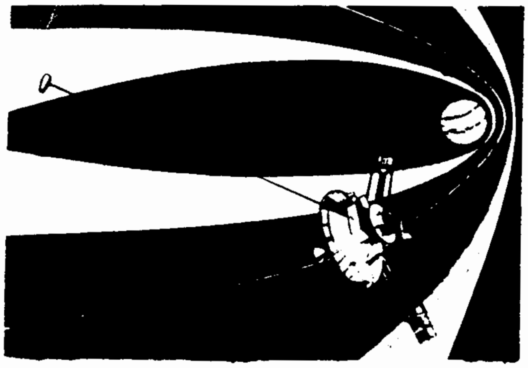

pioneer/jupiter

NEWSLETTER

Number 1 NASA/AMES RESEARCH CENTER • MOFFETT FIELD, CALIFORNIA 94035 February 23, 1972

PIONEER F READY FOR LAUNCH

Launch and mission operation activities are nearing completion in preparation for the launch of Pioneer F from Cape Kennedy Air Force Station during the 1972 Jovian opportunity. It is planned to launch the spacecraft on February 27 at approximately 9 pm EST (59/0100 GMT), the first day of the 16-day opportunity. After a successful launch, the spacecraft will be designated Pioneer 10 and is expected to be the first spacecraft to travel beyond the orbit of Mars, pass through the Asteroid Belt, swing by Jupiter, and escape the solar system.

THOUGHTS OF THE PROJECT MANAGER

In this, the first issue of the Pioneer Jupiter Newsletter, and in anticipation of the forthcoming launch, it is most appropriate to compliment the many dedicated people who have worked so hard to reach this first goal of the Pioneer F mission to Jupiter and to congratulate all for a job well done. I estimate that at the time of the Pioneer F launch more than 15 million manhours will have been expended to make this goal possible. I am sure that you all feel as I do that a successful mission wherein we will be exploring new frontiers in space will be a just compensation for this large effort and that we are indeed a fortunate, select group who has been given the opportunity to participate in and contribute to the Pioneer F mission.

For some of you, the Pioneer F launch will be the end of your direct participation in the Pioneer F/G missions to Jupiter. I hope these Newsletters will continue to provide you a tie to these missions. Obviously without you, they could not have been accomplished.

Thank you all.

C. F. Hall

Launch Operations

On December 22, 1971, Atlas Centaur launch vehicle AC-27 was erected on Launch Complex 36A in preparation for the launch of Pioneer F. The spacecraft (without RTGs), equipped with a full complement of scientific instruments, was airlifted from TRW, the spacecraft contractor, via a Mini-Guppy aircraft to the Cape Kennedy Air Force Station on January 15, 1972. A series of tests were performed in Building AO to assure that all elements of the spacecraft and scientific instruments were in operational readiness for launch. These tests consisted of a spacecraft leak test, a third-stage fit check, an integrated system test, detailed subsystem performance tests, and scientific instrument performance tests. Following these tests a spacecraft/Deep Space Station interface performance test was conducted to verify the compatibility of the commmunication system between the spacecraft and the Deep Space Net. The activities in Building AO were concluded with a prctice countdown, final inspection and biological sampling. During this period the Radioisotope Thermoelectric Generators (RTGs) were delivered to the Kennedy Space Center, performance tested, and stored under secure conditions where they await installation on the spacecraft at the launch pad one day before launch. A terminal countdown demonstration and flight acceptance composite test of the launch vehicle were also performed during this period.

Following the activities in Building AO, the spacecraft was moved to the Propellant Loading Building where it was loaded with propellant, pressurized and weighed, and a thruster-cluster assembly firing test was performed to exercise the propulsion subsystem. The spacecraft was then mated to the launch vehicle third-stage followed by encapsulation of the spacecraft/third-stage combination. This assembly was moved to Launch Complex 36A where it was mated to the Atlas/Centaur launch vehicle. After installation of the third-stage thermal shield, an on-stand integrated system test was performed, followed by final spacecraft/Deep Space Station interface checks.

A launch vehicle Composite Readiness Test was performed on February 22 which demonstrated the readiness of the total launch vehicle in support of the Pioneer F mission.

Mission Operations

The Mission Operations System and Deep Space Network testing program has been completed with the performance of the final Operational Readiness Test on February 21, 22, and 23. These tests involved the coordinated participation of the Deep Space Stations, the Ground Data System at JPL and the Remote Information Center at NASA/ARC.

The configuration of the hardware and software for the Ground Data System has been frozen awaiting initiation of the Pioneer F flight mission. Priority agreements have been established between the Mariner Mars 71 Project, the Deep Space Network and the Pioneer Project for usage of the Ground Data System and in particular the IBM 360/75 computers, which make up the heart of this system.

The Remote Information Center at NASA/ARC has been tested and is ready to perform instrument health analysis and to function as a back up for flight operations during the initial phases of the mission.

All procedures and activities have been integrated with the final detailed task sequence of events, and the Pioneer Mission Operations Team is in a state of readiness to support a launch of Pioneer F.

Launch Readiness Review

A Launch Readiness Review, participated in by NASA Headquarters officials, was held at Cape Kennedy on February 22 to assess the state of readiness of all elements of the Pioneer Project in support of a Pioneer F launch. On the basis of this review it was concluded that the spaceflight system as well as the ground support system will be ready for a launch of Pioneer F on February 27.

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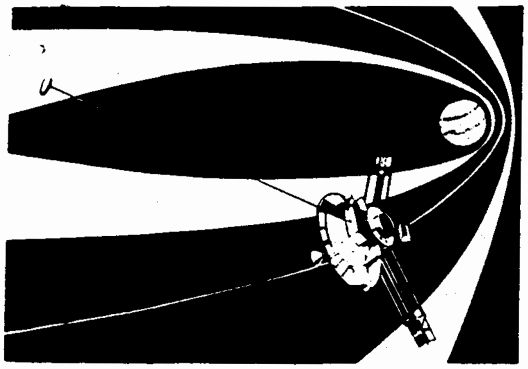
JUPITER VITAL STATISTICS

- Largest planet in the solar system.
  - Mass 318 times that of Earth
  - Diameter 11 times that of Earth
- Density one quarter that of Earth
- Distance from Sun approximately 484 million miles or 5.2 AU
- Rotational period - 9.55 hours
- Orbital period - 11.86 years
- Frequency of Jupiter - Earth opposition - 13 months
- 12 Satellites, two larger than Earth's moon.



pioneer/jupiter NEWSLETTER

NO. 2 NASA/AMES RESEARCH CENTER • MOFFETT FIELD, CALIFORNIA 94035 Mar. 3, 1972

PIONEER 10 - TRAILBLAZING TO JUPITER

At 8:49 P.M. EST, March 2, 03/0149 GMT the first Pioneer spacecraft destined for Jupiter and beyond, roared up into a cloudy sky from Cape Kennedy Air Force Station, Florida. Previously on Feb. 27, the launch was scrubbed because of a sudden storm accompanied by high winds and an electrical failure in the blockhouse. On Feb. 28 the countdown had progressed to L -5 minutes but was called off because of high winds in the upper atmosphere. On March 1 another attempted launch was cancelled. Today the countdown proceeded smoothly. The spacecraft, housed on top of the Atlas/Centaur/TE364-4 launch vehicle, lifted smoothly off Pad 17A. Atlas booster engine cutoff (BECO) occurred at 8:51 EST followed by the sustainer engine cutoff (SECO) 8:53 EST. Centaur/TE364-4 separated from the spent Atlas, the main engine ignited at 8:54 EST and continued to burn until 9:00 EST when main engine cutoff (MECO) occurred. Following separation from the Centaur the TE364-4 burned from 9:02 to 9:03 EST, and was then jettisoned. (During this time the spacecraft was tracked by downrange tracking stations.) Initial downrange acquisition was accomplished by Deep Space Station Johannesburg, S.A. (DSS 51), which began receiving data from Pioneer 10 at 9:10 EST. These data indicated that all systems were operational. At 9:36 EST the University of Iowa/Geiger Tube Telescope and the University of Chicago/Charged Particle Instrument were commanded to turn on. The deployment of the Radioisotope Thermoelectric Generators (RTGs) was completed followed by the boom for the JPL/Helium Vector Magnetometer. The spin speed of the spacecraft was stabilized at 4.8 rpm; shortly thereafter, the earth-pointing orientation began to utilize the high-gain dish antenna. This operation was completed at 3:18 EST. At 3:27 EST the Lewis RC/Meteoroid Detector was turned on; the remaining scientific instruments will be activated sequentially, later.

THOUGHTS FROM MOM
(MISSION OPERATIONS MANAGER)

Our motto, "We're Going Regardless," does not apply anymore since we are already off and on our way. But our motto served its purpose. It inspired a lot of people who had a heck of a lot of work to do, and not much time to do it.

One Los Angeles newspaper recognized our team spirit and called it "...... a defiant determination to get the job done." Well, that's part of it but I would rather call it plain and simple, "dedication" – a dedication from every single individual on our team who put the whole thing together when it seemed impossible.

We did it as a team because each member performed beyond the call of duty. We have reached our goal and Pioneer 10 is "flying."

I want to thank each and every one of you for your past effort which got the whole thing going; and thank you again for your current effort to make the mission work, and ultimately to be a brilliant success.

R. R. Nunamaker

LAUNCH OPERATIONS

Following the Launch Readiness Review on Feb. 22, the launch vehicle was subjected to an RF interference test, followed by the spacecraft RF signal-strength measurement. During the activity the spacecraft radiated signals to DSS 71 to determine how weak a signal could be received. The same type of measurement was performed by transmission of signals from DSS 71 to the spacecraft. On the day before the first scheduled liftoff, the four RTGs were installed on the spacecraft. These units provide the principal source of electrical power to all systems and all scientific instruments. During this time the flight battery was installed and the spacecraft was secured for the countdown.

LAUNCH VEHICLE DATA

The Atlas rocket has a total thrust of 411,353 pounds, consisting of two 174,841-pound-thrust booster engines; one 60,317-pound thrust sustainer engine, and two vernier engines, each developing 676 pounds thrust. Propellants are liquid oxygen and RP1.

The Centaur second stage has two engines having a total thrust of 29,200 pounds. This engine carries insulation panels which are jettisoned just before the vehicle leaves the Earth's atmosphere and are used to prevent heat or air friction from causing boil-off of liquid hydrogen during flight through the atmosphere. Propellant is liquid hydrogen and liquid oxygen.

The solid-fueled TE364-4 third stage develops approximately 15,000 pounds of thrust. This stage spins the spacecraft up to 60 rpm.

MISSION OPERATIONS

The scientific data received from the spacecraft is of vital importance to the success of the mission. The chief function of the Remote Information Center (RIC) and the Science Data Area at Ames Research Center is to assure that good data is received, analyzed, and distributed to the scientific investigators. The planning, implementation, and extensive testing of the RIC hardware and software have taken more than one year to complete. The science instrument health analysis and flight operations backup functions have been extensively-tested during the Integrated Systems Tests with the spacecraft at TRW, and at Cape Kennedy during the Operational Readiness Tests. All elements of the project participated in these tests. Following launch, the RIC will continuously monitor the status of the scientific instruments and the data received.

The JPL Deep Space Network prepared for the Pioneer F launch with many months of planning and implementation work, extensive training of personnel, and exhaustive testing of facilities. At the same time the Pioneer Project Mission Operations Team engaged in simulated mission operations activities to assure that the Project and Network teams obtain the necessary training. On Feb. 15, 16, 17, and 21, 22, 23 two Operation Readiness Tests were conducted to verify the actual launch and cruise configurations of the near-Earth and deep space phases of the mission. Concurrent with the Tracking and Data System tests, DSN provided the resources of DSS 71 at Cape Kennedy for the Pioneer F Spacecraft/RF and Data System Compatibility Tests. The performed measurements verified that the flight equipment was compatible with the Ground Support and that the spacecraft could be operated and controlled as planned during the launch and cruise operations. During the powered flight of the current mission, the Atlantic Test Range Stations track the launch vehicle and the spacecraft and acquire spacecraft telemetry. After the spacecraft was injected into a solar orbit toward Jupiter, the initial S-band signal acquisition was made by a 26-meter antenna station of the Deep Space Network located at Johannesburg, South Africa. The Ascension Station of Goddard's Satellite Tracking and Data Network now serves as a full backup of the Johannesburg facility.

PIONEER 10 TO SET SPACE TRAVEL RECORDS

The journey of Pioneer 10 will set several records for the NASA space program:

First spacecraft to investigate Jupiter.

First man-made object to leave the solar system.

First spacecraft to pass through the Asteroid Belt.

First test of harnessing Jupiter's gravity to decrease travel time to orbits of outer planets.

First NASA spacecraft to use nuclear energy as its primary power source.

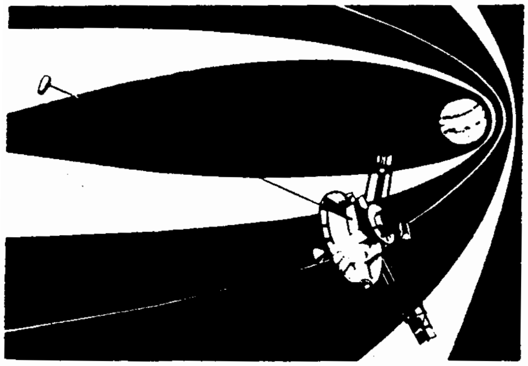
First use of a third stage on Atlas-Centaur.

Fastest spacecraft, peak velocity of 32,000 mph, traveling 1/2 million miles a day.

Longest communications distance: 1.5 billion miles; round trip communications will take about 5 hours, requiring new concepts in command and control.

Farthest planet visited, 8 times farther than Mars; round trip communications will take 90 minutes near Jupiter.

Pioneer 10 will pass the moon's orbit in 11 hours; Apollo astronauts take three days. The spacecraft will be in vicinity of Jupiter for 4 days, and will be behind Jupiter for less than 2 hours.



pioneer/jupiter

PIONEER 10 LAUNCHED - MARCH 2, 1972

NEWSLETTER

NO. 3 NASA/AMES RESEARCH CENTER • MOFFETT FIELD, CALIFORNIA 94035 Mar. 14, 1972

PIONEER 10 DRAWS A BEAD ON JUPITER

On the sixth day of the Pioneer 10 mission, the initial midcourse maneuver was performed. The primary objectives of this maneuver were to locate encounter at 3 radii from the center of Jupiter 14° below a parallel to the ecliptic through the planet's center, and to time the arrival within one of the daily 5 hour overlaps of tracking capabilities of the 64 meter antennas at Goldstone, Calif. and at Canberra, Australia. These conditions satisfy design objectives of the science experiments and insure against failure to receive data at either tracking station in the most critical hours of data recording. Based upon a priority list made with the experimenters previously, and upon subsequent analysis, preferences were to attempt occultation by the satellite Io, or to closely approach satellites for polarimetry and imaging, in addition to accommodating the primary objectives.

During reorientation of the spacecraft to earth alignment after injection, signal dropouts were experienced in the interference region between forward and aft (oppositely polarized) spacecraft antennas. Therefore, as expected, the maneuver was restricted to within 45° of earth alignment. Also, equipment compartment temperatures were near their upper design limits, so it was preferred not to turn the spacecraft backside towards the sun during this maneuver. The maneuver strategy was selected 48 hours after launch, and sustained by the excellent performance of the propulsion system and JPL's measurements during calibration maneuvers in the ensuing 15 hours. Orbit determinations were continued by JPL with very close convergences through the fourth flight day when final computations were completed. Calibrations from flight performance to that time were entered into the specially prepared computer program, and command instructions were returned

THOUGHTS FROM THE MANEUVER OPERATIONS DIRECTOR

A large proportion of the work of Pioneer Jupiter Project participants over the past two years was dedicated to the success of the midcourse maneuvers. It is a great pleasure to report the evidence of our success in the crucial first execution. Accommodation to conditions observed after launch in selecting strategy and fine tuning the velocity adjustments was a gratifying reward for the long list of options and flexibility insistently planned for.

A note of special appreciation is due for the intense cooperation by JPL participants in the midcourse maneuver. The navigation support group assigned to Pioneer over the past two years has contributed with outstanding energy and creativity. I am sure an outsider could not distinguish our separate organizational affiliations in any of our working sessions. And all this planning and final computations were facilitated with DSN's ready accommodation of our flexible schedule of antenna orientation and command sequences.

J. W. Dyer

the same evening. The first midcourse maneuver was completed on March 7.

The combined first and final midcourse maneuvers were to aim for arrival on December 4, 1973 at 02:35 GMT when Io would occult the spacecraft and some optical observations of satellites would be possible. This maneuver was accomplished by precessing 45° from earth line into a plane containing the required velocity vector and the earth line, accelerating 18 meters/sec away from the Earth, and returning to earth line to accelerate 9 meters/sec towards Earth. On approximately March 23 a final velocity change of about 1/2 meter/sec near the direction of the earth line will be made to insure maneuver execution errors smaller than the uncertainty of Jupiter's ephemeris.

SCIENCE DATA ANALYSIS

Real time data from scientific instruments on board Pioneer 10 are being monitored at ARC by the principle investigators or their representatives, and by project personnel. To date power to ten instruments has been turned on in the following order:

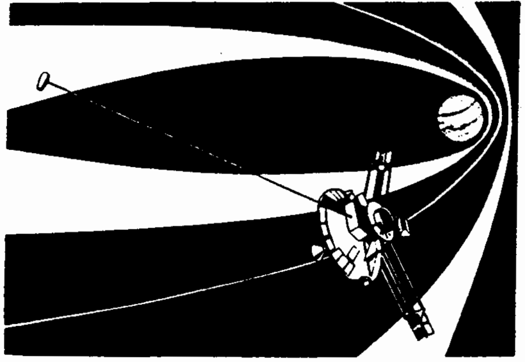
1. Trapped Radiation Detector
2. Geiger Tube Telescope
3. Charged Particle Instrument
4. Helium Vector Magnetometer
5. Meteoroid Detector
6. Cosmic Ray Telescope
7. Ultra Violet Photometer
8. Asteroid-Meteoroid Detector
9. Imaging Photopolarimeter
10. Plasma Analyzer

The principle investigators have expressed satisfaction with the initial instrument operation based on data received to date.

TRACKING AND DATA ACQUISITION SUPPORT

The worldwide facilities of the Deep Space Network will continue to furnish tracking and data acquisition support for Pioneer 10 as long as communications can be maintained. This operation started with the initial view of the spacecraft from a Deep Space Station located in Johannesburg, South Africa (DSS 51). This station established S-band telemetry contact with the spacecraft 22 minutes after launch. After two-way S-band acquisition was completed, the Pioneer Operations Team started to send commands to the spacecraft 26 minutes after launch. At the end of the view of DSS 51, the STDN station at Ascension took over the support for one hour to close the gap between the views of the Johannesburg and Goldstone, Calif. (DSS 11). Nine hours after launch DSS 11 established two-way contact and at the end of the Calif. view, DSS 42 at Weemala, Australia, tracked Pioneer 10 and tied in to the next tracking and data acquisition pass into Johannesburg. This typical sequence was followed during the second, third, and fourth days after launch, with the addition that on the third day the DSN also provided support from DSS 14, the 64 meter antenna at Goldstone which was used to enhance a velocity correction measurement. The Project team fired the velocity correction thrusters of the spacecraft for a short time and DSS 11 and 14 furnished the telemetry, tracking and command capabilities necessary to make this calibration measurement possible. Since the successful launch of Pioneer 10, all prime and backup facilities operated as planned and DSN has furnished real-time telemetry information almost continuously for the Flight Control Team. This team has transmitted 175 commands during the first 72 hours of flight. The DSN has also provided two-way precision doppler data which were used by the navigation team to establish the spacecraft's solar orbit and to determine the results of the midcourse maneuver performed on March 7.

Earth - Spacecraft Distance	8,789,201 km
Spacecraft - Jupiter Distance	817,799,413 km



pioneer/jupiter NEWSLETTER

PIONEER 10 LAUNCHED – MARCH 2, 1972

NO. 4 NASA/AMES RESEARCH CENTER • MOFFETT FIELD, CALIFORNIA 94035 APRIL 5, 1972

THE ANATOMY AND HEALTH OF PIONEER 10

Pioneer 10 has completed the first month of its journey, and the performance of the spacecraft continues to be excellent, giving every indication of continuing in the "science workhorse" tradition established by its predecessors, Pioneers 6 through 9. The Communications/Command subsystems provide the capability of controlling the operating modes of the spacecraft and scientific instruments. Fixed dish antennas focus radio signals in a narrow beam which are locked on Earth at all times. Speed, distance and direction from the Earth are calculated by analysis of the doppler shift. Performance of these subsystems has been excellent. At the time of the first acquisition of the Spacecraft all transmitter parameters were well within the resolution of the telemetry system, and have remained constant. Both downlink and uplink communications were acquired almost precisely on the anticipated schedule after launch. Downlink signal strength, from first acquisition until the automatic orientation of the spacecraft started three hours after launch, was within one dB of predicted levels. Just prior to the first midcourse maneuver, the conscan system which the spacecraft uses to home automatically on the ground stations was exercised. The medium-gain antenna and the prime receiver were used first, followed by the high-gain antenna and the redundant receiver. To the present, Pioneer 10 has responded to all commands transmitted from Earth.

The Data Handling subsystem formats and merges science and engineering information into a stream of data bits which are coded, stored and transmitted to Earth with timing and operational signals. This system has been operating flawlessly; transmitting all types of data. After six days of flight the system was commanded to the coded telemetry mode which will furnish superior data quality for the duration of the mission. The spin period sector generator which provides timing pulses for the spacecraft and instrument system is functioning as predicted. Approximately once a day a command is sent to the spacecraft to resynchronize the roll index pulse with the reference sun pulse. This is necessary due to a very slow continuous increase in the spin rate associated with perhaps a miniscule propellant leak of less than 0.02 pounds per year or small daily changes in RTG guide rod temperatures. The Electrical Power/Distribution subsystem has as its source four SNAP 19 radioisotope thermoelectric generators (RTGs) outboard of the spacecraft. Power from these generators is converted and filtered to furnish 28 volts direct current for component and instrument operation. There is also a battery, which is charged automatically, to meet any temporary overloads. The RTGs are operating normally; external temperatures in space are 10° to 20°F lower than anticipated, resulting in even higher power performance than expected. Total power output is now about 165 watts. This power level will decrease gradually throughout the mission, but is expected to be well above the required level at encounter with Jupiter.

THOUGHTS FROM THE SPACECRAFT MANAGER

Now that we have had a chance to recover from the emotional trauma of getting Pioneer 10 launched, it is time to sit down and perform a factual engineering examination of this machine "we" have wrought. As Pioneer 10 settles into the "cruise" phase of its voyage to Jupiter, many analyses must be made of the live operation of this vehicle in a spatial environment – as compared to its performance during testing in Earth environment – to insure specified performance during the crucial Jupiter encounter. This information is also needed to insure a successful Pioneer "G" launch and mission.

Preliminary indications are that Pioneer 10 is a good spacecraft and a good mission; only time and our continued diligent effort will tell. However, I wish to add an expression of my deep gratitude for the extraordinary effort put forth by so many to make our participation in this historic achievement a success.

Ralph W. Holtzclaw

The Propulsion/Attitude Control subsystems are required for maneuvering the spacecraft to change velocity, to change the attitude so as to keep the antenna pointed precisely at Earth, and to maintain the spin rate at 4.8 rpm. The attitude of the spacecraft is adjusted by pulses from small thruster jets located on opposite sides of the reflector of the high-gain antenna, one pointing forward and one to the rear. Spin rate changes are accomplished by tangentially aligned nozzles thrusting with or against the spin. Thrust is provided by liquid hydrazine which is decomposed into a gas and then ejected through the nozzles. These systems performed their functions properly in despinning, initially reorienting for Earth pointing, and correcting the spacecraft trajectory for its cruise mode. First utilization of the Stellar Reference Assembly (SRA) will be attempted soon after April 24 when the SRA will be completely within the shadow of the 9-foot high-gain antenna dish. The Sun Sensor Assembly, performing with a noise jitter of one order of magnitude less than originally anticipated will continue to serve as roll attitude reference in the interim.

The Thermal Control Subsystem provides required thermal environments for the spacecraft components and scientific instruments by use of louvers, insulation, heaters, and special surface finishes. At present the spacecraft internal compartment temperatures are in a transition state between the side-sun condition following launch and the front-sun condition towards which the spacecraft is moving. When the compartment is fully shaded from the sun by the 9-foot antenna, the temperatures will be considerably lower. Spacecraft temperatures in the compartment at side-sun were generally about 8° F below those predicted from tests. At present the temperature is about 73° F in the spacecraft component section and about 64° F in the scientific instrument section.

PIONEER 10 SECOND MIDCOURSE CORRECTION

On March 24, the 21st flight day of Pioneer 10, the second and final midcourse correction was executed. Two days previously the maneuver plans were confirmed, as orbit determinations calculated from tracking data had refined the spacecraft trajectory accuracy to a small fraction of the uncertainty in Jupiter's ephemeris. The maneuver was accomplished in two components lying very nearly in the spacecraft-Earth-Sun plane. The first was directly away from Earth 1.8 meters/sec, and the second was 2.143 meters/sec, 24° off the earthline away from the Sun and generally towards Earth. The earth's line component, fortunately the most directly measured and the most critical to our objective, was trimmed to within an estimated 0.3 mm/sec upon completion of the maneuver. The spin axis was then turned 10° away from earthline toward the Sun to minimize equipment heating. No further adjustments are expected until after the earthline passes close to this antenna alignment about May 2.

MAJOR EVENTS OF PIONEER 10 LAUNCH

Event	Day	Time(GMT)
LIFTOFF FROM CAPE KENNEDY	(063)	0149:03.6
Atlas Booster Engine Cutoff		0151:32.8
Booster Package Jettison		0151:34.8
Jettison Insulation Panels		0152:17.8
Atlas Sustainer Engine Cutoff		0153:06.5
Atlas/Centaur Separation		0153:09.8
Centaur Main Engine Start		0153:20.1
Jettison Nose Fairing		0153:32.5
Centaur Main Engine Cutoff		0200:48.9
Stage 3 Spinup		0201:59.6
Stage III Separation		0202:00.8
Centaur Retrothrust		0202:02.0
Stage III Ignition		0202:14.7
Centaur Power Changeover		0202:28.7
Stage III Burnout		0202:59.4
Spacecraft Separation		0204:39.0
Stage III Yo Deployment		0204:41.5

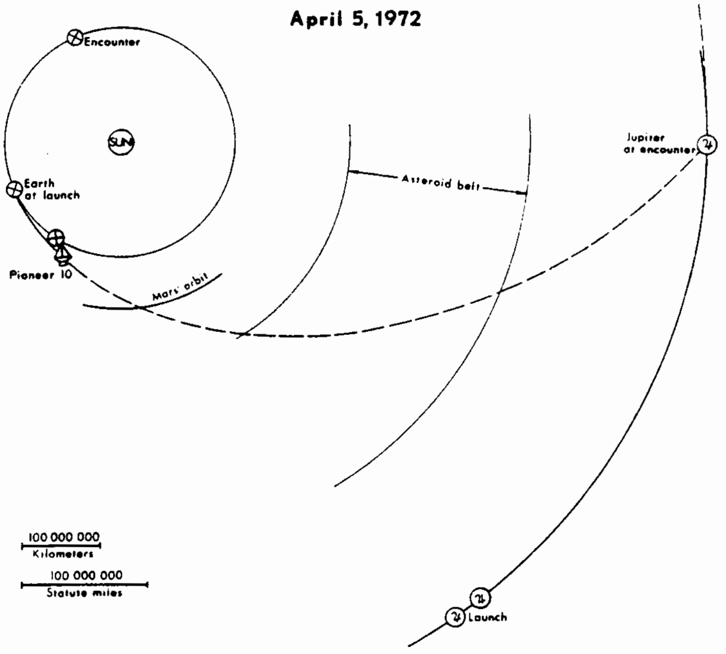
SCIENTIFIC INSTRUMENT TURNON	Day	Time
UCSD/Trapped Radiation Detector		0215
UI/Geiger Tube Telescope		0233
UC/Charged Particle Instrument		0234
JPL/Helium Vector Magnetometer		0248
LaRC/Meteoroid Detector		0326
GSFC/Cosmic Ray Telescope	(065)	1849
USC/Ultraviolet Photometer	(066)	2120
GE/Asteroid-Meteoroid Detector	(069)	0513
UA/Imaging Photopolarimeter	(070)	2131
ARC/Plasma Analyzer	(073)	2120

SPACECRAFT MANEUVERS

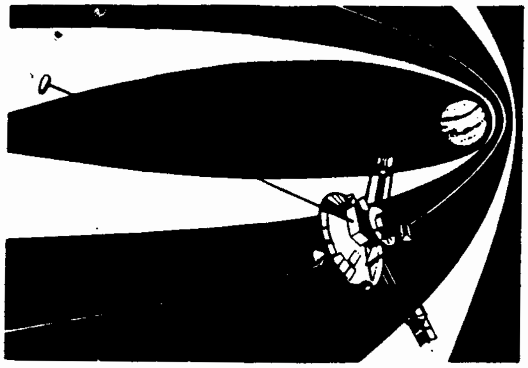
First midcourse complete	(067)	1935
Second midcourse complete	(084)	1330

Pioneer 10 Position

April 5, 1972



Earth – Spacecraft distance 26.22 Million Km
Spacecraft – Jupiter distance 728.96 Million Km



pioneer/jupiter

PIONEER 10 – LAUNCHED MARCH 2, 1972

NEWSLETTER

NO. 5 NASA/AMES RESEARCH CENTER • MOFFETT FIELD, CALIFORNIA 94035 MAY 8, 1972

INTERPLANETARY SURVEY STARTS

Since launch, Pioneer 10 has experienced many novel and exciting events. The attached sequence of events has been prepared to call attention to the more important activities. During this period, all scientific instruments have been turned on and are operating satisfactorily. Preliminary results from five of the instruments have already been analyzed and are summarized below.

METEOROID DETECTOR

W.H. Kinard of NASA Langley Research Center is concerned with measuring very small particles of matter in space. His Meteoroid Detector consists of panels of .001-inch thick stainless-steel gas-filled cells which, when punctured, register a "hit". Punctures occur in the cells when impacted by meteoroids of 10^{-9} grams mass or greater. Since launch, the instrument has detected in excess of 20 punctures spaced quite evenly on a time basis. It appears significant that the average penetration rate is more than double that predicted using the present model of the interplanetary meteoroid environment.

THOUGHTS FROM THE EXPERIMENTS MANAGER

In the flight of Pioneer 10 a unique opportunity is afforded the 13 Pioneer experiments to evaluate outer space beyond the orbit of Mars, traverse the Asteroid Belt, encounter Jupiter, and pass through the solar wind boundary. Knowledge gained from these experiments will be added to the present store of information to aid in man's search for the origin of the solar system.

The scientific instruments carried on board Pioneer 10 represent the most sophisticated and complex array of instruments every assembled on a space vehicle. These instruments were designed to sense and record scientific data for years in outer space and are the ultimate in compactness and minaturization.

Instrument performance has, to date, been exceptionally good. The data obtained has compared favorably with that of experiments carried on space flights traversing the same area. On May 24, 1972 only 83 days after launch, Pioneer 10 will pass the orbit of Mars and commence to evaluate space never before penetrated by man-made instruments.

J. E. LEPETICH

ASTEROID/METEOROID DETECTOR

Dr. R.K. Soberman, General Electric Co., has an Asteroid/Meteoroid Detector aboard which records particles ranging upward from 10^{-6} gram mass. Asteroids and meteoroids are detected by the solar light they reflect and scatter. This is accomplished by a system of four independent telescopes which provide over-lapping fields of view for photomultiplier tubes. Ranges and velocities are found by timing the entries and departures of the reflections of optically observable particles in three of the four fields of view. More than 20 events have been recorded and there is the possibility of an equal number in the data remaining to be analyzed, which is a greater number than had been predicted.

JOVIAN CHARGED PARTICLES

Dr. J.A. Van Allen, University of Iowa, for whom the Earth's radiation belts are named, has a Geiger Tube Telescope aboard which will characterize Jupiter's radiation belts. These belts consist of charged particles from the interplanetary medium surrounding a planet which are trapped by its magnetic field. The instrument employs seven Geiger-Mueller tubes to survey the intensities, energy spectra, and angular distributions of electrons and protons through the Jupiter magnetosphere. It will count protons with energies above five million electron volts (MeV) and electrons with energies greater than .050 MeV. Measurements were made during the out-bound passage through the Earth's magnetosphere to calibrate the detector systems under realistic conditions. This calibration will serve as one basis for interpreting observations in Jupiter's magnetosphere. In addition, the interplanetrary counting rates of all detectors have been determined. The in-flight performance of the Geiger Tube Telescope provides an improved assessment of its capabilities during Jovian encounter as well its capabilities for detecting solar energetic particles ıd for measuring the heliocentric radial gradient of lactic cosmic ray intensity. Excellent data have been ɔtained to date, and the performance of all detectors ıs been satisfactory; approximately as predicted.

IMAGING PHOTOPOLARIMETRY

Dr. Tom Gehrels, University of Arizona, has a ʋo-color (red and blue) 1-inch diameter pointable lescope aboard which, when commanded, operates as Photopolarimeter or a spin scan imager. The strument also measures zodiacal light periodically to ɜtermine the amount of interplanetary solid material. hen approaching Jupiter it will scan the planet and ansmit pictures of the surface; permitting analysis of ıe structure and composition of the clouds and the nount and nature of atmospheric gas above the ouds. A picture of one of the moons may be ɔtained during the scan period.

This instrument is being used in the interplanetary uise by Dr. J.L. Weinberg, Dudley Observatory, lbany, N.Y. to obtain the first deep-space measure-ent of starlight and zodiacal light. Dr. Weinberg ports that as part of these measurements the egenschein was observed on March 14 and that the lative brightness distribution was similar to that ɔtained from earlier ground based studies. The egenschein or counter glow is a brightening observed ı the region opposite the Sun and is believed to be rimarily sunlight back-scattered from interplanetary ust grains. A number of other theories for its origin ave been proposed including suggestions that it is sociated with the Earth's shadow or its dust or gas ıil or with particles trapped near the Earth. The ioneer 10 observation made when the spacecraft was million kilometers from the Earth (1.011 AU from ıe Sun) show that the Gegenschein is not primarily if : all associated with the Earth. Two scientific papers ave been prepared based on the zodiacal light bservations returned from the spacecraft. Among the odies observed by this instrument are Jupiter, Sirius, ɹcturus, Regel, Centaurus and Mercury.

JOVIAN TRAPPED RADIATION

Dr. R.W. Fillius, University of California at San ›iego, uses a Trapped Radiation Detector to determine ıe types of particles trapped by Jupiter, their angular istributions and intensities. The detectors used in the ıstrument include an unfocused Cerenkov counter, lectron scintillator, proton scintillator, detector for igh energy protons and minimum ionizing particles, nd a detector for observing electron scatter. The ıstrument has a range of energies from .01 to 100 ſeV for electrons and from .05 to 350 MeV for rotons. The Trapped Radiation Detector was the first instrument to be turned on (26 minutes after liftoff) in order to obtain measurements in the Earth's radiation belts. These measurements provided an in-flight calibration of the instrument for use in reduction of the data obtained in the Jovian environment. To date the instrument is performing well and returning nominal interplanetary data.

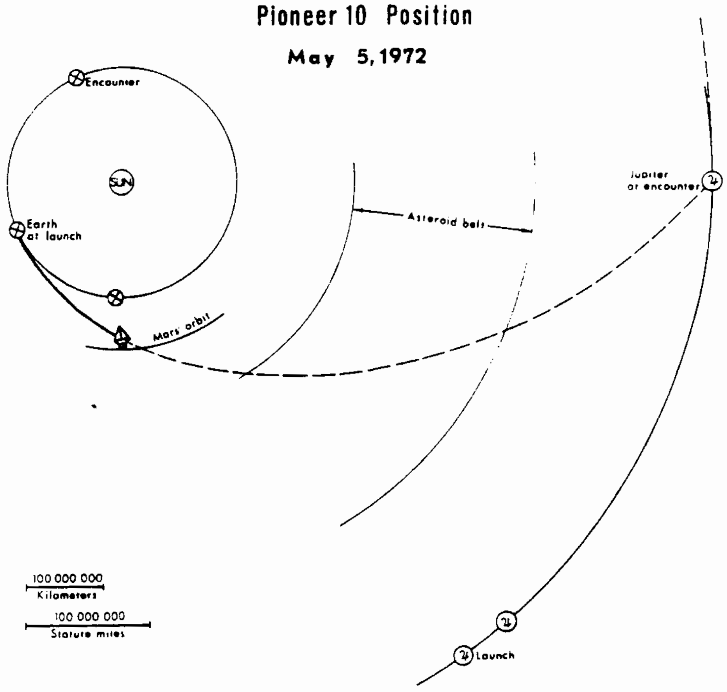
FLIGHT OPERATIONS

Pioneer 10 Flight Operations continuously monitors the data generated by all instruments, which are transmitted by the spacecraft and received in a high speed data stream at Ames Research Center via the JPL Deep Space Network. The information is extracted for each experiment and magnetic tapes containing the processed experiment data records are sent to each principal investigator for reduction and analysis. The design of Pioneer 10 is such that more interaction via ground command than in previous Pioneer spacecraft is required, and to date more than 1,770 commands have been sent to the science instruments.

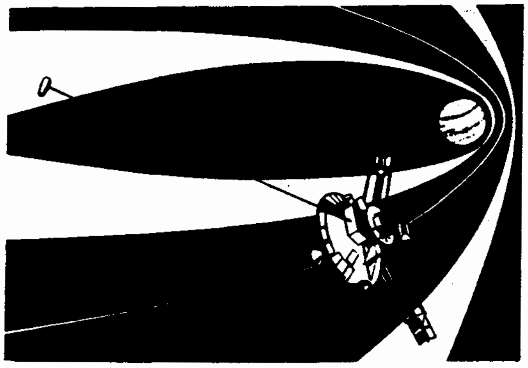
Knowledge gained from Pioneer 10 about the hazards of encounters with potentially destructive particles will influence the design of future space probes.

Pioneer 10 Position

May 5, 1972



Earth – Spacecraft distance 50.53 Million Km
Spacecraft – Jupiter distance 650.94 Million Km



pioneer/jupiter
PIONEER 10 LAUNCHED – MARCH 2, 1972
NEWSLETTER
NO. 6 NASA/AMES RESEARCH CENTER • MOFFETT FIELD, CALIFORNIA 94035 JULY 3, 1972

PIONEER 10 PENETRATES UNEXPLORED SPACE

On May 25, 1972, Pioneer 10 passed the orbit of Mars and now holds the record for farthest distance from Earth achieved by a man-made spacecraft. It also holds the speed record as it is traveling at 30 km/sec relative to the Earth. The spacecraft is expected to enter the region of the Asteroid Belt about July 15.

THOUGHTS FROM THE AEC

The Space Nuclear Systems Division of the Atomic Energy Commission is very pleased to have the opportunity to apply radioisotope thermoelectric power to such an unprecedented and significant space project as Pioneer F/G.

The isotopic power technology developed under the sponsorship of the AEC has produced generators which have furnished power safely and efficiently to space projects where no other power source could have performed adequately. The lessons learned from research in the design of power systems and the handling and use of isotopic fuels will be applied to the development of sources which will be used to power the nation's increasingly complex efforts in planetary exploration as well as other space exploration and utilization programs.

Many organizations participated to meet the challenges of a complex job with a true team effort. I know each shares with me a feeling of personal involvement in the Pioneer mission as a result of this association.

On behalf of the AEC and its supporting contractors and laboratories, I wish all those associated with the Pioneer Project continued success.

Harold Jaffe, Manager
Isotope Flight Systems, SNS

PIONEER POWER SOURCE

The requirement for adequate, reliable electrical power for the unprecedented duration of the Pioneer/Jupiter spacecraft flight posed a problem which had to be solved by the designers. As a power source, batteries would not last for the necessary time, and enormous numbers of solar cells would be required to furnish adequate power at 5 AU and beyond. A decision was made to use advanced SNAP 19 (Systems for Nuclear Auxiliary Power) radioisotope thermoelectric generators (RTGs) because of their long life, compactness and relatively low weight. This marks the first use of nuclear electric power as the primary source on an interplanetary spacecraft.

An RTG consists basically of the radioisotope heat source, a thermoelectric converter, a radiator to reject waste heat and the thermal coupling between these components. Modules containing thermoelectric elements, imbedded in thermal insulation to minimize heat leakage, surround the heat source. Once the radioisotope heat source is inserted into the cavity of the generator and the cover sealed, the power generation begins. The heat flow across the thermoelectric elements creates the required temperature difference to generate a voltage. Since approximately 5 percent of the total heat is converted into electricity, the remaining heat energy produced by the fuel flows into the outer container where it is rejected by radiation into space.

The thermal output decreases slowly with time and after five years is about 96 percent of initial power. At the time of fueling, all Pioneer flight RTGs produced in excess of 40 electrical watts with the nominal fuel loading.

Among the many characteristics of the RTGs which had to be considered prior to integration with the Pioneer spacecraft were the mechanical properties including configuration, mounting, weight, center of gravity, and moment of inertia; the electrical properties including performance, operational limitation, power connector, grounding, internal resistance and open circuit voltage; the thermal properties including total heat rejection, housing temperature, external surface thermal coating temperature restrictions and a mathematical thermal model; the magnetic properties and the RTG telemetry requirements. Safety is an overriding requirement in RTG design. Rigid safety requirements have been established for survival in all significant planned and accident environments.

Prior to the manufacture of the flight RTGs, an extensive series of functional tests were conducted. Both prototype RTGs and ETGs were used, the latter being electrically heated thermoelectric generators identical to the RTGs except for the substitution of an electric heater for the heat source. These tests demonstrated the capability and performance of the system. Three ETGs are continuing on test after having accumulated in excess of 20,000 hours of operation each. Three RTGs also are continuing on ground test operations. These ETGs and RTGs form the basis for the performance predictions at Jupiter encounter and beyond.

Analysis of the performance of the RTGs aboard Pioneer 10 through the first 2,300 hours of mission life indicates that all units are performing nominally. At launch the four generators had a combined power output of 166 watts. This has now decreased to 159 watts. On the basis of the performance to date and the degradation model, available power at encounter is estimated as 135 watts. It is further estimated that the generators will continue to supply a major fraction of their launch power up to the time the spacecraft exceeds communication distance.

ELECTRICAL POWER SUBSYSTEM

The low voltage electrical power, approximately 4 volts, produced by the RTGs is brought into the spacecraft through flat cables. To provide for efficient distribution, inverters are employed which chop the low voltage dc power after which it is inverted and stepped up to supply a 30.5/61 volt 2.4 kHz square wave ac output. Up to that point the 4 RTG outputs are independent. Failure of one RTG, its flat cable or its inverter channel would not compromise the mission, which could continue on the power from the other 3 RTGs, as the 4 inverter outputs are parallel. Most of the ac power is rectified and filtered to 28 volts dc, but some of it is transformed, rectified and filtered to provide numerous isolated outputs at other dc voltage for use by spacecraft subsystems. The approximate size of the principal electrical loads are:

Scientific Instruments	24 watts at 28 volts
TWT Amplifier	28 watts at 28 volts
Other spacecraft loads	4 watts at 28 volts
Other spacecraft loads	15 watts at lower v.

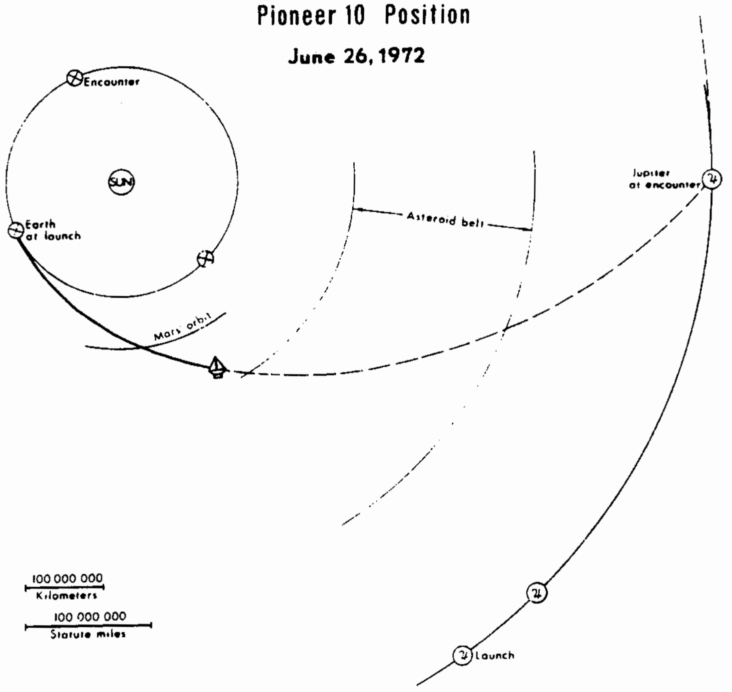
FLIGHT OPERATIONS

All active scientific instruments on the spacecraft are generally in good working order and returning continuous data. During the period between June 19 and 26 the Langley Research Center Meteoroid Detector detected 6 meteoroid hits. This makes a total of 47 impacts detected to date.

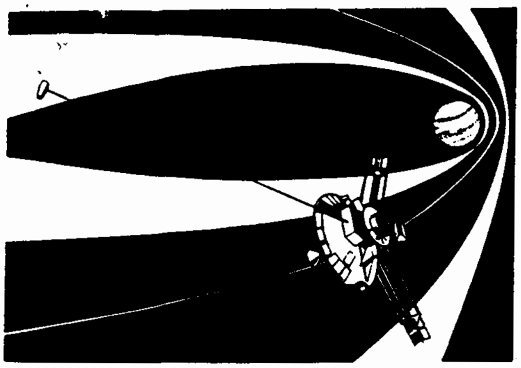
A syzygy condition in which Pioneer 10, the Earth and the Sun were in a straight line occurred on May 17, 1972. Since the spacecraft is essentially earth-pointing, this condition resulted in the Sun changing from the right side to the left side of Pioneer 10 with an attendent large rate of change of sun-clock-angle. Because of this large rate of change, the stellar reference assembly was used for the roll reference pulse from May 8 until June 13 instead of the normally used sun sensor.

Pioneer 10 Position

June 26, 1972



Earth-Spacecraft distance 138.40 million Km
Spacecraft-Jupiter distance 530.84 million Km



pioneer/jupiter

PIONEER 10 LAUNCHED – MARCH 2, 1972

NEWSLETTER

NO. 7 NASA/AMES RESEARCH CENTER • MOFFETT FIELD, CALIFORNIA 94035 OCTOBER 2, 1972

PIONEER 10 MIDWAY THROUGH ASTEROID BELT

Pioneer 10 entered the Asteroid Belt on July 15, 1972 and has been penetrating this doughnut shaped area which measures approximately 3 billion kilometers around, 280 million kilometers wide and 80 million kilometers thick. The material in the belt travels at speeds of about 20 km/sec. and ranges in size from dust particles to rock chunks as big as Alaska. Scientists believe the Asteroid Belt contains enough sparsely scattered material to make a small planet with a volume of about 1/1,000th that of the Earth. Astronomers have identified and calculated orbits for the 1831 largest asteroids.

When the Pioneer 10 spacecraft entered the Asteroid Belt, the Asteroid/Meteoroid Detector which detects particles having masses of 10^{-6} grams or greater, gave no initial indication of this entry. However, in the past four weeks the event rate as determined from the "on-line" system has increased as the spacecraft approaches the region of maximum concentration of the asteroids visible from the Earth. The Principal Investigator estimates that some 100 events have been detected to date. Preliminary analysis of two early events has been performed to determine the Solar System orbits of the observed meteoroids. Results of the analysis indicate that the meteoroids were moving in direct elliptical orbits with relatively low inclinations to the ecliptic plane.

To date 80 sensor cell penetrations have been experienced by the Meteoroid Detector on Pioneer 10 which detects particles having masses of 10^{-9} grams or greater. The rate at which these events have occurred has been constant since the initial ten-day period of the mission, indicating no increase in activity in the Asteroid Belt.

SPACECRAFT HEALTH

The ten active scientific instruments on Pioneer 10 are operating satisfactorily and continuously. The eleventh, the Infrared Radiometer, which will be used only during the Jupiter fly-by to record the planet's heat emissions, has been checked and is functioning properly. All spacecraft systems are operating well, and the nuclear-electric power sources are providing normal levels of power. Temperatures in the spacecraft are nominal. Gas reserves for course changes are about twice the amount which will be needed.

PIONEER GROUND DATA SYSTEM

Pioneer 10, like the other active Pioneer spacecraft (6 through 9), is used for making complex scientific measurements in interplanetary space and then transmitting the data to Earth. Success in obtaining meaningful information requires a reliable ground data system to acquire spacecraft data and a knowledgeable operations team to fly the spacecraft properly. The Pioneer Ground Data System consists of three main parts located at the following facilities: Deep Space Stations, Jet Propulsion Laboratory and Ames Research Center, interconnected by the Ground Communication Facility (GCF). The Deep Space Stations have 26 or 64 meter antennas which are used to receive telemetry from the spacecraft and simultaneously transmit commands to the spacecraft. The receiver, subcarrier demodulator assembly and symbol synchronizer assembly convert the received signal to a usable sequential symbol stream. The digital decoder assembly then converts the spacecraft encoded symbol stream back to the original data stream. The data are time tagged and placed in high speed data blocks by the Telemetry and Command Processor for transmission to JPL and ARC. At JPL the high speed data blocks are received by the Mission Control and Computing Center (MCCC) at which time they are made available to the IBM 360-75 computer. At the same time, either through the 360-75 computer or direct from the DSS, the high speed data blocks are sent to ARC.

During launch, midcourse maneuvers and encounter, the MCCC facility at JPL, known as the Pioneer Mission Support Area (PMSA), is used as the primary source of activity with both digital television and hard copy devices supplying the data to the spacecraft analysts. After the second mid-course maneuver the primary real-time data activity for mission control is transferred to ARC and the PMSA becomes a reduced effort back-up for the real time data activity at ARC.

Master Data Records (MDR) are generated by the MCCC at JPL which are used for off-line production at ARC of the Experiment Data Records (EDR).

The Pioneer Mission Analysis Area (PMAA) at ARC is the prime source of real-time science data during the entire mission and for real-time engineering data during the cruise phase of the mission. The system consists of Xerox Data Systems (XDS) Sigma V computers interfacing directly with the High Speed Data lines to receive, process and display telemetry, command, and DSS status information and to transmit command instructions. Telemetry can be either direct from the Deep Space Stations or reformatted by the MCCC. Command data must be transmitted via the 360-75 computer at MCCC, or via direct 360-75 Input/Output interface at the PMSA. Commands are entered in mnemonics form for simplicity and are translated to a spacecraft meaningful bit stream by the 360-75 computer, which then formats and sends them to the Telemetry and Command Processor via High Speed Data line. This processor controls the timing and transmission to the spacecraft. Each step is under operator control at either JPL or ARC.

PIONEER MISSION OPERATIONS

The spaceflight operations encompass the acquisition of data from all the Pioneer spacecraft. Pioneers 6 through 9 are in heliocentric orbits approximately 1 AU from the Sun. Pioneer 10 has been traversing the Asteroid Belt since July 15, and is currently traveling at a speed of approximately 20.07 km/sec relative to the sun and 45.82 km/sec relative to the earth.

The JPL Deep Space Network (DSN), a world-wide system of large antennas, is used to communicate with all of the Pioneer spacecraft. The distance between Earth and Pioneers 6, 7 and 8 is so great that the DSN must use the 64-meter antenna at Goldstone, California, to communicate with these spacecraft. Communication with Pioneers 9 and 10 is accomplished by the DSN 26-meter stations, except for special occasions when the 64-meter station must be used for higher data rates.

The Operations Team at JPL provides predicts and pointing angles for the Deep Space Stations of the DSN to use for properly pointing the antennas and for acquiring receiver lock on the spacecraft signals. In addition, this team schedules the station and equipment, monitors the station performance, and provides instructions on the required operating configurations. Since the on-board spacecraft data and command storage capability is very limited for the Pioneer spacecraft, close coordination is required between the JPL Operations Team and the Pioneer Project Operations Team located in the Mission Analysis Area at Ames Research Center.

The Pioneer Project Operations Team analyzes the on-line incoming telemetry data to determine the health of the spacecraft and the instruments and to select the operating modes for the various instruments. Indications of anomalous performance require immediate action on the part of the Spacecraft Analyst or Science Analyst to determine the cause of the anomaly and to take corrective action.

Most of the scientific instruments are designed to have multiple operating ranges for acquisition of interplanetary data and to have commandable calibration modes. The spacecraft has multiple formats to accommodate the transmission of data from the various instruments. Under these circumstances the operation of Pioneer spacecraft in the cruise mode is far from a routine acquisition of data. The Science Analyst interfaces with the Principal Investigators to determine their requirements for mode changes and calibrations. On-line analysis is made to assure that these requirements are being met. In the cruise mode during periods of high activity, it is not unusual to send from 100 to 200 commands to Pioneer 10 during an eight-hour period. As of the end of September, a total of 8,097 commands were sent to Pioneer 6, 10,330 to Pioneer 7, 9,006 to Pioneer 8, 9,321 to Pioneer 9 and 11,756 to Pioneer 10. Pioneer 10 is being tracked continuously 24 hours a day, seven days a week. Pioneer 9 tracking coverage is about three passes per week. Since the demand for use of the 64-meter antenna at Goldstone is so great, the tracking of Pioneer 6, 7 and 8 is very infrequent.

The Pioneer 10 communication distance is such that the spacecraft high-gain antenna must be used. This antenna has a dish-type reflector with the axis lying in the ecliptic plane. The beam width of this antenna is about 1.6° requiring that the antenna be kept pointing close to Earth. The relative motion of the Earth and the spacecraft is such that the Pioneer Operation Team commands the spacecraft to precess to a new attitude approximately every seven days in order to maintain the optimum data rate for the current communication distance.

Pioneer 10 was commanded to perform a small velocity correction on September 19, 1972. The time of arrival at Jupiter was adjusted by about 15 minutes so that the spacecraft will be occulted by one of Jupiter's moons, Io, shortly after periapsis. This occultation is expected to provide more sensitive measurements of the atmospheric characteristics of this moon than have been obtained previously from ground based observations.

PIONEERS MEASURE SOLAR STORM

During August a series of explosions on the sun's surface created the most intense solar storm ever measured. During the peak of the storm Pioneer 9 was 116 million kilometers from the sun, Pioneer 10 was 213 million kilometers from the sun, and both spacecraft were located on a common radial line from the Sun. During the storm Pioneer 9 saw the highest solar wind speeds ever recorded, and Pioneer 6 and 9 the greatest numbers of high energy particles ever seen in space. At the peak of the storm solar cosmic rays traveled the 116 million kilometers from the sun to Pioneer 9 in less than one hour, compared with 33 hours for slower solar wind particles. High energy particle counters saw 4,000 times more particles than normal, quantities never before recorded. Solar wind speeds of more than 1,000 km/sec (2.237 million miles per hour), the highest ever recorded were sensed by Pioneer 9. While crossing the 213 million kilometers to Pioneer 10 in 76 hours, the same solar wind gases slowed down to about one half of this velocity. Apparently particle motion straight out from the Sun had been converted to thermal motion of the total mass of high speed solar gas, at temperatures of 2 million°K compared with a normal of 100,000°K. The interplanetary magnetic field at Pioneer 10 rose to 100 times higher than normal. A solar storm on August 7 produced, during a one-hour period, energy equal to the entire U.S. electrical power consumption for 100 million years at present rates.

LOST AND FOUND – ONE SPACECRAFT

Sometime between July 25 and August 6, 1972 Pioneer 7 stopped sending radio signals that could be detected by the 64-meter antenna at Goldstone, California. The Pioneer Operations Team theorized that at its most distant point from the sun the spacecraft's electrical output power from its solar panels had fallen below the level required to operate the spacecraft and the scientific instruments. The spacecraft is designed to turn off the instruments and the transmitter amplifier tube when the power requirements exceed the output power, and it was not known when the turn off occurred. It was calculated that the spacecraft receiver temperature would decrease by 50 degrees thus changing the lock frequency of the receiver. Estimates were made of the frequencies at which the tracking station should transmit commands "in the blind" for the spacecraft to turn on the high-power transmitter tube. The antenna pointing angles were determined from past tracking data.

Thirty-five minutes after the turn-on command was transmitted at the proper frequency, signals came from the spacecraft 190 million miles away indicating the success of the team's strategy.

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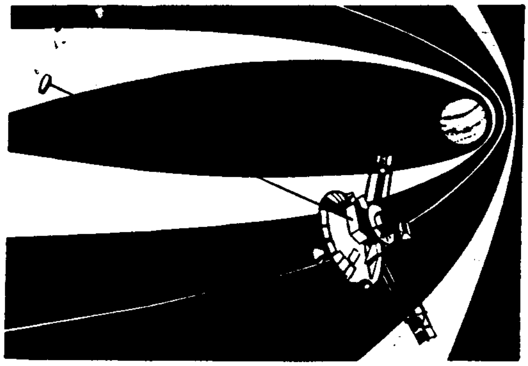
Earth-Spacecraft distance 422.99 million Km
Spacecraft-Jupiter distance 377.33 million Km



pioneer/jupiter

PIONEER 10 LAUNCHED – MARCH 2, 1972

NEWSLETTER

NO. 8 NASA/AMES RESEARCH CENTER • MOFFETT FIELD, CALIFORNIA 94035 JAN. 2, 1973

FIRST SCIENTIFIC RESULTS FROM PIONEER 10

Pioneer 10, with all systems operating satisfactorily, continues to direct a stream of scientific and engineering data back to Earth. The spacecraft will complete its transit of the Asteroid Belt in January and has sustained no known damage so far. In general, scientists believe that the Asteroid Belt will not constitute a dangerous area for spacecraft passing through it on future outer planet missions.

Enough scientific data have been received and processed by the On-Line and Off-Line Data Processing Systems to enable the scientific investigators with experiments on board to reach some conclusions. On November 29, 1972, the investigators met at Ames Research Center to present preliminary results based on data received from the spacecraft.

MAGNETIC FIELDS

Dr. E. J. Smith, of the Jet Propulsion Laboratory, discussed the results from the Helium Vector Magnetometer (HVM) which measures with extreme accuracy the interplanctary magnetic field and the Jovian magnetosphere. Dr. Smith stated that in August a series of major solar flares were observed by the HVM in the form of magnetic fields which accompanied the shock waves associated with the flares. As a result of the largest flare, the magnetic field was observed to increase from a "quiet" background level of 3 to 4 gamma to a level of 15 to 16 gamma in 3 minutes at the time the shock wave was detected by Pioneer 10. Comparison between Pioneer 9 and Pioneer 10 data seemed to indicate that the shock waves associated with the solar flares were slowing down as they propagated outward from the Sun.

In connection with the magnetic field data, as it related to the 27-day solar cycles, Dr. Smith has computed averages taken over the solar radiation period. As expected, the field decreased with distance from the Sun. He also stated that changes in large scale properties of the magnetic field are, in general, consistent with extrapolation from 1 AU outward.

In dealing with discontinuities in the magnetic field data, Dr. Smith indicated that high spacecraft data rates help in the analyses of these discontinuities. The preliminary conclusion is that the magnetic field is just as irregular in terms of discontinuity at large distances (3 AU) as it is closer to the Sun (1 AU).

PLASMA

The Plasma Analyzer consists of two detectors which measure solar plasma (ions and electrons in space) as a function of temperature, density, direction of flow and velocity. This instrument maps the solar wind as the plasma flows from the vicinity of the Sun to outer space.

Dr. J. H. Wolfe of NASA, Ames Research Center, stated that comparison of data from Pioneers 9 and 10 made it possible to obtain a direct comparison of the plasma temperature, velocity and density as the plasma transversed from Pioneer 9 to Pioneer 10.

The data to date show that as the plasma streams flow outward from the Sun, the velocity decreases but the temperature does not decrease adiabatically. The velocity at Pioneer 9 was 1050 km/sec and 700 km/sec at Pioneer 10, and the temperature did not decrease proportionally. Also, the solar fluxes or streams tend to overrun and merge with each other making it difficult to identify solar flares with their associated plasma streams as the plasma travels through space. This was evidenced by higher velocity plasma observed at Pioneer 9 which overtook slower, previously released plasma and produced a low density plasma observed at Pioneer 10.

CHARGED PARTICLE COMPOSITION

The Charged Particle Instrument, consisting of a charged particle telescope and electron, fission and proton detectors, records interplanetary cosmic radiation. Dr. J. A. Simpson, of the University of Chicago, stated that the galactic cosmic ray integral intensity gradient is consistent with the expected manner in which the solar wind and corresponding magnetic field effect the particle flux in this energy range. The differential radial gradients for protons and helium from 29–67 MeV per nucleon falls within the range of 0 to 50 percent per AU for proton or helium fluxes. Spectra of protons and helium below 20 MeV per nucleon, which was discovered in 1964, is present at more than 2 AU and remained remarkably constant over the solar cycle 1964–1972. Pioneer 10 measurements firmly establish the existence of this component. Present evidence points towards a heliospheric or galactic origin for this component.

JOVIAN CHARGED PARTICLES

The Geiger Tube Telescope (GTT) measures the intensities, energy spectra and angular distribution of electrons and protons. Dr. J. A. Van Allen of the University of Iowa reviewed the significant results obtained to date with this instrument.

The early August solar event has been of exceptional interest due to its high intensity and prolonged duration. Maximum intensity for the early August solar disturbance as measured by the GTT occurred in mid-day of 5 August for protons $E_p \geq 80$ MeV (Detector C) whereas the maximum intensity for protons $E_p \geq 8$ MeV (Detector B) occurred in mid-day of 6 August. The observations of Explorer 35 at 1 AU clearly show an enormously greater intensity on 8 August than do the observations of Pioneer 10. A comparison of the Explorer 35 data for $E_p >$ 55 MeV at 1 AU and Pioneer 10 data for $E_p > 80$ MeV at 2.2 AU indicates that the Explorer 35 proton intensity is approximately a factor of 50 greater than the Pioneer 10 data. This difference is attributed to the difference in effective heliographic longitude of the two sets of observations.

COSMIC RAY ENERGY SPECTRA

The Cosmic Ray Telescope measures charged particles spectra and angular distribution over an extended energy range. Dr. B. J. Teegarden, NASA/Goddard Space Flight Center, stated that the large solar flares in early August 1972 have provided an excellent opportunity to study the propagation of solar cosmic rays at large distances from the Sun on Pioneer 10. The maximum intensity of particles in the low MeV region was observed to occur two days later on Pioneer 10 at 2.2 AU than it did on IMP 5 at 1 AU. This long delay is difficult to understand in view of the relatively good connection of the magnetic field between Pioneer 10 and IMP 5.

The low energy telescope has displayed far better charge and isotopic resolution than any other telescope flown in the past. It's excellent performance has, for the first time, provided for resolution of the isotopes of carbon, oxygen, neon and magnesium and their relative abundances in the solar cosmic rays. Preliminary analysis shows a number of very interesting differences between the solar and terrestrial abundances. For example, O^{17} appears to be present at a level equal to 100 times the terrestrial abundance.

JOVIAN TRAPPED RADIATION

The Trapped Radiation Detector was designed to measure the characteristics of trapped radiation belts around Jupiter. Dr. R. W. Fillius of the University of California at San Diego explained that the instrument has five detectors which measure the energy levels of electrons and protons over the general ranges of .2 MeV to 12 MeV for electrons and 70 MeV to 350 MeV for protons. A cursory review of the data has indicated that the energy patterns for the electrons and protons during the August 1972 solar flare activity were very similar to energy patterns presented by other experimenters. It was noted, however, that the electron energy patterns were different than the proton energy patterns.

ULTRA VIOLET PHOTOMETRY

The Ultraviolet Photometer determines the interplanetary neutral hydrogen density by observing its interaction with the solar wind, and will measure the hydrogen/helium ratio and temperature of the Jovian atmosphere. Dr. D. L. Judge of the University of Southern California presented some intial Pioneer 10 results on the interplanetary and interstellar hydrogen and helium glow. The data are from the measurements of the Lyman-α and helium 584Å resonance scattering and show that the direction of maximum flux for hydrogen Ly-α is near the plane of the ecliptic at a right ascension of about 240°. Similar results were found for the helium glow. The hydrogen glow results obtained by the USC/UV instrument are similar to the measurements obtained by scientists from France and Russia and an earlier U. S. measurement. The helium glow measurement is a new result.

Since the present data are the first such measurements to be obtained over a large radial distance from the Sun, they provide unique data on the density and velocity of the two gases in the "local" interstellar medium. In addition, the radial gradient data permits separation of the local interplanetary hydrogen and helium glow from the interstellar or galactic component.

IMAGING PHOTOPOLARIMETRY

The Imaging Photopolarimeter performs zodiacal light mapping to assess the quantity, distribution and nature of particulate matter in space, make photometric and photopolarization measurements of Jupiter and its satellites, and will make two-color visible light images by spin-scan optical sensing. Dr. M. S. Hanner, Dudley Observatory, Albany, New York, reported that the most significant data recorded with respect to measurements of zodiacal light (interplanetary dust cloud) concern the gegenschein, or after-glow phenomenon. Pioneer 10 measurements yield direct confirmation that this particular phenomenon is not associated with a dust cloud surrounding the Earth. Measurements to date indicate that the gegenschein is due to sunlight reflecting from a collection of interplanetary dust particles at some point in space other than the Asteroid Belt.

ASTEROID METEOROID DETECTOR

The objectives of this experiment are to assess solid particle flux, particle size and velocity, and to establish a basis for determining particulate origin and spacial distribution. The Asteroid Meteoroid Detector consists of an array of four telescopes and the associated electronics which uses optical sensing to obtain data on particles as small as 10^{-6} grams mass.

Dr. R. K. Soberman presented data on two "events" seen by the instrument early in the mission. The data carried the analysis from telemetered data through trajectory analysis to orbits of the particles. Detailed statistical analysis is proceeding using background and peak data to determine the threshold position as a function of background light.

A brief review was given of pre-flight estimates of the AMD asteroid event rate at 2.5 AU. The NASA model predicted about one per week. Now, preliminary data indicate a value closer to one per day.

METEOROID DETECTION

The Meteoroid Detector consists of panels of pressurized cells mounted around the high gain antenna, the penetration of which is counted. Mr. W. H. Kinard, NASA/Langley Research Center, explained that the objective of the experiment is to measure flux levels and distribution of particulate matter in the mass range 10^{-9} grams and larger in space.

The main conclusion drawn from LaRC/MD data from Pioneer 10 so far is that the spatial density of meteoroids with mass 10^{-9} grams and larger between 1 and 3 AU from the Sun is almost constant. Previous estimates were for a marked increase in the Asteroid Belt.

OFF-LINE DATA PROCESSING SYSTEM

The objective of the Pioneer Off-Line Data Processing System (POLDPS) is to extract information to be used by the experimenters from the high speed data stream received from the spacecraft. These data are received at the Deep Space Stations and routed directly into large scale computers at the Mission Control and Computing Center (MCCC), Jet Propulsion Laboratory, Pasadena, California. MCCC also records these data on a Master Data Record (MDR) tape which is sent to Pioneer Mission Operations Center (PMOC), Ames Research Center, for off-line processing. Data inputs from several sources are used to assure that the information on the MDR is as complete and accurate as possible.

At PMOC, POLDPS validates the MDR by checking for sequence, timing and data outages, then strips out the science data and associated engineering data for each of the scientific instruments on board for 24-hour periods. Other pertinent information, such as spacecraft attitude as a function of time, along with the commands which were sent to the spacecraft during the period is merged into the record. All this information constitutes the Experimenter Data Record (EDR), which is written and sent to each experimenter for processing and analysis. This has been a difficult problem, as the EDR must be compatible with the computer used by the experimenter, and the 12 experimenters use 9 different types of computers. A trajectory data tape, which is a time-indexed set of parameters describing the location of the spacecraft in space is forwarded with the EDR.

The experimenter analyzes and interprets the results, presenting them in the form of technical papers and reports to the scientific community. He is required to furnish his findings and his source data to the National Space Sciences Data Center. This is a data bank from which all scientific findings can be made available to the scientific community.

STATUS OF PIONEER G

The Pioneer G spacecraft has had all of its scientific instruments integrated and has successfully passed the system acceptance vibration and thermal-vacuum tests. The only remaining activities are minor tests, alignments and shipping preparations.

The spacecraft is scheduled to be shipped via air to Cape Kennedy on February 13, 1973. The launch will take place early in April.

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Earth-Spacecraft distance - 639.54 million km
Spacecraft-Jupiter distance - 280.56 million km
Spacecraft-Sun distance - 497.51 million km

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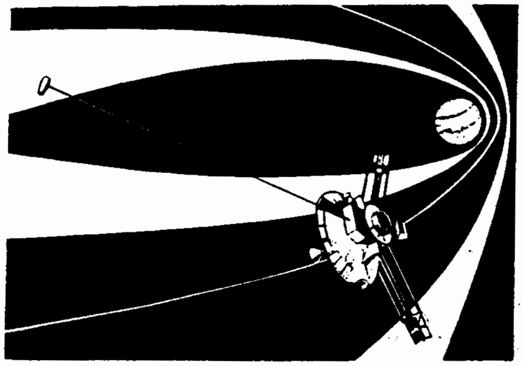


pioneer/jupiter

PIONEER 10 LAUNCHED – MARCH 2, 1972
PIONEER 11 LAUNCHED – APRIL 5, 1973

NEWSLETTER

NO. 9 NASA/AMES RESEARCH CENTER • MOFFETT FIELD, CALIFORNIA 94035 APRIL 20, 1973

PIONEER 11 LAUNCH TO JUPITER SUCCESSFUL

Pioneer G lifted off from Launch Complex 36B at the Cape Kennedy Air Force Station on April 5 at 9:11 PM, EST, (096/0211:00.117 GMT) at the opening of the launch window on the first day of the 1973 Jupiter opportunity. After successful injection into the planned trajectory the spacecraft has been redesignated Pioneer 11, the second of two spacecraft designed to explore the interplanetary medium, the asteroid belt and the planet Jupiter.

The prelaunch operations went smoothly, except for a five-hour period when the gantry had to be evacuated due to an electrical storm. Pioneer 11 was launched on an Atlas/Centaur/TE 364 three-stage vehicle. Atlas booster engine cutoff (BECO) occurred at 9:13 PM, EST, followed by the Atlas sustainer engine cutoff (SECO), Centaur/TE 364 separation from the Atlas, and start of the Centaur Main Engine at 9:15 PM. Main engine cutoff (MECO) occurred at 9:22 PM. Burnout of the TE 364 third stage and separation of the spacecraft from the third stage occurred at 9:26 PM.

After the Radioisotope Thermoelectric Generators (RTG) were commanded to deploy, telemetry indicated that only one set of RTGs had deployed; the other had only partially deployed. The on-board sequencer was inhibited and the conditions of all systems were thoroughly analyzed. Several courses of action were planned to possibly solve the problem. It was finally agreed that an initial precession maneuver should be conducted. During the precession maneuver which required several hundred short bursts of the thrusters, the RTG boom completed deployment. The magnetometer boom was then deployed and normal flight operations including turn-on of scientific instruments were continued. At launch the spacecraft accelerated to 31,100 mph and about 11-1/2 hours later crossed the lunar orbit. Midcourse maneuvers were begun five days after launch.

THOUGHTS OF THE PROJECT MANAGER

It is with the mixed emotions of elation and regret that I write this. Elation, of course, for the very successful launch and flight operations of Pioneer 11. Regret because so many of the people who have worked so hard to make Pioneer 10 and 11 successful will no longer be actively participating in the program. To them I say "Thank you for your dedication to the Pioneer Program and your technical excellence in making possible its success. It has been a pleasure working with you and good luck in your next activity."

To those still actively participating in the program. I congratulate you for a job well done. But the most important task remains to be accomplished – planning and conducting the encounter operations. That time can easily be the most exciting in our lives. Let us, therefore, resolve to dedicate ourselves to making that a successful activity and to carry on in the tradition of those persons now leaving the program.

Charles F. Hall
Manager, Pioneer Project

INTEGRATION AND TESTING

Integration of the subsystems into Pioneer G began in March 1972. In June the spacecraft was completely assembled and all the scientific instruments were installed. Beginning in July, a series of tests were executed to evaluate the performance of the spacecraft and instruments. These included integrated systems tests, magnetic mapping, alignments, RTG interference, vibration and thermal-vacuum acceptance tests. On February 1, 1973, a Preship Review was held during which the performance of the spacecraft and the instruments was reviewed by all responsible organizations, and it was agreed that Pioneer G was ready. The spacecraft was shipped to Cape Kennedy on February 13, 1973, aboard the Super-Guppy, an aircraft designed to carry outsized cargo.

PRELAUNCH OPERATIONS

After arrival at Kennedy Space Center, integrated systems tests, instrument tests and RTG performance tests were performed to verify the flight condition of the

the spacecraft systems. The spacecraft was then mated to the third stage, which was then mated to the Atlas-Centaur launch vehicle. A final integrated system test was run to assure launch readiness. This was followed by the testing of computer programs and the communication links between the spacecraft, Deep Space Stations, Jet Propulsion Laboratory and Ames Research Center. A series of launch rehearsals were performed to familiarize all personnel with their tasks. The Launch Readiness Review was held on April 3, and on the following day the RTGs were installed and the launch countdown was begun. April 5 was the first day of the 1973 launch opportunity for Pioneer G, and will bring the spacecraft into encounter position in 609 days. The last day of the opportunity is April 26, and due to the relative motion of the two planets, the trip time would be increased to 825 days.

MISSION OPERATIONS

NASA's Tracking and Data Acquisition Network, operated by Jet Propulsion Laboratory, supported the planning, test and training, and operations for the Pioneer 11 launch operations and mission control. During the boost phase of the mission, the Air Force Eastern Test Range at Cape Kennedy and the NASA Near Earth Space Flight Tracking and Data Network furnished continuous telemetry information to Pioneer Mission Operations groups at Jet Propulsion Laboratory and Ames Research Center. Twenty minutes after liftoff, Deep Space Station 51, at Johannesburg, South Africa, acquired spacecraft telemetry signals, and two-way communication was established. Communications with Pioneers 10 and 11 in deep space will be enhanced by the implementation of two more 64-meter tracking stations, one in Australia and one in Madrid, Spain. These, together with the 64-meter station at Goldstone, California, will permit nearly continuous coverage for the Pioneer spacecraft throughout their missions.

Pioneer Mission Operations Center (PMOC), located at Ames Research Center, serves as the focal point for all six Pioneer spacecraft currently in operation. The computer and communications equipment located at PMOC enable controllers and scientists to process and analyze spacecraft engineering and science data on a real-time basis, generate commands for all spacecraft operations, monitor spacecraft subsystem and instrument status, and provide quick-look telemetered information to all users.

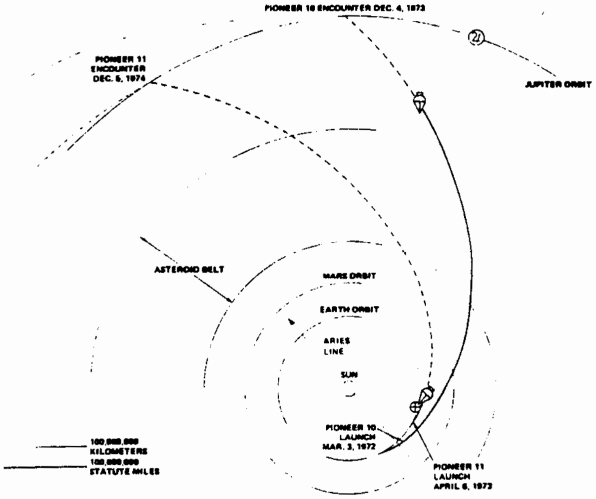
MIDCOURSE MANEUVERS

Strategy for selecting the aim point for Pioneer 11 was complicated by the variety of potential scientific interests after Pioneer 10 encounter. Execution of calibration and midcourse maneuvers began at L+5 day and continued for approximately fourteen hours. On the evening of April 11, sensitive tests demonstrated that spin axis alignment was correct. The previously selected optimum aim point was therefore retained as the midcourse maneuver objective.

In its present trajectory state, the Pioneer 11 encounter will take place on December 4, 1974 at 10:13 GMT at 1.3 Jupiter radii from the center, 45.3° below the ecliptic parallel. These conditions provide for uncomplicated adjustment of Pioneer 11 target point by acceleration along the earth-line after Pioneer 10's encounter with Jupiter and the assessment of its scientific data. Among those options available for the Pioneer 11 encounter are the following: (1) target to nearly duplicate the Pioneer 10 approach, (2) target such that the post-Jupiter encounter trajectory may permit a flyby of Saturn in 1979, (3) target to a closer-in or farther-out flyby depending upon the results from Pioneer 10, and (4) target for either a polar or near-equatorial flyby of Jupiter.

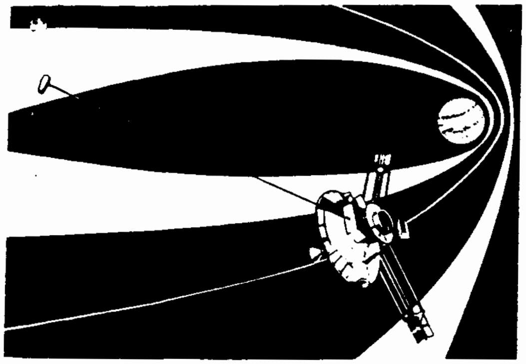
The midcourse maneuver was accomplished by a single velocity increment of 38 m/sec generally away from Earth, while the spacecraft spin axis was turned 35° away from Earth, towards the Sun and northward.

Pioneer 10 & 11 Position



April 20, 1973

Earth-Pioneer 10 Distance – 628.52 Million Km
Pioneer 10–Jupiter Distance – 178.84 Million Km
Pioneer 10–Sun Distance – 602.19 Million Km
Earth–Pioneer 11 Distance – 11.19 Million Km
Pioneer 11–Jupiter Distance – 773.33 Million Km
Pioneer 11–Sun Distance – 153.02 Million Km



pioneer/jupiter
PIONEER 10 LAUNCHED – MARCH 2, 1972
PIONEER 11 LAUNCHED – APRIL 5, 1973
NEWSLETTER

No. 10 NASA/AMES RESEARCH CENTER • MOFFETT FIELD, CALIFORNIA 94035 January 14, 1974

PIONEER 10 ENCOUNTER WITH JUPITER A RESOUNDING SUCCESS

On December 3, 1973 at 6:25:05 PM, PST (Day 338 022505 GMT) the Pioneer 10 spacecraft passed within 130,000 Km (81,000 miles) of Jupiter's cloud tops. Prior to this date, the anticipation was great as a close-up image of the Giant Red Spot was received and as the radiation level at the spacecraft reached the design limits and continued to rise above these limits. The spacecraft indicated the existence of these high radiation levels, but continued to operate normally with the on-board scientific instruments making detailed measurements successfully. Each bit of newly received data reported results which in many cases had not been previously predicted. As the scientists and mission control personnel monitored the data, 46 minutes old by spacecraft time, the radiation levels peaked. After reaching the point of closest approach to Jupiter, Pioneer 10 passed behind the Galilean moon, Io, and then the planet itself. During the passage behind Jupiter no data were received from the spacecraft for approximately one hour due to occultation of the telemetry signal by the planet. The spacecraft signal reappeared as the spacecraft emerged from behind the planet. All radiation levels continued to subside, and the spacecraft with its valuable science payload continued normally. Initial results of the mission indicate that the radiation levels are different from the predicted values and that the effects of the Jupiter radiation environment on the spacecraft were less than feared.

The velocity of Pioneer 10 was increased by its passage by Jupiter to the extent that it was placed on an escape trajectory from the solar system. The interplanetary portion of the Pioneer 10 mission is continuing as the science payload searches for the boundary of the Sun's influence, or the Heliosphere, where the origin and motion of particles and fields are not Sun controlled but follow the physics of the Galaxy.

A total of nearly 15,000 commands were issued from the Pioneer Mission Operations Center through the critical 60-day period centered on the date of closest approach.

QUICK-LOOK RESULTS

Throughout the encounter period, experimenter teams located in the Pioneer Project offices were eagerly taking their computer generated real-time-data averages printed out by the mission operations software and plotting these quick-look results. Analyses, models, and predictions were then generated from these results. As experimenter teams compared their results and as more data were received fewer of the old models seemed to fit the results, and fewer predictions were made. The detailed analysis will take place over the months to follow as the many Experiment Data Record tapes are delivered to the Principal Investigators for analysis in their dedicated computer programs.

The energetic particle concentration increased markedly once Pioneer 10 passed within 15 to 10 radii of the planet. The energetic electron fluxes were an order of magnitude greater than those of the JPL Radiation Post Workshop Nominal Model. However, the proton fluxes were less than those of the model. The spacecraft passed through trapped radiation belts many times more intense than the design levels. However, only minor detrimental effects have been noted in the performance of the spacecraft subsystems and the scientific instruments. The planetary magnetic field that entraps the radiation belts was found to be tilted about 15 degrees from the planet's spin axis and the planetary magnetic center is offset approximately one half radius from Jupiter's geometric center. It was also found that at large distances from the planet the magnetic field lines are more elongated than those associated with a typical dipole field and that the magnetic field is apparently easily compressible by the solar wind resulting from solar activity. The magnetic field strength was determined to be eight times that of the earth and reversed in polarity. The larger of the planet's moons seemed to affect particle activity in the radiation belts. Further analysis will be required to define this effect.

Helium was detected in the planet's atmosphere which, with further analysis, will allow determination of the important hydrogen/helium ratio. The Occultation Experiment detected an ionosphere and a very tenuous atmosphere on the Galilean satellite, Io. The planet's ionosphere was noted to be multilayered, but more analysis will be required to determine specific characteristics of the Jovian atmosphere.

Planet and Galilean satellite mass and density measurements were refined by evaluating their gravity effects on the spacecraft trajectory. Accuracy of the measurement of the amount of polar flattening due to high spin velocity was also improved.

Infrared radiometric measurements to date indicate that Jupiter's bright belts are slightly cooler than its dark belts and that no temperature difference exists between the sunlit and dark surfaces. These measurements also indicate that the planet radiates heat at a rate greater than that at which it receives heat from the Sun, thus confirming results of astronomical observations The planet's average surface temperature was measured at approximately 140° K, with Io and Ganeymede measured at approximately 110° K and 126° K, respectively. Infrared radiometric measurements of the giant red spot indicate that the temperature of this feature is no higher than the average surface temperature of the planet.

Solid particles detected near the planet equator indicate the presence of a dust belt with a concentration roughly twice that at earth, but compressed closer to the planet surface (cloud tops).

Images received from the Imaging Photopolarimeter provided high quality surface details of the planet. Rectified images are currently being produced for quick-look purposes, and enhancement of these images are expected to provide even better definition. Photometric and polarization measurements made during the encounter period will aid in determining the characteristics of the Jovian atmosphere.

PIONEER 10 MISSION

The Pioneer 10 Mission began at 5:49 PM PST March 2, 1972 (Day 063 014903 GMT) after three attempts were scrubbed due to high winds over Cape Kennedy, Florida. The primary objectives of the Pioneer 10 mission are (1) to investigate the particles and fields of the interplanetary medium, their motions, their solar and galactic relationships, and the extremes of the solar influence; (2) to investigate the hazards of traversing the Asteroid Belt and to determine particle sizes and fluxes in this belt; (3) to investigate the planet Jupiter and determine its characteristics.

Six-hundred and forty-one days after launch Pioneer 10 reached Jupiter having accomplished two of its objectives and then completed its third objective successfully by determining specific characteristics of the planet. In the days and months ahead the millions of data bits collected by the science payload on board Pioneer 10 will be analyzed to unravel the many mysteries of this dynamic planet. The Mission will continue in the interplanetary medium beyond Jupiter to investigate the extreme limits of the solar influence (heliosphere).

The following is a list of the Pioneer 10 mission sequence of events, both those accomplished and those yet to occur:

Event	Date
Lift Off	March 3, 1972
First Midcourse	March 7, 1972
Second Midcourse	March 24, 1972
Inferior Conjunction	May 11, 1972
Cross Mars Orbit	May 21, 1972
Enter Asteroid Belt	June 12, 1972
Superior Conjunction	January 11, 1973
Depart Region of Asteroid Belt	January 20, 1973
Inferior Conjunction	July 31, 1973
Jupiter Encounter Period	November 3, 1973–January 3, 1974
Cross Orbit of Outermost Moon, Hades (J IX)	November 4, 1973
Cross Orbit of Poseidon (J VIII)	November 8, 1973
Cross Orbit of Pan (J XI)	November 9, 1973
Cross Orbit of Andrastea (J XII)	November 11, 1973
Cross Orbits of Demeter (J X), Hera (J VII) and Hestia (J VI)	November 22, 1973
Cross Bow Shock	November 26, 1973
Cross Magnetopause and into Magnetosphere	November 27, 1973
Cross Orbit of Callisto (J IV)	December 2, 1973
Periapsis Day	December 3, 1973
(Earth - S/C Distance 5.53 AU)	
Cross Orbits of Ganymede (J III), Europa (J II), Io (J I) and Encounter with Amalthea (J V)	
Closest Approach (Periapsis)	– 6:25:05 PM PST
Enter Io Occultation	– 6:41 PM PST
Exit Io Occultation	– 6:42 PM PST
Enter Jupiter Occultation	– 7:43 PM PST
Exit Jupiter Occultation	– 8:43 PM PST

Enter Planet's Shadow	– 8:19 PM PST
Exit Planet's Shadow	– 8:59 PM PST
Pass Out of Magnetosphere into Magnetosheath between Magnetosphere and Bow Shock	December 10, 1973
Cross Bow Shock into Interplanetary Medium	December 12, 1973
Due to Solar Activity Bow Shock Changed Position Placing Spacecraft back in Magnetosphere	December 13, 1973
Final Exit from Magnetosphere and Bow Shock	December 18, 1973
Cross Saturn's Orbit (Earth-S/C Distance 9.5 AU)	January 26, 1976 (est.)
Cross Uranus' Orbit (Earth-S/C Distance 19.9 AU)	July 14, 1979 (est.)
Distance from Sun as far as Neptune and Pluto (Sun-S/C Distance 30 AU)	March 1983 (est.)

PIONEER 10 STATUS

As Pioneer 10 traverses its post-encounter trajectory, the spacecraft continues to function normally. Although the spacecraft has traversed a region of concentrated high-energy particles, only minor changes have occurred in some of the on-board subsystems. Most of these changes are self correcting or curing.

The photomultiplier tubes in the Asteroid/Meteoroid Detector have darkened as the result of exposure to the radiation environment during encounter. The primary function of this instrument was to study the characteristics of the particulate matter in the Asteroid Belt. Therefore, no specific protection against radiation was provided. This darkening raises the threshold of the brightness that can be detected and in turn the size of the object that can be observed.

Following periapsis passage, excess background noise was noted in the Ultraviolet Photometer Experiment. It was commanded off, and then turned on each day for five minutes. The background problem continued to subside as it healed itself. The background disappeared and the instrument is presently operating normally.

The Cosmic Ray Telescope is experiencing a minor effect associated with one of its measuring ranges.

The spacecraft communications subsystem has shown several minor effects of exposure to the radiation field of Jupiter. The transmitted power output has diminished by 0.06 dB, a reduction which will have no adverse effect on the post-encounter portion of the mission. The communications subsystem frequencies have indicated a minor shift, which appears to be settling out. Two other transmitter parameters have shifted slightly as the result of the slight power loss indicated above.

Evaluation of the performance of the spacecraft and scientific instruments is continuing on a daily basis to identify any effects of encounter. As of this writing the spacecraft is operating normally and a successful extended mission is anticipated.

PIONEER 10 FIRSTS

Pioneer, as the name implies, is a precursor, the first to forge ahead in deep space missions. Pioneer 10 successfully achieved its mission objectives and in the process accomplished or will accomplish the following firsts:

First spacecraft to venture beyond the orbit of Mars.

First spacecraft to enter and traverse the Asteroid Belt.

First spacecraft to encounter and investigate the planet Jupiter.

First use of Jupiter's gravity to adjust spacecraft velocity to accomplish additional mission objectives

First man-made object to escape the solar system.

First use of a third stage on the Atlas Centaur Launch Vehicle.

First NASA spacecraft to use nuclear energy as its primary power source.

First spinning spacecraft to "home" on uplink rf signals for attitude reference.

Additional firsts may be identified as interest in Pioneer 10 results continues through the active life of the mission, five or six years from now.

Pioneer 10 will continue on into interstellar space, heading generally for the red star ALDEBARAN, which forms the eye of the bull in the constellation TAURUS. It will take Pioneer 10 approximately eight million years to reach this star.

IMPRESSIONS

Many impressions have been made known since the beginning of the Pioneer 10 mission. The Project Office and the Principal Investigators have received a considerable amount of correspondence, most of which was favorable to the mission. A trip beyond Mars, through the Asteroid Belt, to an encounter with a planet that captured the interest of Galileo Galilei has made an impression on individuals in all walks of life throughout the world. Initially, most of the popular interest expressed in the Pioneer Jupiter missions was related to the plaque carried on board the spacecraft. However as the encounter activity increased, interest shifted to the product of those activities and new impressions were generated. The spacecraft passed close to Jupiter, traversed the radiation belts successfully, and continued to perform normally. The first image received as the spacecraft passed behind the planet and came out of solar eclipse has been referred to as the sunrise image. This image inspired a member of one of the Experimenter Teams to write the following verse:

Feelings

We went regardless, in nineteen-seventy-two.
Some died on Earth, but on we went,
    unable to stop even the final plunge
    through hell,
    emerging as a child of man seeking audience
    in the stars.

Released forever, we twist back to view the past,
    and witness our first sunrise on Jupiter.

- See

PIONEER 11 MISSION

The Pioneer 11 spacecraft has been moving along through the Asteroid Belt toward its encounter with Jupiter on December 2, 1974. The spacecraft with its science payload continues to function successfully.

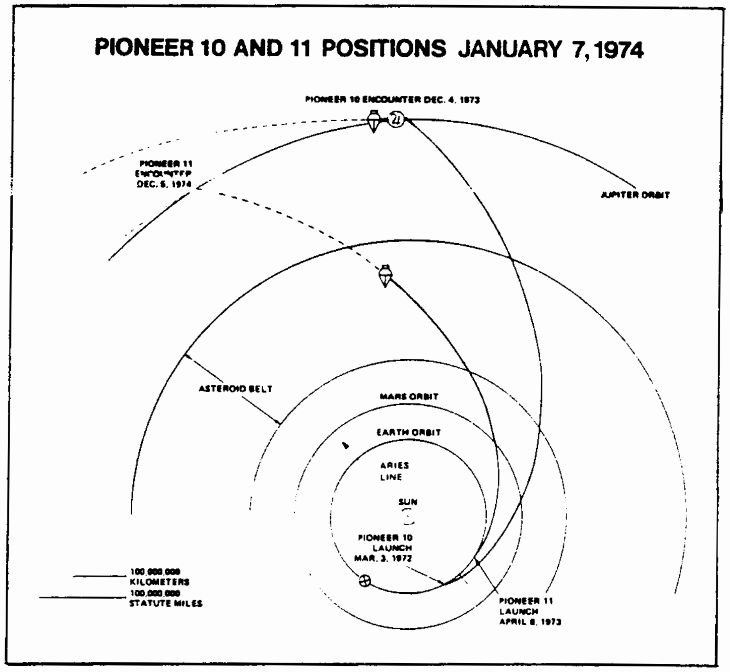
Many meetings are being held by the Project Office with the Principal Investigators to plan the Pioneer 11 midcourse maneuver based on what we now know about the planet. Our targeting computer programs are being altered to model the magnetosphere and radiation belts based on the Pioneer 10 results. The Principal Investigators are being very helpful in assisting the Project in this modeling and planning effort.

The consensus for a target position at Jupiter presently favors high latitudes, a closest approach of less than $2R_J$, and a radiation dose no greater than that experienced by Pioneer 10. Analysis is continuing in preparation for a final decision on the targeting of Pioneer 11.

SUMMARY AND ACKNOWLEDGMENT

We in the Pioneer Project Office are exceedingly gratified with the success of the Pioneer 10 encounter at Jupiter. We are indebted to the many groups and organizations in this country and throughout the world whose dedication made this success possible. It has always been and will continue to be our extreme pleasure to be associated with such teams as they form together to become a part of the Pioneer Project.

This Newsletter is the tenth in a series inaugurated at the launch of Pioneer 10. The next and final Pioneer/Jupiter Newsletter is planned to be issued after the Pioneer 11 encounter of Jupiter. Intervening newsletters will be issued by the Project only if a future need is identified.



January 7, 1974

Earth - Pioneer 10 Distance –	880.55 Million Km
Pioneer 10 - Jupiter Distance –	29.29 Million Km
Pioneer 10 - Sun Distance –	758.74 Million Km
Earth - Pioneer 11 Distance –	594.52 Million Km
Pioneer 11 - Jupiter Distance –	285.05 Million Km
Pioneer 11 - Sun Distance –	472.74 Million Km