



JET PROPULSION LABORATORY California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91105  
FHD-328

14 July 1976

Mr. Chuck Wende  
National Space Science Data Center  
Code 601.1  
Goddard Space Flight Center  
Greenbelt, Maryland 20771

Dear Mr. Wende:

This is to notify you that I have mailed a magnetic tape containing Pioneer 11 Doppler tracking data to you at the National Space Science Data Center (NSSDC). These data, which cover the period 15 October - 28 December, 1974, were taken near Jupiter and used by the Pioneer 10/11 celestial mechanics experiments, Dr. J. D. Anderson of JPL and myself. The tape you will receive (tape 40) was written at JPL on a Univac 1108 computer in the standard 7 track, BPI Fortran mode with 36 bit word length. Please send a replacement to me at the address given above.

The following explanatory materials are enclosed:

1. A description of the data tape format. Some of the doppler tracking data were taken while the ground transmitter frequency was changing at a precisely controlled linear rate. A list of the times at which these data were taken is given in the following table. The necessary information about the ramped transmitter frequency is given in the ramped transmitter groups on the tracking data tape. These groups are defined in appendix A of the tracking format description.

PIONEER 11 RAMP PASSES

<u>DATE</u>	<u>STA</u>	<u>Approx. Ground Transmit Time (U.T.C)</u>	<u>Approx. Ground Receiver Interval</u>
22 Oct. '74	14	0500 - 0520	0430 - 0730
27 Oct. '74	14	0600 - 0620	0530 - 0830
3 Nov. '74*	14	0400 - 0420	0330 - 0630
7 Nov. '74	14	0100 - 0170	0030 - 0330
13 Nov. '74*	43	0730 - 0750	0700 - 1000
21 Nov. '74	14	0100 - 0120	0030 - 0330
25 Nov. '74	43	0800 - 0820	0730 - 1030

Mr. Chuck Wende

2

13 July 1976

1 Dec. '74	14	0150 - 0210	0120 - 0420
3 Dec. '74	14	0401 - 0427	0400 - 0627
10 Dec. '74*	43	0530 - 0550	0500 - 0800
15 Dec. '74	43	0530 - 0550	0500 - 0800

\* 3 Nov., 13 Nov., 10 Dec., Ramped Intervals had bad data (round trip signal delay was about 80 minutes)

2. On copy of TR 32-1527 defining the standard S-band, two-way observable found on the data tape. See pages 19-22, 46-50, 72-75. The observables on both the Pioneer 10 and Pioneer 11 data tapes were adjusted for the effect of spacecraft spin on the observable and the revised values substituted for the original ones. The correction ( $\Delta f$ ) added to the S-band Doppler observables was computed from

$$\Delta f = \omega(.034766213) \text{ Hertz}$$

where  $\omega$  is the spacecraft spin rate in revolutions per minute. This correction follows from the fact that the Pioneer 10 antenna is rotating and right hand circularly polarized; the correction was verified by ground tests and with the spacecraft themselves. The Pioneer 10 corrections for 15 October - 28 December '73 were in the range .16531 Hz to .16525 Hz. The Pioneer 11 corrections for 15 October - 26 December, '74 were in the range .17558 Hz to .17542 Hz.

Doppler biases of the size shown have a negligible effect on the Jupiter gravity solution provided that either a constant Doppler bias or a conic planetary ephemeris correction is included in the solution. The use of the wrong value of the bias would produce an erroneous range rate correction to the planetary ephemeris, however.

3. One copy of TM 391-412 by T. D. Moyer giving the necessary equations for computing ramped Doppler.

4. A reprint of a Pioneer 11 journal article giving the preliminary results of the Pioneer 11 Celestial Mechanics Experiment (pp. 1-2, 476-477), and a preprint of results from the Pioneer 10 and 11 combined analysis (submitted to the Astronomical Journal, July, 1976).

5. A list of Deep Space Net Tracking station locations.

6. Trajectory coordinates sufficient to start a least squares adjustment.

7. A listing of the beginning records of tape X440.

Mr. Chuck Wende

3

14 July 1976

The Pioneer 11 spacecraft was perturbed by orientation maneuvers at the following times (UTC)

17 October 74 17<sup>h</sup>  
 6 December 74 16<sup>h</sup>  
 20 December 74 16<sup>h</sup>  
 3 January 74 3<sup>h</sup>

The velocity perturbations were almost entirely along the earth line with a magnitude of less than 0.5 mm/sec. The tracking data provided is S-band, two-way Doppler data. Each data record contains both the observed Doppler (F) and the transmitter frequency ( $f_q$ ) as defined in item (2).

Please instruct any potential users of the data to contact me if any questions arise concerning its use. Information concerning the Pioneer 10 solar radiation pressure can be obtained upon request to me; the memos describing this effect were too lengthy and complicated to include in this mailing. The effect of solar pressure on the Pioneer 10 and 11 spacecraft (primarily from the parabolic antenna and RTG's) can be approximated for the 15 October - 28 December period by an acceleration in the sun-spacecraft direction given by

$$\ddot{r}_R = k/r^2 \text{ where } \ddot{r} \text{ is in km/sec}^2,$$

$r$  = sun - spacecraft distance in km

and

$$k = 3.89 \times 10^6 \text{ km}^3/\text{sec}^2.$$

This approximation has an error less than  $10^{-13}$  km/sec<sup>2</sup>. In addition there is an acceleration ( $\ddot{r}_n$ ) of  $.6 \times 10^{-12}$  km/sec<sup>2</sup> normal to the sun-spacecraft line and located in the sun-spacecraft-earth plane. This acceleration is in the same half plane (divided by sun-spacecraft line) as the Earth.

The following table shows the actual solar pressure accelerations  $\ddot{r}_R$  and  $\ddot{r}_n$  for the full solar pressure model and the inferred value of  $K$ .

Date	Earth-spacecraft sun-angle	$\ddot{r}_R \times 10^{12}$	$K \times 10^{-6}$	$\ddot{r}_n \times 10^{12}$
18 Oct 74	8.4°	7.758	3.938	.49
3 Dec 74	11.4°	7.019	3.882	.61
22 Dec 74	11.1°	7.323	3.888	.62

The maximum earth-spacecraft sun angle for the encounter period was 11.49 degrees on 28 November, 1974.

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Mr. Chuck Wende

4

14 July 1976

Sincerely yours,

*George W. Null*

George W. Null  
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GWN:ii

enclosures