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The Mariner Jupiter/Saturn 1977 project is part of the National Aeronautics and Space Administration (NASA) program with objectives of advancing knowledge of these planets and relating their properties to those of Earth. Findings/Conclusions: NASA's cost estimate of \$450.9 million for the project did not include \$35.7 million of project-related costs. The project was on schedule and delays were not anticipated. Plans were being considered to extend the project to include interplanetary/interstellar research which would add about \$61 million to costs, exclusive of tracking and data acquisition costs. Recommendations: The NASA Administrator should identify and bring together in the project status report all identifiable costs and pertinent schedule and performance data, and should submit them to responsible congressional committees. (HTW)

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# *REPORT TO THE CONGRESS*

*BY THE COMPTROLLER GENERAL  
OF THE UNITED STATES*

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## **Status Of The Mariner Jupiter/Saturn 1977 Project**

**National Aeronautics and Space Administration**

This report advises the Congress that

- the mission performance and schedule objectives for the two Mariner Jupiter/Saturn spacecraft to be launched in 1977 probably will be met,
- \$35.7 million of project-related costs were excluded from NASA's \$450.9 project cost estimate, and
- if NASA extends the project's scope, about \$61 million could be added costs, exclusive of tracking and data acquisition costs.



COMPTROLLER GENERAL OF THE UNITED STATES

WASHINGTON, D.C. 20548

B-183134

To the President of the Senate and the  
Speaker of the House of Representatives

This report discusses the cost, schedule, and performance status of the National Aeronautics and Space Administration's Mariner Jupiter/Saturn 1977 project.

Our review was made as part of our continuing effort to inform the Congress of the status of major system acquisitions and to assist it in exercising its legislative and review functions. A preliminary copy of this report was reviewed by agency officials responsible for managing the project, and their comments are incorporated as appropriate.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

We are sending copies of this report to the Director, Office of Management and Budget; and the Administrator, National Aeronautics and Space Administration.

A handwritten signature in cursive script that reads "Thomas B. Staebli".

Comptroller General  
of the United States

COMPTROLLER GENERAL'S  
REPORT TO THE CONGRESS

STATUS OF THE MARINER  
JUPITER/SATURN 1977 PROJECT  
National Aeronautics and  
Space Administration

D I G E S T

The National Aeronautics and Space Administration (NASA) tentatively plans to extend the Mariner Jupiter/Saturn 1977 project to include interplanetary/interstellar research and possibly to explore the planet Uranus. Since the project would cost about \$61 million more, exclusive of tracking and data acquisition costs, the Congress should request NASA to

--keep it advised of NASA's plans to extend the mission and

--periodically provide it with updated cost estimates of the extended mission, including those for tracking and data acquisition.

PROJECT STATUS

The Mariner Jupiter/Saturn 1977 project is part of NASA's lunar and planetary exploration program. Two spacecraft will be launched in 1977 to explore Jupiter in 1979 and Saturn in 1980 and 1981. The mission provides the opportunity to advance man's knowledge of these planets, to compare them to each other, and to better relate their properties to those of the Earth and other planets.

In a March 1977 revision to its December 1976 project status report, NASA reported the cost of the project at \$450.9 million. This does not include \$35.7 million as identifiable project-related costs of which \$23.6 million were unreimbursed costs incurred by the Energy Research and Development Administration. (See pp. 10 to 14.)

The project is on schedule, and NASA does not anticipate any delays in completing the planned events. (See pp. 4 to 8.) In addition to its primary mission of exploring Jupiter and Saturn, NASA may send the two spacecraft beyond Saturn to do interplanetary/interstellar research and possibly to encounter the planet Uranus.

Two spacecraft will be used for the interstellar research while only one spacecraft will encounter Uranus. If the extended mission is undertaken, NASA would incur additional project costs of about \$61 million, exclusive of tracking and data acquisition costs. A decision on the extended mission is not needed until 1981. NASA estimates the cost of maintaining the option on Uranus through 1981 at \$11 million. (See p. 16.)

#### RECOMMENDATIONS

The NASA Administrator should identify and bring together in the Mariner Jupiter/Saturn project status report all identifiable costs and important schedule and performance data which may affect the project and submit it to each of the congressional committees having oversight and appropriations responsibility over NASA. These reports would permit the Congress to monitor more effectively the project's cost, schedule, and performance progress.

#### AGENCY COMMENTS

NASA does not agree with GAO that civil service and other support costs should be classed as related to the Mariner Jupiter/Saturn project. NASA believes such costs are

--relatively fixed,

--not sensitive to changes in project activity,  
and

--reported in their proper place in the authorization and appropriation structure and that the benefiting relationship is fully explained in material submitted to the Congress.

GAO believes that to show fully the total economic impact of a project, costs directly identified with the project must be summarized. By consolidating all project-related costs in a single document, the Congress will have all the necessary information in one place to fulfill its oversight and appropriation responsibilities.

NASA's comments, included as appendix II, are discussed in the report as appropriate.

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## ABBREVIATIONS

ERDA	Energy Research and Development Administration
GAO	General Accounting Office
JPL	Jet Propulsion Laboratory
MIRIS	modified infrared radiometer and interferometer spectrometer
MJS	Mariner Jupiter/Saturn 1977
NASA	National Aeronautics and Space Administration
PSR	project status report

## CHAPTER 1

### INTRODUCTION

The Mariner Jupiter/Saturn (MJS) project is an outgrowth of a program known as the Outer Planets Grand Tour. Using a technique perfected by the Jet Propulsion Laboratory (JPL), a flyby of the planet Jupiter will accelerate a spacecraft and enable it to reach all of the outer planets, which would not be possible with normal launch vehicle capabilities.

Early in 1971 the National Aeronautics and Space Administration (NASA) requested fiscal year 1972 budget authority to start the Grand Tour program. Plans for the Grand Tour mission consisted of two different three-planet flybys: the first to Jupiter, Saturn, and Pluto with two spacecraft launched in 1977; and the second to Jupiter, Uranus, and Neptune with two spacecraft launched in 1979.

The program also proposed the development of a highly sophisticated, long-life spacecraft known as the Thermo-electric Outer Planets Spacecraft. The Congress approved the program for fiscal year 1972 but requested NASA to consider missions of reduced scope to the outer planets.

In January 1972 NASA canceled the Grand Tour missions because of (1) reduction by the Congress in fiscal year 1972 authorizations requested for the missions, (2) instructions from the Congress to reduce the scope of the missions, and (3) the tight restraints of the fiscal year 1973 budget.

As a low-cost alternative to the Grand Tour Program, NASA redirected planning for exploration of the outer planets to two Jupiter/Saturn missions using Mariner spacecraft technology. Subsequently, the Jupiter/Saturn mission was advocated for outer solar system missions by the NASA Science Advisory Group of consulting scientists and endorsed by the Space Science Board of the National Academy of Sciences. On the basis of these scientific recommendations, late in February 1972 the MJS mission was proposed to the Congress as part of the fiscal year 1973 budget.

The MJS mission was justified to the Congress during the 1973 NASA authorization hearings on the basis of its contributions to the three basic purposes for the U.S.



space program: exploration, science, and applications. The mission would be accomplished through efforts to understand the

--origin, evolution, and current state of the solar system;

--past and present processes that affect the Earth's and man's environment by comparative study of solar system bodies; and

--relation of the solar system's chemical history to the origin and evolution of life.

#### OBJECTIVES AND SYSTEM DESCRIPTION

The overall objectives of the MJS project are:

1. To conduct comparative studies of the Jupiter and Saturn systems. Primary emphasis will be placed on studies of
  - a. the environment, atmosphere, surface, and body characteristics of the planets;
  - b. one or more of the satellites of each planet; and
  - c. the nature of the rings of Saturn.
2. To study the variations with time and distance from the Sun of the solar wind plasma and magnetic field, solar energetic particles, and cosmic rays.

Although not a committed objective, a retargeting option is being considered for the second spacecraft not only to fly by Saturn but possibly to continue on to Uranus to study its system. This option is discussed in chapter 4.

Specific objectives of the MJS project include obtaining measurements for the planets and their satellites which will yield information on their physical properties, dynamics, composition of atmospheres, surface features, thermal regimes and energy balances, charged particles and electromagnetic environments, periods of rotation, physical dimensions, and gravitational fields. Items of special interest included in these objectives are Jupiter's great red spot, the question of Io's (one of Jupiter's satellites) anomalous brightening and phenomena associated with its electro-

magnetic behavior, Saturn's rings, and Titan's (Saturn's satellite) atmosphere.

The MJS mission will be accomplished by two Mariner-class spacecraft to be launched in 1977 (the first in August and the second in September) on a trajectory to Jupiter. From Jupiter the spacecraft will continue on to Saturn on a flight made possible by a special alignment of Jupiter and Saturn. This alignment permits a spacecraft launched toward Jupiter to reach Saturn in less than 4 years and eventually to escape from the solar system through the acceleration provided by Jupiter's gravity. The opportunity to carry out such a fast gravity-assisted "swingby" mission occurs approximately every 20 years. The two spacecraft are to fly by Jupiter in March and July 1979 and to fly by Saturn in November 1980 and August 1981.

The MJS mission objectives are expected to be achieved using instruments designed to investigate 11 science areas. The instruments will collect information about the atmosphere, surface, and environment of the planets, and the interplanetary medium. The science investigations and the primary experiment objectives for the MJS mission are listed in appendix I.

#### PROJECT MANAGEMENT

NASA's Office of Space Science is responsible for overall management of the MJS program. JPL, Pasadena, California, is responsible for the day-to-day project management. The Lewis Research Center, Cleveland, Ohio, is responsible for the launch vehicle system. NASA is also obtaining assistance from the Energy Research and Development Administration (ERDA), which is responsible for the development of radioisotope thermoelectric generators used to provide the electrical power for the MJS spacecraft.

#### SCOPE

Our review was performed primarily at NASA Headquarters, Washington, D.C., and at JPL during the period June through December 1976. Information presented herein was obtained by reviewing project plans, reports, correspondence, and other documents, and by discussions with NASA and JPL personnel.

## CHAPTER 2

### PROJECT STATUS

As of December 31, 1976, the project was on schedule and NASA does not anticipate any delays in completing the remaining planned events. NASA considers the project cost estimate range it furnished to the Congress in March 1972 still to be valid. Within that project cost estimate range there have been several adjustments, as discussed in the following.

#### COST

In requesting budget authority to start the MJS project, NASA informed the Congress in March 1972 that the project cost estimate ranged from \$260 million to \$320 million --excluding the cost of the launch vehicle. The \$260 million and \$320 million estimates were for MJS program cost options endorsed by the Space Science Board of the National Academy of Sciences.

In January 1972 JPL developed three cost options in terms of science payload and spacecraft characteristics. The cost estimates for the three options were \$210 million, \$260 million, and \$320 million, respectively. The low option represented the minimum that was practical, while the second and third options represented higher levels of spacecraft capability and science return.

#### Original project cost

Based on the recommendations the NASA Science Advisory Group and the Space Science Board made in their review of the MJS program options, the established project development guidelines assumed the spacecraft in option 2 (\$260 million) but with the science data analysis funded at the option 3 (\$320 million) level. Following these guidelines, NASA estimated total project cost of \$272 million, excluding launch vehicle and flight support costs.

However, in the project approval process, NASA headquarters in April 1972 reduced the project cost estimate from \$272 million to \$250 million. In July 1972 NASA formally approved the project at an estimated cost of \$250 million. The \$22 million reduction resulted from having JPL, rather than a contractor, integrate the various system components.

### Increased project cost

After conditionally selecting 11 science investigation proposals in December 1972, NASA began a detailed science definition phase to determine whether the selected investigations and associated instruments could be accommodated within the overall weight, power requirements, and fiscal constraints of the project. Following the science confirmation review in September 1973, NASA estimated the cost of the MJS project to be \$309 million--\$59 million more than the original estimate of \$250 million. NASA attributed the \$59 million increase to

--updating the estimate for inflation (\$52.5 million) and

--adding a propulsion module to the spacecraft (\$6.5 million).

The original estimate of \$250 million was stated in fiscal year 1972 dollars and included no provision for future inflation. The total was increased by 4 percent in converting the estimate to fiscal year 1973 dollars. A 5-percent inflation rate per year was used for the project's runout years (fiscal years 1974 through 1981).

In March 1973 NASA approved the inclusion of a propulsion module on the spacecraft to replace the final stage of the Titan IIIE/Centaur D-IT/Burner II launch vehicle combination. Studies performed by JPL indicated that using a propulsion module to provide the final injection velocity required by the MJS mission in place of the Burner II stage would increase reliability and provide additional payload capability. This resulted in a project cost increase of \$6.5 million. This amount was shifted from the launch vehicle budget line item to the MJS program for the propulsion module.

### Current planned cost

As of October 1976 NASA's project cost estimate was \$320 million--an increase of \$11 million over the April 1974 estimate of \$309 million. NASA attributed the increase to keeping open the option for a Uranus flyby, involving

--development of a modified version of an infrared radiometer and interferometer spectrometer (\$6.3

million). Without the proposed modification, the instrument would be inadequate for use on Uranus because of the planet's low temperature due to its distance from the Sun.

--trajectory selection to allow a Uranus targeting option, which requires an increase in flight time to Saturn. This selection will also increase the period of time between the original encounter dates at Saturn for the two spacecraft, thereby increasing operational activity required for this portion of the mission (\$4.7 million).

NASA's \$11 million cost estimate for maintaining the Uranus option is \$3.6 million less than the original JPL estimated cost of \$14.6 million.

An initial feasibility effort, costing \$3.3 million, to develop a modified infrared instrument of general space applicability was funded by the NASA advanced technical development program (as discussed on p. 13 ). Funding of hardware development was assumed by the MJS program only after it appeared feasible and reasonable for use on the MJS spacecraft.

The JPL estimate for maintaining the Uranus option included \$1.6 million for project reserves. NASA headquarters allocated \$1.3 million, or \$300,000 less, for these reserves and directed that the \$300,000 be absorbed within the available project reserves.

#### Project reserves

The \$309 million development estimate established in April 1974 included \$54.2 million in contingency reserves, of which \$25.4 million were identified as project reserves and \$28.8 million were identified as an allowance for program adjustments.

NASA's current \$320 million project cost estimate includes additional reserves of \$1.3 million for maintaining the Uranus option, increasing total allotted project reserves to \$26.7 million and combined contingency reserves to \$55.5 million. The project reserves are controlled by the JPL MJS project manager and are intended to cover inflation in excess of 5 percent and other project contingencies. The allowance for program adjustments is controlled by NASA's MJS program manager and is intended

to provide funds for unanticipated changes which might be required to achieve the project objectives. As of November 28, 1976, the MJS project had used \$37.3 million out of \$55.5 million. The balance of \$18.2 million, including a \$1.3 million increase in project reserves for uncertainties associated with the Uranus option, remained unallocated as follows:

	<u>Project reserves</u>	<u>Allowance for program adjustment</u>	<u>Total</u>
	------(millions)-----		
Baseline amount	\$25.4	\$28.8	\$54.2
Uranus option increase	<u>1.3</u>	<u>-</u>	<u>1.3</u>
Subtotal	\$26.7	\$28.8	\$55.5
Amount used	<u>-18.6</u>	<u>-18.7</u>	<u>-37.3</u>
Unallocated balance	<u>\$ 8.1</u>	<u>\$10.1</u>	<u>\$18.2</u>

The project reserves have been used primarily for solving a variety of technical problems, increased procurement costs, and inflation in excess of 5 percent provided for in the baseline estimate. The allowance for program adjustment has been used mainly to (1) fund design and engineering changes to the spacecraft and instruments required when the NASA Pioneer 10 spacecraft encounter with Jupiter in December 1973 revealed higher radiation levels than had been predicted and (2) meet increased costs in subsystem contracts due to spacecraft complexity and unanticipated instrument requirements.

According to a NASA official, the remaining reserves and allowance for program adjustment are considered adequate to cover future program requirements.

#### SCHEDULE

JPL's December 1972 project plan called for two spacecraft to be launched during August and September 1977. These dates remain unchanged. At the time of our review, construction of the spacecraft and launch vehicle was on schedule. Key spacecraft events remaining to be accomplished were assembling and testing of the two flight units at

JPL--scheduled for completion in April 1977 and June 1977, respectively. According to JPL officials, no delays were anticipated in completing the remaining scheduled events.

### PERFORMANCE

The current MJS performance characteristics are consistent with the science objectives established for MJS.

The science payload for MJS was selected according to NASA's normal science experiment selection process. Scientific investigation proposals for the MJS mission were solicited through an announcement of flight opportunity issued in April 1972. The experimenters NASA selected were to provide scientific instruments in support of their proposals except for imaging and radio science experiment equipment considered part of the spacecraft. In December 1972 NASA conditionally selected 11 science investigation proposals and associated instruments from 77 proposals received from the scientific community. Following the conditional selection, each selected experimenter participated with JPL in a detailed science definition phase to insure that the selected investigation could be accommodated within the overall weight, power requirements, and fiscal constraints. This phase, completed in September 1973, showed it was necessary to adjust the scientific investigations' complement to bring estimated cost figures within the funding constraints.

NASA deleted an investigation of the particulate matter in October 1973 because the proposed instrument could not accomplish the scientific objectives of the investigation without design improvements. At the same time, another investigation (hydrogen Lyman alpha) was conditionally added because studies in July 1973 indicated that this investigation could contribute in an important way to understanding the hydrogen dynamics of the Saturn satellite Titan which appeared to have a substantial atmosphere containing both molecular and atomic hydrogen.

The NASA Pioneer 10 spacecraft encounter with Jupiter in December 1973 had revealed intense fluxes of high-energy electrons within Jupiter's magnetosphere several orders of magnitude greater than had been predicted. This generated increased scientific interest in the electromagnetic processes occurring in Jupiter's magnetosphere and led NASA in July 1974 to substitute a plasma wave investigation in

lieu of a hydrogen Lyman alpha investigation. Although the plasma wave investigation will cost \$570,000 more than the hydrogen Lyman alpha investigation, it did not increase the total project cost because program adjustment funds were used to cover the cost increase.



### CHAPTER 3

#### COSTS NOT INCLUDED IN NASA'S PROJECT COST ESTIMATE

We identified a number of cost elements which are directly identifiable with the project but which are not included in the project cost estimate. As a result all project-related costs were not summarized and reported to the Congress so as to show the project's total budget impact.

#### PROJECT-RELATED COST ESTIMATE

As discussed in chapter 2, NASA's December 31, 1976, project cost estimate for MJS was \$320 million. This estimate included \$170 million for the basic spacecraft, \$75 million for science instruments and experiments, \$44 million for mission operations, \$21 million for project management and mission design, and a \$10 million allowance for program adjustment. However, we estimate that NASA will incur additional project related costs of \$143 million, which are directly associated with and in support of the project but which NASA did not include in its \$320 million estimate. These additional costs are funded under various NASA budget line items. In addition ERDA is incurring unreimbursed costs of \$23.6 million in support of the MJS project. With these additional costs, the total project cost estimate would increase by at least \$166.6 million, as shown in the following table.

Total Estimated Cost of MJS Project

<u>Cost category</u>	<u>Amount</u>
	(millions)
Project cost	\$320.0
Project related costs reported by NASA (note a):	
Launch vehicle	\$71.8
Tracking and data acquisition	32.7
Flight support	21.7
Construction of facilities	<u>4.7</u>
Total	130.9
Project related costs not reported by NASA:	
Civil service support	5.0
Low Cost System Office (note b)	3.8
Advanced technical development (note c)	3.3
Launch vehicle support cost (note d)	-
Energy Research and Development Administration (note e)	<u>23.6</u>
Total	<u>35.7</u>
Total identifiable project cost	<u>\$486.6</u>

a/Included in NASA's December 1976 Project Status Report as revised. (See p. 12.)

b/Organization within NASA that will standardize hydrazine thrusters and inertial reference units.

c/Initial development of modified infrared radiometer and interferometer spectrometer (MIRIS).

d/NASA did not have the estimate available.

e/Multihundred-watt radioisotope thermoelectric generators.

PROJECT-RELATED COSTS  
REPORTED TO THE CONGRESS

In October 1975 at the request of the Senate Committee on Appropriations, Subcommittee on HUD-Independent Agencies, NASA submitted pilot project status reports (PSRs) on six of its projects, including MJS. Updated PSRs were submitted in January and July 1976 and January 1977. The PSRs provide information on cost, schedule, and technical aspects of the project. The PSRs also provide estimates of "program acquisition costs" which include costs for the project and launch vehicles; and estimates of "support costs" which include tracking and data acquisition, flight support, and construction of facilities.

In the January 1977 PSR, as revised, the total cost estimate of the MJS project was shown as \$450.9 million, as follows:

	<u>Amount</u>
	(millions)
Project cost	\$320.0
Launch vehicle	71.8
Tracking and data acquisition	32.7
Flight support	21.7
Construction of facilities	<u>4.7</u>
Total	<u>\$450.9</u>

This PSR included \$130.9 million of project-related costs that we believed should be added to NASA's estimate for MJS of \$320 million. (See p. 11.) However, NASA gave this information to only one of the committees--the Senate Subcommittee on HUD-Independent Agencies. The other three committees responsible for NASA's authorization and appropriation legislation do not receive the report and would be unaware of this latest treatment of costs by NASA.

PROJECT-RELATED COSTS NOT REPORTED

The PSR cost estimates for MJS excluded certain project-related costs incurred by NASA or costs incurred by another agency in support of the project. The following table shows additional costs, totaling \$35.7 million exclusive of launch vehicle support, that were incurred

for the support of the MJS project but not included in the PSR. These latter items are discussed in the paragraphs following the table.

	<u>Amount</u>
	(millions)
Civil service support	\$ 5.0
Low Cost System Office	3.8
Advanced technical development	3.3
Energy Research and Development Administration	23.6
Launch vehicle support cost	a/ -
Total	<u>\$35.7</u>

a/ Cost estimate not obtained. (See p. 14.)

#### Civil service support

Goddard Space Flight Center personnel are working on MJS experiment , but their costs are not being included in the project cost estimate. NASA estimated that these personnel and their support costs could total \$5 million during fiscal years 1976-81.

#### Low Cost System Office

The MJS project office and NASA's Low Cost System Office shared the cost of developing a standardized hydrazine thruster and a standardized inertial reference unit for use on the MJS spacecraft. According to NASA, these units have general applicability to all NASA space missions. The Low Cost System Office contributed \$2.9 million for development of the hydrazine thruster and \$948,000 for the development of the inertial guidance unit.

#### Advanced technical development

Advanced technical development funds of \$3.3 million were used to (1) determine the feasibility of modifying the MJS infrared radiometer and interferometer spectrometer for use in a Uranus flyby and (2) study trajectories required for a flyby option. The MJS design of the infrared radiometer and interferometer spectrometer was adequate for Jupiter and Saturn but not for Uranus.

### Launch vehicle support costs

A prior GAO review ("Need for Improved Reporting and Cost Estimating on Major Unmanned Satellite Projects," PSAD-75-90, July 25, 1975) showed that NASA does not allocate funds to specific projects for costs not directly associated with the acquisition of hardware. These costs, which include launch vehicle improvement costs and supporting activities, usually represent about 50 percent of the total cost of a launch vehicle.

### ERDA costs

ERDA is developing the electrical power source for the two MJS spacecraft. Each spacecraft uses a set of three multihundred-watt radioisotope thermoelectric generators. In accordance with a long-standing interagency agreement, ERDA is funding the generator development costs and the cost of fabricating and testing the generators for the first spacecraft, including one spare generator. In return, NASA is to provide ERDA with performance data and to reimburse ERDA for the cost of fabricating and testing the generators for the second spacecraft. The funds for these latter generators are included in the MJS project estimate of \$320 million. According to ERDA officials, unreimbursed costs to be incurred by ERDA in support of developing the generators total about \$23.6 million.

### AGENCY COMMENTS AND OUR EVALUATION

NASA does not agree that civil service and other support costs should be classed as MJS project related. NASA believes such costs are (1) relatively fixed, (2) not sensitive to changes in project activity, and (3) reported in their proper place in the authorization and appropriation structure and the benefiting relationship is fully explained in material submitted to the Congress. It is our view that to show fully the total economic impact of a project, it is necessary to summarize all costs which are directly identifiable with the project. By consolidating all project-related costs on a single document, the Congress will have all the necessary information in one place for fulfilling its oversight and appropriation responsibilities. As shown on page 12, NASA has accomplished this objective somewhat in its revised January 1977 PSR.

## CONCLUSIONS AND RECOMMENDATION

The total costs directly identifiable with the MJS project are not summarized and reported to the Congress as a single estimate to show the total budget impact of the project. Such an estimate would give the Congress a better means of assessing overall progress and aid it in making decisions on the future direction of the project.

Therefore, we recommend that the NASA Administrator identify and bring together on the MJS project status report all costs identifiable with the project, together with significant schedule and performance data which may have an impact on the project, and submit the report to each of the congressional committees having oversight and appropriations responsibility over NASA.

## CHAPTER 4

### EXTENDED MISSION OPTIONS

In addition to its primary mission of exploring Jupiter and Saturn, NASA foresees a possible extended mission option for the two spacecraft beyond their Saturn encounter. The extended mission provides for interplanetary/interstellar research and a possible option for an encounter with Uranus. Two spacecraft will be used for the interstellar research while only one spacecraft will encounter Uranus. If this option is exercised, NASA could incur additional project costs of about \$61 million, exclusive of tracking and data acquisition cost. JPL has not estimated what these costs will be.

#### URANUS OPTION

In October 1975 NASA decided to implement an option whereby an encounter with Uranus could be added to the MJS mission. This option would require retargeting the second spacecraft before it reaches Saturn to continue on to Uranus. If this option is exercised, the spacecraft would encounter Uranus on January 30, 1986. NASA indicates that the option would be exercised only if the first spacecraft achieved the desired Saturn-related science objectives and the second spacecraft proved capable of undertaking the additional 4 1/2 years of flight time from Saturn to Uranus. If the conditions for exercising the Uranus option are not satisfied, the second spacecraft would be targeted to focus on Saturn-related science objectives. A final decision on this matter will not be required until 6 months before the Saturn encounter in August 1981 and, according to NASA, will be preceded by the normal authorization and appropriation requests from the Congress.

NASA estimates the cost of maintaining the Uranus option through 1981 at \$11 million. The Uranus encounter would, according to JPL estimates, require \$10.8 million out of the \$61 million for the extended mission. NASA informed us that the decision to incorporate the Uranus option in the existing mission was made in lieu of proposing a separate Uranus mission which NASA estimated would cost in excess of \$200 million.

## INTERSTELLAR SPACE RESEARCH

During the project mission definition phase, the Science Steering Group, in developing the science rationale for the mission, stressed the importance of the post-Saturn phase of the mission. There was a strong desire on the part of the Science Steering Group to continue communication with both spacecraft as long as possible past the Saturn encounter in anticipation of penetrating the boundary between the solar wind and interstellar medium, allowing measurements to be made of interstellar fields and of particles unmodulated by solar plasma. The project, as formally approved by NASA in July 1972, provides that should the two spacecraft continue to operate past the Saturn encounters, an extended mission would be proposed to measure interstellar fields and particles.

According to JPL officials, even if the Uranus option is dropped, the MJS mission would be extended for interstellar research. JPL estimates that the cost for extending the mission through fiscal year 1986 would be about \$50 million, excluding tracking and data acquisition costs.

## RECOMMENDATIONS TO THE CONGRESS

In view of the potential for increased costs, the Congress should request NASA to (1) keep it advised of NASA's position concerning the extended missions and (2) continually provide it with updated estimated costs of the extended mission, including those for tracking and data acquisition.



SCIENCE INVESTIGATIONS AND THE  
PRIMARY EXPERIMENT INVESTIGATIONS FOR THE MJS PROJECT

<u>Science investigation</u>	<u>Primary experiment objectives</u>
Cosmic ray particles	Energy spectra and isotopic composition of cosmic ray particles and trapped planetary energetic particles.
Imaging science	Imaging of planets and satellites at resolutions and phase angles not possible from Earth. Atmospheric dynamics and surface structure.
Infrared radiation	Energy balance of planets. Atmospheric composition and temperature fields. Composition and physical characteristics of satellite surface and Saturn rings.
Low-energy-charged particles	Energy spectra and isotopic composition of low-energy-charged particles in planetary magnetospheres and interplanetary space.
Magnetic fields	Planetary and interplanetary magnetic fields.
Photopolarimetry	Methane, ammonia, molecular hydrogen, and aerosols in atmospheres. Composition and physical characteristics of satellite surfaces and Saturn rings.
Planetary radio astronomy	Planetary radio emissions and plasma resonances in planetary magnetospheres.

APPENDIX I

Science investigation

Plasma particles

Plasma waves

Radio science

Ultraviolet spectroscopy

APPENDIX I

Primary experiment objectives

Energy spectra of solar wind electrons and ions, low-energy-charged particles in planetary environments, and ionized interstellar hydrogen.

Electron densities and local plasma waves, charged particles' interactions in planetary magnetospheres.

Physical properties of atmospheres and ionospheres, planet and satellite masses, densities, and gravity fields. Structure of Saturn rings.

Atmospheric composition, including the hydrogen-to-helium ratio. Thermal structure of upper atmospheres. Hydrogen and helium in interplanetary and interstellar space.



National Aeronautics and  
Space Administration

Washington, D C  
20546

Reply to Attn of W

MAR 3 1977

Mr. R. W. Gutmann  
Director  
Procurement and Systems  
Acquisition Division  
U.S. General Accounting Office  
Washington, DC 20548

Dear Mr. Gutmann:

Thank you for affording NASA an opportunity to review and comment on the GAO draft report entitled, "Status Of The Mariner Jupiter/Saturn 1977 Project" which was transmitted with your letter, dated January 27, 1977.

NASA representatives worked with members of your staff in resolving some relatively minor differences with regard to the draft report. The remaining NASA comments, keyed to the segments of the report to which they pertain, are enclosed. If you or your staff wish to discuss these comments, please let me know.

Sincerely,

A handwritten signature in cursive script that reads "John M. Coulter".

John M. Coulter  
Acting Assistant Administrator for  
DOD and Interagency Affairs

Enclosure

GAO note: Page references in this appendix refer to the draft report and do not necessarily agree with the page numbers in the final report.

## NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

## COMMENTS ON

GAO DRAFT OF REPORT TO THE CONGRESS OF THE UNITED STATES

STATUS OF THE  
MARINER JUPITER/SATURN 1977 PROJECT  
(CODE 952146)

NASA has concluded its review of the GAO draft report on the status of the MJS77 project and agrees with most of the findings. Members of my staff have worked with the GAO staff to resolve a number of minor changes and corrections to the report. However, there remains an issue which reflects a continued misunderstanding between NASA and GAO concerning the proper definition of project-related costs.

In July 1975, GAO and NASA agreed on the concept that project-related estimates should include costs that show the economic impact of projects on the NASA budget.<sup>1</sup> However, since then, GAO has frequently recommended the inclusion of costs which NASA does not consider project related.

In this report, GAO has recommended inclusion of civil service and other support costs which are of a relatively fixed nature. The costs of these support activities are justified as sustained institutional capability and are not sensitive to inclusion in the budget of the projects to which GAO proposes they be prorated. GAO has also proposed inclusion of the cost of technology development of widespread applicability. General support costs are reported in their proper place in the authorization and appropriation structure and the benefiting relationship to projects is fully explained in material submitted to the Congress.

Therefore in the status report on MJS77, we propose certain cost estimates, classed as project-related by GAO, not be shown as dependent on the MJS77 mission. NASA-recommended

<sup>1</sup>"Need for Improved Reporting and Cost Estimating on Major Unmanned Satellite Project," GAO report dated July 25, 1975.

changes to the GAO treatment of project-related costs and certain other minor corrections in the MJS77 status report are described below:

Page i, Digest, 3rd paragraph

REPLACE: \$38.4 million with \$35.7 million.

Page ii, Digest, 1st paragraph, last sentence

REPLACE WITH THE FOLLOWING: The NASA estimated cost of maintaining the Uranus option through 1981 is estimated at \$11.0 million.

Page 6, 1st paragraph

INSERT THE FOLLOWING AFTER THE LAST SENTENCE: Within that project cost estimate range there have been several adjustments, as discussed below.

Page 9, 2nd paragraph, 12th line

DELETE: -- reserves for implementing the option (\$2.7 million).

COMMENT: NASA's MJS77 project cost estimate of \$320 million includes an \$11.0 million estimate for maintaining the Uranus option: \$6.3 million for development of MIRIS and \$4.7 million for increased mission operation and science support costs. Project reserves of \$1.3 million are included in the \$11.0 million total.

Page 9, 2nd paragraph, lines 13-19

REPLACE WITH THE FOLLOWING:

-- trajectory selection to allow a Uranus targeting option, which requires an increase in flight time to Saturn. This selection will also increase the period of time between the original encounter dates at Saturn for the two spacecraft, thereby increasing operational activity required for this portion of the mission (\$4.7 million).

COMMENT: The NASA estimated cost for increased mission operations and science support associated with the Uranus option trajectory is \$4.7 million.

Page 10, 1st and 2nd paragraph

REPLACE WITH THE FOLLOWING:

NASA's \$11 million dollar cost estimate for maintaining the Uranus option is \$3.6 million less than the original JPL estimated cost of \$14.6 million.

An initial feasibility effort of \$3.3 million for development of a modified infrared instrument of general space applicability was funded by the NASA advanced technical development program (as discussed on page 18). Funding of hardware development was assumed by the MJS program only after it appeared feasible and reasonable for use on the MJS spacecraft.

The JPL estimate for maintaining the Uranus option included \$1.6 million for project reserves. NASA Headquarters allocated \$1.3 million or \$300,000 less for these reserves and directed that the \$300,000 be absorbed within the available project reserves.

Page 10, 3rd paragraph

INSERT THE FOLLOWING AFTER THE 1st SENTENCE:

NASA's current \$320 million project cost estimate includes additional reserves of \$1.3 million for maintaining the Uranus option, increasing total allotted project reserves to \$26.7 million and combined contingency reserves to \$55.5 million.

Page 10, 3rd paragraph, 2nd sentence

REPLACE WITH THE FOLLOWING:

The project reserves are controlled by the JPL MJS project manager and are intended to cover inflation in excess of 5% and other project contingencies.

Page 11, 1st paragraph (partial) and table

REPLACE WITH THE FOLLOWING:

achieve the project objectives. As of November 28, 1976, the MJS project had used \$37.3 million out of \$55.5 million. The balance of \$18.2 million, including a \$1.3 million increase in project reserves for uncertainties associated with the Uranus option, remained unallocated as follows:

	<u>Project reserves</u>	<u>Allowance for program adjustment</u>	<u>Total</u>
	----- (millions) -----		
Baseline amount	\$25.4	\$28.8	\$54.2
Maintain Uranus option	<u>1.3</u>	-	<u>1.3</u>
Subtotal	<u>\$26.7</u>	<u>\$28.8</u>	<u>\$55.5</u>
Amount used	<u>-18.6</u>	<u>-18.7</u>	<u>-37.3</u>
Unallocated balance	<u>\$ 8.1</u>	<u>\$10.1</u>	<u>\$18.2</u>

Page 15, 2nd paragraph

REPLACE WITH THE FOLLOWING:

NASA's December 31, 1976, project cost estimate for MJS is \$320 million. This estimate includes \$170 million for the basic spacecraft, \$75 million for science instrumentation and experiments, \$44 million for missions operations, \$21 million for project management and mission design, and a \$10 million allowance for program adjustment. NASA also estimates MJS project related costs of \$130.9 million. GAO estimates that NASA will incur an additional \$12.1 million in project related costs which NASA does not include in its \$130.9 million estimate. NASA does not agree with GAO that these additional costs, which are shown below, should be reported as project related and instead reports them to Congress under various and separate NASA budget line items. In addition, GAO feels that

ERDA is incurring unreimbursed costs of \$23.6 million in support of the MJS project. NASA states that these ERDA unreimbursed costs, which are for development of radioisotope thermoelectric generators having general applicability to DOD and NASA space missions, are appropriately reported to Congress by ERDA.

Page 16, Table

CHANGE TABLE TO READ AS FOLLOWS:

TOTAL ESTIMATED COST OF MJS PROJECT  
(as of Dec. 31, 1976)

<u>Cost Category</u>	<u>Amount</u> <u>(millions)</u>
Project cost	\$320.0
Project-related costs reported by NASA:	
Launch vehicle	71.8
Tracking and data acquisition	32.7
Flight support	21.7
Construction of facilities	4.7
Subtotal.....	<u>\$130.9</u>
Total project and support estimate.....	<u><u>\$450.9</u></u>
Additional costs defined as project related by GAO:	
Civil service support	5.0
Low Cost Systems Office <u>a/</u>	3.8
Advanced technical development	
<u>b/</u>	3.3
Launch vehicle support cost <u>c/</u>	--
Energy Research and Development	
Administration <u>d/</u>	23.6
 TOTAL	 <u><u>\$ 35.7</u></u>



Page 17, 1st full paragraph, 2nd sentence

DELETE THE ENTIRE SENTENCE

COMMENT:

The \$2.0 million difference between NASA MJS project cost estimates of \$318 million reflected in the July PSR and the current cost estimate of \$320 million should not be construed as costs excluded by NASA in the PSR. The final decision as to NASA's estimate for increased costs associated with the Uranus option trajectory was made during the FY 1978 budget reviews in August and September 1976. At that time, the \$2.0 million was added to the estimate. Likewise, flight support estimated costs were increased by \$700,000 with the selection of the Uranus option trajectory.

Page 22, 1st partial paragraph, 2nd sentence

ADD THE FOLLOWING TO THE END OF THE SENTENCE:

will be preceded by the normal authorization and appropriation approvals from the Congress.

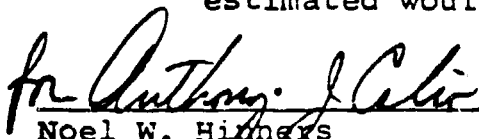
Page 22, 1st full paragraph, 1st sentence

REPLACE "\$11.3 million" WITH "\$11.0 million".

Page 22, 1st full paragraph

ADD THE FOLLOWING TO THE END OF THE PARAGRAPH:

The decision to incorporate the Uranus option in the existing mission was made in lieu of proposing a separate Uranus mission which NASA estimated would cost in excess of \$200 million.

  
 Noel W. Hinners  
 Associate Administrator  
 for Space Science

Date: 3/3/77

PRINCIPAL OFFICIALS OF THE  
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
RESPONSIBLE FOR ACTIVITIES  
DISCUSSED IN THIS REPORT

	<u>Tenure of office</u>	
	<u>From</u>	<u>To</u>
<b>ADMINISTRATOR:</b>		
Alan M. Lovelace (acting)	May 1977	Present
James C. Fletcher	Apr. 1971	May 1977
<b>DEPUTY ADMINISTRATOR:</b>		
Alan M. Lovelace	June 1976	Present
George M. Low	Dec. 1969	June 1976
<b>COMPTROLLER:</b>		
William E. Lilly (note a)	Feb. 1967	Present

a/Position established in December 1972. Before that date the comptroller function was part of the Office of the Associate Administrator for Organization and Management.