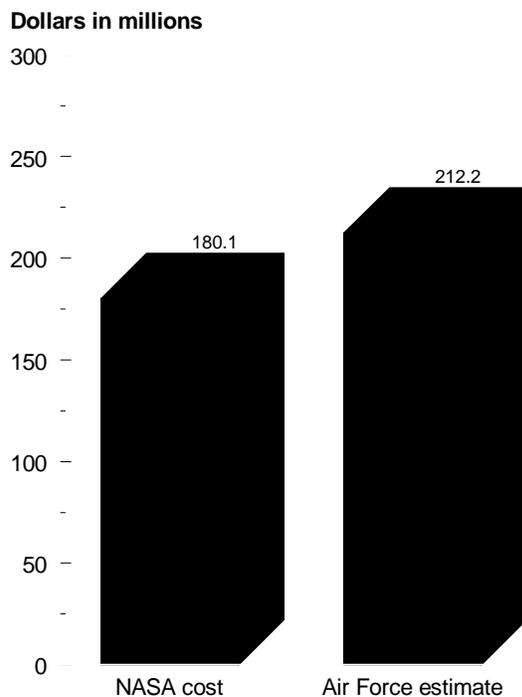
The total charges to NASA under the agreement are \$98 million less than a September 1994 Air Force estimate for the Titan IV-Centaur launch vehicle and launch services. NASA costs, except for range support and launch operations, reflect initial contract costs or estimated costs at varying points during the period when NASA and the Air Force were negotiating the agreement.

Air Force officials stated there are a number of benefits associated with the agreement. For example, the Air Force has a backlog of hardware because it has launched Titan IVs at much lower rates than originally planned. By providing a Titan IV unit to NASA, the Air Force avoids an estimated \$11.5 million to \$13.8 million in storage charges and reduces mission reliability risk due to the aging of components.⁶

⁶However, NASA will pay an estimated \$7 million in storage charges. These charges are included in the "miscellaneous" category in the table.

GAO Launch Vehicle Cost Difference

- NASA is paying the initial contract cost for the Titan booster and upper stage.
- NASA is not paying cost increases stemming from subsequent slowdowns.



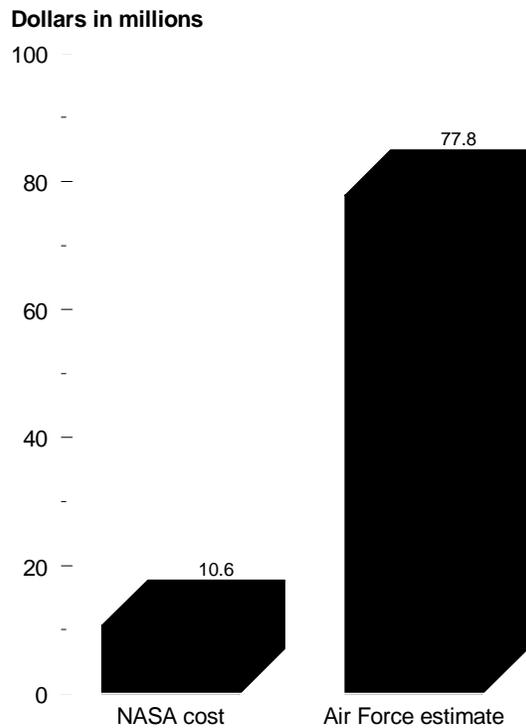
Source: GAO analysis of data provided by the Air Force.

The \$98-million difference between NASA charges under the agreement and the later Air Force estimate is primarily due to two reasons. First, NASA is paying the initial contract cost for the specific unit that it will use but not cost increases stemming from subsequent slowdowns in launch vehicle production.

Recent production slowdowns were necessary because the Air Force has launched Titan IVs at much lower rates than originally planned. The launch vehicle that the Air Force is providing to NASA was acquired under an existing \$12.1-billion contract with Martin Marietta for 41 vehicles. The Air Force negotiated a number of production slowdowns with the Titan IV contractor during the period when NASA and the Air Force were negotiating the launch costs for Cassini. Each slowdown resulted in an increase in Titan IV unit costs. The Air Force estimates that production slowdowns have added about \$32 million in costs to the Titan IV-Centaur vehicle it is providing to NASA. However, under the MOA, NASA is not paying the increased costs as the Air Force's Titan IV classified customer is required to do.

GAO Range Support & Launch Operations Cost Differences

- Air Force is not charging NASA for routine, recurring costs.



Source: GAO analysis of data provided by the Air Force.

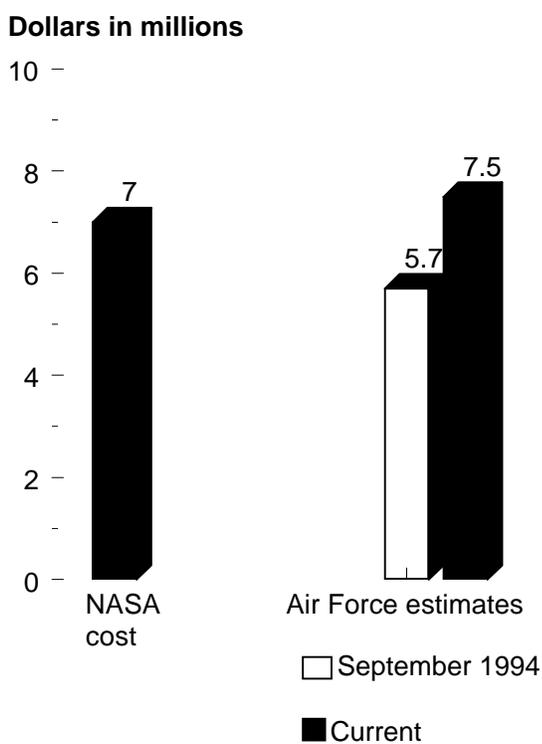
Second, under a reciprocal agreement,⁷ the Air Force is not charging NASA for the routine, recurring costs of operating and maintaining launch facilities and ranges. These are funded annually by the Air Force at a set amount and prorated among scheduled launches for the fiscal year. NASA will not reimburse the Air Force for about \$63 million in estimated costs for launch operations, including the receipt, inspection, assembly, integration, servicing, and testing of the Titan IV system. NASA will pay \$10.6 million, or almost \$5 million less than the Air Force estimate, for range support. NASA range support charges are based only on those services that are directly related to the Cassini mission, such as planning and range documentation, safety, security, launch pad refurbishment, contractor supplies, and utilities.

The Air Force has a different arrangement with its other Titan IV customer for launch services. For example, the Air Force funds the classified user's launch services at Cape Canaveral. The classified user funds all launch services for its West Coast launches.

⁷Memorandum of Agreement between the National Aeronautics and Space Administration and United States Air Force on Launch Services and Range Support to Government Expendable Launch Vehicle Programs," Feb. 1, 1994.

GAO Propellant Cost Difference

- NASA's cost is based on an earlier, higher estimate.
- The Air Force's current estimate exceeds NASA's cost.

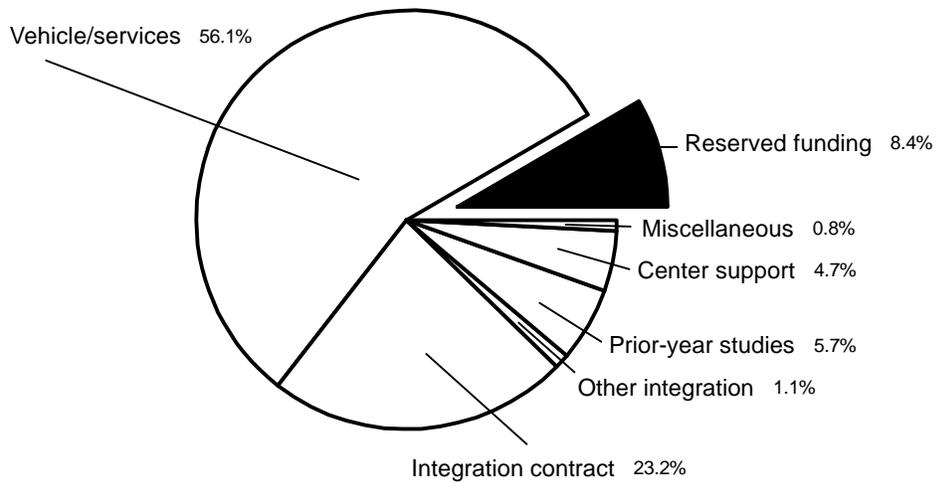


Source: GAO analysis of data provided by the Air Force.

NASA is paying \$7 million for propellant—\$1.3 million more than the Air Force's September 1994 estimated cost for propellant because NASA's cost is based on an earlier, higher price. A NASA official noted that the cost of propellants has fluctuated significantly in recent years, and NASA and the Air Force established the cost early in discussions about Air Force launch support for the Cassini mission. The NASA official also noted that propellant cost was not an area of concern for NASA or the Air Force, because it represents a small fraction of total launch costs. Air Force officials noted that the Air Force's current estimate for Titan IV propellant is \$7.5 million, or about \$500,000 more than NASA's cost under the agreement. The Air Force will absorb the projected higher cost.

GAO Reserved Funding

NASA will retain \$38 million, or about 8 percent of estimated launch costs, to pay for future changes.



Source: GAO analysis of data provided by NASA.

Under its agreement with the Air Force, NASA agreed to retain \$45 million, or about 10 percent of the estimated cost of the Cassini launch, to pay for future cost increases or unanticipated future changes to hardware. However, NASA's fiscal year 1996 budget estimate includes \$38 million in reserved funding. NASA officials said the reserved funding reduction was made when the agency was directed by Congress to reduce its launch budget by \$7 million.

The \$45-million funding reserve estimate established in the MOA was developed by the Air Force based on experience, historical data, and estimated hardware costs. The current Air Force funding reserve estimate is almost \$67 million. NASA will have to pay for any costs for changes for the Cassini launch that exceed its current reserved funding level of \$38 million.

Changes covered by reserved funding can stem from mission-driven, safety, or mission assurance modifications or from other unanticipated cost increases, including those for integration and launch services. Approximately \$11.7-million worth of hardware changes have already been proposed by or negotiated with the launch vehicle contractor. An Air Force official noted that the Air Force was aware of the need for some of these changes when NASA and the Air Force were negotiating the agreement, and the Air Force is in the process of determining if it will charge NASA for these costs.

GAO Mission Integration Costs

Dollars in millions

Item	Maximum cost
Payload integration	
Cost	\$76.1
Award fee	8.3
Base fee	1.9
Minimum positive incentive	1.2
Total payload integration	87.5
Special studies and analyses	
Cost	\$1.8
Award fee	0.2
Base fee	^a
Total special studies and analyses	2.0
Total contract cost	\$89.5

^aBase fee for special studies and analyses is \$43,750.

Source: NASA's mission integration contract.

NASA's fiscal year 1996 budget includes \$104.7 million for a Cassini mission integration contract. In December 1994, NASA finalized an \$89.5-million cost-plus-award-fee contract to integrate the Cassini spacecraft with the Titan IV launch vehicle. The contract is divided into two main areas—\$87.5 million for payload integration and \$2 million for special studies and analyses. Estimated fees in the contract total \$11.7 million, including \$8.5 million in award fees, \$1.9 million in base fees, and a \$1.2-million performance incentive fee that will be paid to the contractor for successfully completing integration tasks in a timely manner.⁸

Although the Air Force has a separate contract providing for integration services on Titan IV launches, it has agreed to allow NASA to contract directly for these services for the Cassini mission. NASA officials believe the direct contract will enhance the agency's ability to manage integration activities for Cassini and to control costs. NASA's Lewis Research Center will oversee mission integration.

⁸The performance incentive may be increased by award fee not paid to the contractor up to a total of \$2 million, as discussed in more detail later.

GAO Mission Integration Contract Cost Elements

- Payload integration
 - management and support
 - launch site services
 - interface design and verification
 - mission-unique hardware and software design
 - independent verification and validation
-

Under NASA's contract, payload integration covers management and support, including launch site services; interface design and verification; mission-unique hardware and software design; and independent verification and validation.

GAO Mission Integration Contract Cost
Elements

- Special studies and analyses
 - task orders
 - related to general scope of payload integration

NASA will issue task orders for special studies and analyses related to the general scope of payload integration.

GAO Other Integration, Studies, Centers' Support, and Miscellaneous Costs

- \$5 million for other integration.
 - \$25.7 million for earlier studies funded through the Air Force.
 - \$21.1 million for support provided by Lewis Research Center and Kennedy Space Center.
 - \$3.8 million for other services.
-

Other mission integration costs of approximately \$5 million include the cost of integration studies and about \$1.7 million to pay the contractor for preparing the proposal and negotiating the integration contract. NASA officials said the contractor, who was already under contract with the Air Force to perform Cassini integration, was paid because there was no reason for the contractor to prepare documentation or to assemble a negotiation team, except to comply with NASA's request for a separate integration contract. NASA believes that the advantages of having a separate integration contract outweighed the added costs. These advantages were discussed previously.

The \$25.7 million for prior-year studies represents the cost of studies funded through the Air Force over a period of 4 or 5 years, when Cassini was paired with the Comet Rendezvous Asteroid Flyby program, which was canceled in 1992. Studies included reviews of launch vehicle integration and performance analysis.

The combined budget for Lewis Research and Kennedy Space Centers for the Cassini mission is \$21.1 million, including costs for launch support activities by contractors and use of facilities. Lewis' responsibilities for the Cassini mission include overseeing the technical areas of the integration contract, independently validating critical analyses, and identifying and defining mission-unique requirements. Kennedy is responsible for a variety of activities, including coordinating Cassini mission and Air Force range activities.

Miscellaneous costs estimated at \$3.8 million cover a variety of services, including government inspections, audits, and contract services at contractors' facilities.

GAO Cost Savings Are Possible, but There Is Also Cost Growth Risk

- Integration contract negotiated for \$15.2 million less than earlier estimate.
 - Most of NASA's costs are firmly established under MOA with Air Force.
 - Costs for range support and launch operations could increase.
 - Maintaining solid rocket motor as option could increase costs.
 - Reserves are below MOA amount.
-

Reductions in the cost of the Cassini launch may be possible. In December 1994, NASA completed negotiations on a mission integration contract with an estimated cost of \$89.5 million—\$15.2 million less than the fiscal year 1996 budget estimate. If other estimated launch costs remain relatively stable, this reduction could lead to a decrease in total estimated launch costs.

However, cost savings are unlikely in other areas of the launch budget, including NASA's \$253.4-million agreement with the Air Force, under which most of NASA's costs are firmly established. In addition, some costs could increase. For example, NASA would have to pay additional costs for range support and launch operations if it is responsible for launch delays or changes that increase Air Force costs. Both NASA and Air Force officials believe such increases are unlikely. A NASA official noted that it is critical that Cassini be launched on schedule, and the agency will make a concentrated effort to do so. He also said the agency has launched all other planetary missions within their initial time frames. An Air Force official said that, due to the way the Air Force contracts for launch operations (i.e., a level of support over a period of time rather than by launch vehicle), a launch delay does not necessarily result in increased costs.

An unresolved issue that could significantly increase NASA's launch costs is that of maintaining the solid rocket motor (SRM) as an option for the Cassini launch. NASA currently plans to use the solid rocket motor upgrade (SRMU) for the Cassini launch. The first use of the SRMU is planned for October 1996, and two other launches using the SRMU are scheduled before the Cassini mission. NASA is currently evaluating the feasibility and cost of maintaining the SRM as a risk reduction option and expects the results in late April 1995. According to NASA officials, maintaining the SRM as an option could add \$50 million or more to the cost of the launch.

One cost category in the Cassini launch budget with the potential for future reduction is that of engineering change orders and risk. However, as previously noted, NASA's current budget reflects a funding level of \$38 million, or \$7 million less than the amount agreed to with the Air Force. If the \$45-million reserve estimate in the MOA is accurate, NASA will overspend, rather than underspend, in this cost category. Also, there is already about \$11.7 million in proposed or negotiated hardware changes, accounting for more than 30 percent of the \$38 million currently budgeted for unanticipated cost increases.

GAO Missed Savings Opportunities

- The MOA does not require the Air Force to refund any NASA payment that exceeds actual costs.
 - Air Force is not required to refund fees it does not pay to the contractor. NASA could pay \$9 million to the Air Force for an unsuccessful launch.
 - Excess payments will be used to fund other program costs.
-

NASA's agreement with the Air Force does not provide for potential cost savings for NASA for the Cassini launch. Under this agreement, there is no provision requiring the Air Force to refund any NASA payment that exceeds actual costs. For example, NASA's payments to the Air Force would not decrease even if actual fees paid to the contractor were lower than the maximum amounts scheduled. This could result in NASA's paying \$9 million to the Air Force to cover the contractor's incentive payment even if the launch is unsuccessful. In addition, NASA's payments to the Air Force for award fees are based on the contractor's maximum potential award fee of \$2 million for the Titan IV vehicle. However, for the last two Titan IV units built, payments have averaged about 90 percent of the total available award fee. Based on this recent payment history, NASA could give the Air Force about \$200,000 more for award fee than the Air Force will pay to the contractor.

A NASA official acknowledged that NASA and the Air Force have not discussed the possibility of the Air Force's refunding incentive or award fees that are not paid to the contractor. He noted that NASA and the Air Force would discuss unpaid fees should a serious performance problem arise, and NASA would probably request that some of the money be refunded or be used for investigating the problem and taking corrective action. An Air Force official noted that excess payments by NASA in incentive or award fees and other cost categories in the agreement will be used to fund other program costs that exceed the price negotiated with NASA.

GAO NASA's Mission Integration Contract

- NASA's revised award fee policy encourages contractors to deliver quality products at reasonable cost.
 - Mission integration contract does not fully comply with revised policy.
 - Contract allows for "roll-over" of some unearned award fee.
-

In October 1993, NASA revised its award fee policy to encourage contractors to deliver quality products at reasonable costs.⁹ However, NASA's integration contract does not fully comply with the revised policy. The policy states (1) the center procurement officer must determine in writing that the use of base fee is in NASA's best interest and (2) base fee, if used, will be paid only if the contractor's performance is satisfactory or better. The determination that the use of base fee is in the agency's best interest was not made for the mission integration contract, which includes about \$2 million in base fees, and these fees will be paid to the contractor regardless of performance. NASA officials noted that the Air Force's Titan IV integration contract has a base fee that is not tied to satisfactory performance, and this fee provision was transferred to the NASA contract. Officials stated they attempted to convince the contractor to agree to modify the base fee provision in order to comply with the agency's revised award fee policy.

In addition, a provision in the mission integration contract, although not expressly prohibited by award fee policy, highlights the need for management oversight of the agencywide implementation of NASA's revised award fee policy. While the policy eliminates the "roll-over" of unearned award fee from one award fee period to a later period, the integration contract allows the roll-over of up to \$800,000 in unearned award fee to a performance incentive. NASA officials at Lewis Research Center believe that, by allowing the contractor to recoup a relatively small proportion of the total award fee—less than 10 percent—as part of a performance incentive, they are providing the contractor with an additional incentive to perform well and to help meet the objective of launching the Cassini mission successfully at the optimal time. NASA headquarters' procurement officials told us that other centers have also converted unearned award fee to increase an incentive fee. These officials indicated that award fee guidance will be revised to ensure that this practice is used appropriately and effectively.

⁹We reported on NASA's award fee policy revisions in NASA Procurement: Challenges Remain in Implementing Improvement Reforms (GAO/NSIAD-94-179, Aug. 18, 1994).

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