

URANUS SCIENCE PLANNING

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MR. JESSE MOORE: As John Lewis said earlier, Uranus is somewhat of a unique planet in our solar system. I will talk about science planning as related to a mission to Uranus (Figure 2-33).

Specifically, I will talk about the possibility of a 1979 Mariner Jupiter-Uranus mission with the possibility of launching the first outer planet atmospheric entry probe. What I will cover initially, to give you background information, are mission recommendations that have been developed by recent science advisory groups concerned with the type of missions that make sense scientifically, to plan for the outer planets. Then, I will focus on what I call the MJU Science Advisory Committee and talk specifically about the charter, some of the objectives that this group has and some of the outputs that are now emerging. I also will give you a brief summary of where we think we are going from here.

Figure 2-34 presents some of the past advisory groups, and studies that have considered plans for the outer planets over the past couple of years. These certainly are not all; they don't address all the specific things like the Titan Workshop or the Saturn Rings Workshop that have been held. One of the earliest planning groups which existed over a fairly long period of time, was the OPSAG. OPSAG looked at defining a broad program of outer-planet exploration. A Mariner mission to Uranus in 1979 was recommended by OPSAG. Its output was published in the Space Science Reviews in 1973 and it existed for approximately fifteen months. Also, shortly after the OPSAG was initiated, the Space Science Board conducted a Summer Study and in the report of the Space Science Board there was considerable interest expressed in going to Uranus. The Summer Study publication came out in June, 1971.



URANUS SCIENCE PLANNING

- PRESENTATION TOPICS
 - PAST SCIENCE PLANNING GROUPS
 - RECOMMENDATIONS
 - MJU SCIENCE ADVISORY COMMITTEE
 - CHARTER
 - URANUS SCIENCE RATIONALE AND OBJECTIVES
 - PRELIMINARY RECOMMENDATIONS
 - FUTURE ACTIVITIES

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5/20/74

Figure 2-33

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OUTER PLANETS SCIENCE ADVISORY GROUPS

- OUTER PLANETS SCIENCE ADVISORY GROUP (OPSAG)
 - 4/71 - 6/72
 - PUBLICATION: "INVESTIGATION OF THE OUTER SOLAR SYSTEM",
SPACE SCIENCE REVIEWS 14, 1973
- SSB SUMMER STUDY, NATIONAL ACADEMY OF SCIENCE
 - 6/71
 - PUBLICATION: "OUTER PLANETS EXPLORATION, 1972-1985,"
SSB, 1971
- OUTER PLANETS SCIENCE WORKING GROUP (OPSWG)
 - 9/72 - 6/73
- MARINER JUPITER URANUS SCIENCE ADVISORY COMMITTEE (MJUSAC)
 - 12/73 - PRESENT

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Figure 2-34

Following the OPSAG was an Outer Planet Science Working Group (OPSWG) which looked at the work that had gone on previously and recommended various modifications to the programs of exploration.

In December of last year, the Mariner Jupiter-Uranus Science Advisory Committee (MJUSAC) was initiated. Let me now spend a few minutes giving you some of the strategies that came out of these groups and, also, identify the members who participated. My intent here is to illustrate the point of commonality of membership as well as commonality of identifying the Mariner Jupiter Uranus mission as an important mission.

Figure 2-35 presents the membership of the OPSAG group, divided into various disciplines. As you can see, it represented a fairly broad spectrum of the scientific community.

Figure 2-36 shows the recommendations that came from the OPSAG. With regard to the 1979 Mariner Jupiter-Uranus mission two launches were recommended as a logical program to follow the 1977 MJS mission which is currently approved and on-going.

You will also note there was a Pioneer-Uranus entry probe mission planned in 1980, via Saturn. Dan Herman, earlier this morning, mentioned how NASA's plans have changed. Now, the Uranus entry probe is being considered as an integral part of the 1979 MJU flyby. You will be hearing more during the course of the workshop concerning the mission design and spacecraft design associated with this particular mission.

Figure 2-37 contains the membership list for the OPSWG. I think you can recognize the commonality of membership with the OPSAG. The recommendations from this group came out in two strategies. Strategy A (Figure 2-38) recognized the 1979 Mariner Jupiter-Uranus mission. It also added the Pioneer Jupiter-Uranus mission in 1980 with the Uranus probe.

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OPSAG MEMBERSHIP

ATMOSPHERES AND IONOSPHERES

G. MÜNCH, CHAIRMAN
D. HUNTEN
A. KLIORE
J. LEWIS
M. MC ELROY
N. SPENCER
P. STONE

PARTICLES AND FIELDS

J. VAN ALLEN, CHAIRMAN
W. AXFORD
S. GULKIS
C. KENNEL
M. MONTGOMERY
E. PARKER
C. SONNETT
R. STONE
J. TRAINOR

PLANETOLOGY

G. WETHERILL, CHAIRMAN
A. CAMERON
W. HUBBARD
B. MURRAY
S. PEALE

JPL LIAISON

D. REA
J. LONG

ARC LIAISON

B. PADRICK

Figure 2-35

JWM-5/7/74
131-3

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OPSAG RECOMMENDED EXPLORATION STRATEGY

ON-GOING PROGRAMS

- 1972 AND 1973 PIONEER 10, 11 JUPITER FLYBYS
- 1977 MARINER JUPITER/SATURN (2 MISSIONS)

RECOMMENDATIONS FOR FUTURE MISSION PLANNING

- 1976 PIONEER JUPITER/OUT-OF-ECLIPTIC (1)
- 1979 MARINER JUPITER/URANUS FLYBYS (2)
- 1979 PIONEER ENTRY PROBE TO SATURN
- 1980 PIONEER ENTRY PROBE TO URANUS (3)
VIA SATURN FLYBY
- 1981/1982 MARINER JUPITER ORBITER (2)

JMM-5/7/74

131-4

Figure 2-36

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OPSWG MEMBERSHIP

DR. J. VAN ALLEN, CHAIRMAN

DR. I. AXFORD

DR. G. MUNCH

DR. M. BELTON

DR. E. PARKER

DR. W. BRUNK

DR. I. RASCOOL

DR. A. CAMERON

DR. D. REA

DR. W. HUBBARD

DR. C. SONETT

DR. J. LEWIS

DR. E. STONE

MR. J. LONG

DR. J. WARWICK

MR. H. MATTHEWS

DR. J. WOLFE



OPSWG RECOMMENDED EXPLORATION STRATEGY

STRATEGY A

- 1976 PIONEER H EX-ECLIPTIC (ONE MISSION)
- 1977 MARINER JUPITER/SATURN (2)
- 1979 MARINER JUPITER/URANUS (2)
- 1980 PIONEER JUPITER/URANUS (1)
- URANUS PROBE
- 1981 PIONEER SATURN DIRECT (1)
- SATURN PROBE
- 1981/82 MARINER JUPITER ORBITER (2)
- 1982 PIONEER SATURN (TITAN) OR URANUS (1)
- PROBE AT TITAN OR URANUS

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5/20/74

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Strategy B (Figure 2-39) was very similar. It however, recommended the 1979 MJU mission with the addition of a Uranus probe on the flybys. It also recommended two launches following the MJS 1977 program.

The remainder of my discussion will be specifically about the MJU mission and the MJUSAC activities. The MJUSAC (Figure 2-40) was asked to develop detail science objectives, rationale and requirements; to quantitatively evaluate payload options and various instrumentation requirements; and to determine the science instruments currently available to meet these requirements.

The final outputs were to develop an advisory committee position on this mission, indicating the scientific value of the addition of the Uranus probe, and to recommend any SR&T developments for the science instrumentation.

Figure 2-41 presents the membership of MJUSAC. It is chaired by Dr. Van Allen with Dr. Al Cameron as Vice-Chairman. Spacecraft and probe inputs for the scientists to consider are being developed while the science objectives, rationale, and payload are evolving. I would like to point out that the spacecraft inputs to this particular group are coming from Ron Toms of JPL and the probe inputs for consideration are being supplied by Ben Padrick and Howard Matthews of Ames. I would like, also, to recognize that Dr. Lewis is a member of MJUSAC.

For the engineers here who may not be familiar with Uranus, I will describe several properties of Uranus (Figure 2-42). It has a very long orbital period, as most of the outer planets do, making the billiard ball or the gravity-assist technique occur in fairly rare opportunities: 1979 is a rare opportunity. The energies and planet alignments are favorable to get a good swing-by of Jupiter to go to Uranus in a reasonable flight time. The

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OPSWG STRATEGY - CONTINUED

STRATEGY B

- 1976 PIONEER H EX-ECLIPTIC (ONE MISSION)
- 1977 MARINER JUPITER/SATURN (2)
- 1979 MARINER JUPITER/URANUS (2)
- URANUS PROBE
- 1980 PIONEER SATURN DIRECT (2)
- SATURN AND/OR TITAN PROBE
- 1981/82 MARINER JUPITER ORBITER (2)

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Figure 2-39

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Figure 2-40

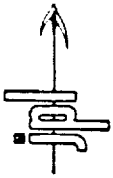
MJUSAC CHARTER (OBJECTIVES)

- FOCUS ACTIVITY ON URANUS SCIENCE
- CONSIDER MARINER-CLASS MISSION ONLY
- DEVELOP:
 - (A) DETAILED SCIENCE RATIONALE
 - (B) QUANTITATIVE SCIENCE OBJECTIVES AND REQUIREMENTS
- QUANTITATIVELY EVALUATE:
 - (A) PAYLOAD OPTIONS
 - (B) INSTRUMENTATION REQUIREMENTS
 - (C) INSTRUMENTATION CURRENTLY AVAILABLE OR UNDER DEVELOPMENT
- DEVELOP SAC POSITION ON 1979 MJU MISSION
 - SCIENTIFIC VALUE OF URANUS PROBE
 - SRT DEVELOPMENTS FOR SCIENCE

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5/20/74

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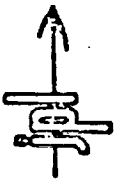


MJUSAC MEMBERSHIP

- DR. J. VAN ALLEN, CHAIRMAN
U. OF IOWA
- DR. A. CAMERON, VICE-CHAIRMAN
HARVARD COLLEGE OBSERVATORY
- DR. M. BELTON
KITT PEAK OBSERVATORY
- DR. W. HUBBARD
U. OF ARIZONA
- DR. T. JOHNSON
JPL
- DR. C. KENNEL
UCLA
- DR. J. LEWIS
MIT
- MR. J. MOORE, RECORDING SECRETARY
JPL
- MR. B. PADRICK
ARC
- DR. D. REA
JPL
- DR. G. SISCOE
MIT
- DR. P. STONE
GODDARD INST. OF SPACE
STUDIES
- DR. R. VOGT
CALTECH

JWM-5/7/74
131-10

Figure 2-41



PHYSICAL PROPERTIES OF URANUS

• ORBITAL PERIOD, YR	84.0
• MEAN SOLAR DISTANCE, AU	19.2
• INCLINATION OF EQUATOR, DEG	98.0
• ROTATIONAL PERIOD, HR	10.8
• RADIUS, KM	27,000
• MASS (EARTH = 1.0)	15
• SATELLITES	MIRANDA, ARIEL, UMBRIEL TITANIA, OBERON
• RANGE OF RADII, KM	140-1200
• RANGE OF SEMIMAJOR AXES, R_U	4.8 - 21.6

JWM - 5/7/74
131-12

distance of Uranus from the Sun is 19.2 AU. Uranus is about twice as far out in the solar system as Saturn, the second planetary target of the 1977 MJS mission. The Pioneer 11 mission also is currently targetted to Saturn as well. One of the unique characteristics of Uranus is its inclination. The equator of Uranus is inclined by 98° which means that as you approach Uranus and its near equatorial satellites, the system appears as a bull's-eye with Uranus at the center. The period of rotation is about ten hours. It is a fairly large planet with a mass about fifteen times that of the Earth. There are five satellites, all within a very compact range. They range from about 4.8 Ru (radius of Uranus) out to about 21.6 Ru. Miranda is closest to Uranus. The satellite radii range from about 140 to 1200 kilometers.

I will now discuss the science rationale (Figure 2-43) and I will summarize very briefly the work that the MJUSAC has accomplished to date. The case for a Mariner Jupiter-Uranus mission can be based primarily on the uniqueness of Uranus; the axial orientation of Uranus; the cosmogonical considerations relating to its origin within the solar system; the unique atmospheric circulation which is likely to result from its axial orientation; and, if it has a dipole field, the characteristics as would be measured by approaching the planet from a head-on position looking at a "pole-on" magnetosphere. Further, the dipole axis would be pointed closest to the Sun at about the time the MJU spacecraft gets to Uranus in 1986.

As John Lewis pointed out, Uranus has a low atmospheric turbulence level, which leads to the conclusion that it apparently lacks an internal heat source, although there is certainly some question on that. One of the other key points of rationale for this mission is that previous groups have stated that the pair of outer planets, Jupiter and Saturn, and the pair Uranus and Neptune form very contrasting bodies. We now have missions that are

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URANUS SCIENCE RATIONALE

◆ CASE FOR MJU BASED ON UNIQUENESS OF URANUS

⊙ AXIAL ORIENTATION

⊙ ORIGIN?

⊙ UNIQUE ATMOSPHERIC CIRCULATION?

⊙ "POLE-ON" MAGNETOSPHERE? DIPOLE AXIS POINTED

NEAREST TO SUN IN 1986?

⊙ LOW ATMOSPHERIC TURBULENCE (APPARENTLY LACKS HEAT SOURCE)

⊙ JUPITER/SATURN AND URANUS/NEPTUNE FORM OUTER PLANET PAIRS

⊙ COMPACT, REGULAR SATELLITE SYSTEM WHOSE COMPOSITION

MAY BE DIFFERENT FROM JUPITER AND SATURN SATELLITES

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131-13

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planned or enroute to explore Jupiter and Saturn and a mission to Uranus would certainly give us some data on the other pair of outer planets to compare with the Jupiter and Saturn pair.

Finally, and certainly not of least importance, is the satellite system of Uranus. The satellites are compact. They form a very regular system, and there is considerable speculation that their composition is quite different from the satellites around Jupiter and Saturn.

Figure 2-44 is a generalization of the science objectives that are being formulated in the MJUSAC. From these kinds of objectives, the MJUSAC is formulating the measurement requirements and the payload to meet these particular requirements. The first objective is pointed toward the physical properties of Uranus. Secondly, as John Lewis pointed out, atmospheric characteristics are extremely important with composition probably being the most important. Because of the "pole-on" effect, Uranus may have an exciting magnetosphere and you would like to get very good measurements of its character; you would like to measure the solar wind interaction; and, also, make measurements within the ionosphere. For the satellites, their masses, radii, topography, and rotational period are extremely important determinations. Because of the distance of Uranus, understanding the satellite properties is difficult to do from Earth-based observations. Finally, you would like to measure the interstellar/interplanetary media. This mission will go out to about 20 AU, possibly beyond, and certainly data in that region would add to the base of knowledge we expect to acquire over the next several years from Pioneer 10 and 11 and MJS77.

Figure 2-45 presents the measurement categories that the MJUSAC is developing. On the flyby science we are talking about conducting imaging experiments; experiments both in IR and UV spectral



URANUS SCIENCE OBJECTIVES

- ◉ URANUS PHYSICAL PROPERTIES
 - ◉ MASS, RADIUS, ROTATIONAL PERIOD, GRAVITATIONAL FIELD
- ◉ ATMOSPHERIC CHARACTERISTICS
 - ◉ COMPOSITION (MOST IMPORTANT), TEMPERATURE, DYNAMICS, STRUCTURE
- ◉ PARTICLES AND FIELDS ENVIRONMENT
 - ◉ MAGNETOSPHERE, SOLAR WIND, INTERACTION, IONOSPHERE
- ◉ SATELLITES
 - ◉ MASSES, RADII, TOPOGRAPHY, ROTATIONAL PERIOD
- ◉ INTERPLANETARY/INTERSTELLAR MEDIA

JJM - 5/7/74
131-14

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URANUS SCIENCE MEASUREMENT CATEGORIES - PRELIMINARY

1979 MJU (W PROBE)

FLYBY SCIENCE

• IMAGING

• IR, UV

• MAGNETIC FIELD

• PLASMA

• ENERGETIC CHARGED PARTICLES

• R. F. RADIO SCIENCE

PROBE SCIENCE

• TEMPERATURE

• PRESSURE

• ACCELERATION

• ATMOSPHERIC COMPOSITION

• CLOUD STRUCTURE

• SOLAR RADIATION

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5/20/74

Figure 2-45

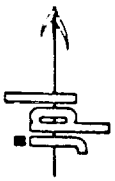
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ranges; experiments associated with the magnetic field; plasma experiments; charged-particle experiments; and S- and X-Band occultation measurements as the spacecraft encounters Uranus.

In the probe arena I think you have heard earlier about the particular measurements listed here. I think it is very important as Dan Herman pointed out that NASA is planning to formulate a specific science group to address the Uranus atmospheric question in-depth and, subsequently, define in more detail the probe payload. The data generated by this group will be used to plan a Phase B probe activity beginning in July 1975.

To develop a scientifically viable MJU mission, it is mandatory that flyby and probe science measurements be complimentary in nature. Data from the probe and flyby spacecraft science instrumentation should be designed to contribute uniquely to the total integrated science return.

My final figure (Figure 2-46) describes the current activities and future plans of MJUSAC. We are in the process of getting more specific inputs on the payload options and the instrument requirements, and in the process of developing final MJUSAC recommendations. I will comment that the MJUSAC has strongly endorsed the 1979 Mariner Jupiter-Uranus mission with an atmospheric entry probe of Uranus. I think the outputs of this technology workshop will certainly serve as valuable input to the planning and further development of the 1979 mission possibility. As far as our future plans are concerned, the scientists under the direction of Dr. Cameron, are planning a publication in the fall of this year in Icarus on detail science rationale, objectives and requirements; the MJUSAC is preparing a final report which will appear in draft form in early August. This report will integrate both the science work as well as the mission, spacecraft and probe design work.



MJUSAC CURRENT ACTIVITIES AND FUTURE PLANS

- CURRENT ACTIVITIES
 - DEVELOPING PAYLOAD OPTIONS AND INSTRUMENTATION REQUIREMENTS
 - DEVELOPING FINAL COMMITTEE RECOMMENDATIONS
- FUTURE PLANS
 - PREPARE ARTICLE FOR PUBLICATION IN ICARUS
 - "URANUS SCIENCE RATIONALE, OBJECTIVES AND REQUIREMENTS"
 - PREPARE FINAL REPORT WHICH INCLUDES SCIENCE, MISSION DESIGN, SPACECRAFT AND PROBE DESIGNS

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5/20/74

Figure 2-46

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Again, I wish to say that I think the probe workshop will provide some very valuable inputs to the MJUSAC and we are looking forward to seeing the outputs.