JET PROPULSION LABORATORY

INTEROFFICE MEMORANDUM
Voyager-RSST-86-0005

January 10th 1986.

TO: J. Hardman

FROM: S. Kinslow (X 0708) RAK

SUBJECT: Request for Mag Tape of Limb Track Maneuver during Radio Science Events for Voyager 2 Uranus Encounter

In support of Radio Science analysis of the Voyager 2 Uranus Encounter, the Radio Science Support Team is requesting the generation and delivery of a Magnetic Tape containing data, showing the Limb Tracking Maneuver execution profile and execution errors. The delivery and format of this Magnetic Tape will be as specified in Interface Agreement SCT-20 and Software Interface Specification SIS # 4-8003-19, respectively (both attached). The delivery of the reconstruction data on tape should be made after correction of all known error sources affecting the maneuver design and execution accuracies. It is desirable that a Sample Interval of approximately 6 seconds should be used.

The Characteristics of the Magnetic Tape should be as follows:

9-Track, recorded at 1600 Bits per inch.

Covering the Time Period from DOY-024 18:50 to DOY-025 00:00 SCET

The nominal delivery schedule for this Mag Tape should be within 30 days of the Encounter, in accordance with Interface Agreement SCT-20 (attached). If you have any questions regarding this matter or if there is any difficulty in meeting the proposed delivery schedule please contact me on (x0708) as soon as possible.

Concurrence: DNSweet

D. N. Sweetnam
RSST Team Chief

Distribution:

RSST
H. Marderness
W. McLaughlin
J. P. de Vries
C. Hamilton
L. Tyler (Stanford)
M. Belhadef

INTERFACE AGREEMENT

BETWEEN SCT AND RSST

ORIGINATOR:	S. Kinslow	DATE:	8/10/85
TITLE:	Data Production Engineer	CONTROL NO:	SCT-20
ORGANIZATION:	RSST	REVISION:	B

PRODUCT OR SUPPORT REQUIRED: Limb Tracking Maneuver Implementation/Execution Data

AGREEMENT:

The SCT will provide for the generation and delivery of data showing the implementation of planned spacecraft maneuvers for support of the Radio Science Experiment. After such maneuvers have been executed, the SCT shall provide data showing the maneuver execution profile and execution errors. The general precision of the data provided per this interface agreement shall be as described in JPL IOM 3396-75-089 (attached). The format of the data will be as specified in Software Interface Specification #48003-19. The delivery of the reconstruction data shall be made after correction of all known error sources affecting the maneuver design and execution accuracies.

SOURCE: RASMA pointing file (1100/81 Mag Tape) via file release form.

DURATION OF SUPPORT: For each spacecraft maneuver executed during Near Encounter Test and Near Encounter in which the spacecraft was on inertial references and open-loop Radio Science data was acquired. In addition, it is desired and may be requested that reconstruction be provided for other such periods, such as ORT2A and ORT4.

THE TIMING REQUIREMENT FOR DELIVERY/PERFORMANCE OF THIS PRODUCT OR SERVICE IS: Before M&E file transfer for implementation data, within 30 days for execution data.

REMARKS: This data is required to successfully compensate for amplitude variations caused by implementation techniques and execution errors.

APPROVED: H. P. Marderness 9/24/85 APPROVED: D. Sweetnam 9/24/85

TITLE: SCT Chief, H. Marderness TITLE: RSST Chief, D. Sweetnam

---

REVOCATION

THE ABOVE AGREEMENT IS RESCINDED AS OF: ____________________

APPROVED: ____________________ APPROVED: ____________________

TITLE: ____________________ TITLE: ____________________

C. E. KOHLHASE, JR.

JUN 23 1975

JET PROPULSION LABORATORY

INTEROFFICE MEMO
3396-75-089

TO: C. E. Kohlhase

June 19, 1975

FROM: G. E. Wood

SUBJECT: Radio Science Occultation Limb Tracking Maneuvers

INTRODUCTION

The radio science limb tracking maneuvers provide the capability to track the virtual image of earth as the spacecraft is occulted by the planets. Without these maneuvers the antenna pointing error would be the earth-spacecraft-near limb angle, which is large compared to the spacecraft antenna beamwidth. The resulting power loss would be catastrophic to the radio occultation investigations. By performing accurate limb tracking maneuvers, the following benefits are realized:

a. Increased occultation data deeper in the atmospheres;

b. Higher signal-to-noise ratios; and

c. Improved dual-frequency absorption measurements.

The implementation of such maneuvers involves requirements for both control accuracy and reconstruction knowledge. The requirement for control accuracy assures that adequate power will be returned during the occultations. Failure to meet the control accuracy requirements will result in a loss of signal-to-noise ratio. The requirement for reconstruction knowledge assures that the power variations that occur due to imperfect maneuvers can be removed from the final data so that differential absorption measurements will be of high quality.

The error sources involved in maneuver implementation are numerous and the equation of angular error to power loss is extremely non-linear. Certain errors are unavoidable due to the strategy employed in performing the maneuvers.

In the paragraphs that follow I summarize the requirements for these maneuvers and offer a few ideas relating to their implementation. The requirements below have been iterated extensively over the past year with both the Project Office and with Division 34. These requirements are believed to be consistent with current system capabilities.

REQUIREMENTS

Control

The X-band power loss due to imperfect maneuver control shall not exceed (2.5) dB (3σ) at any time during the occultations. During the first 20 minutes of an occultation this loss shall not exceed (1.0) dB (3σ).

Knowledge

After reconstruction of the observed occultation maneuver the residual uncertainty in X-band relative amplitude due to imperfect maneuver execution knowledge shall not exceed 0.2 dB (3σ) during the first 20 minutes of an occultation. This requirement is based on reconstruction data having a time resolution of 1.0 second or less with the reference amplitude being that value derived immediately prior to occultation entrance.

MANEUVER IMPLEMENTATION

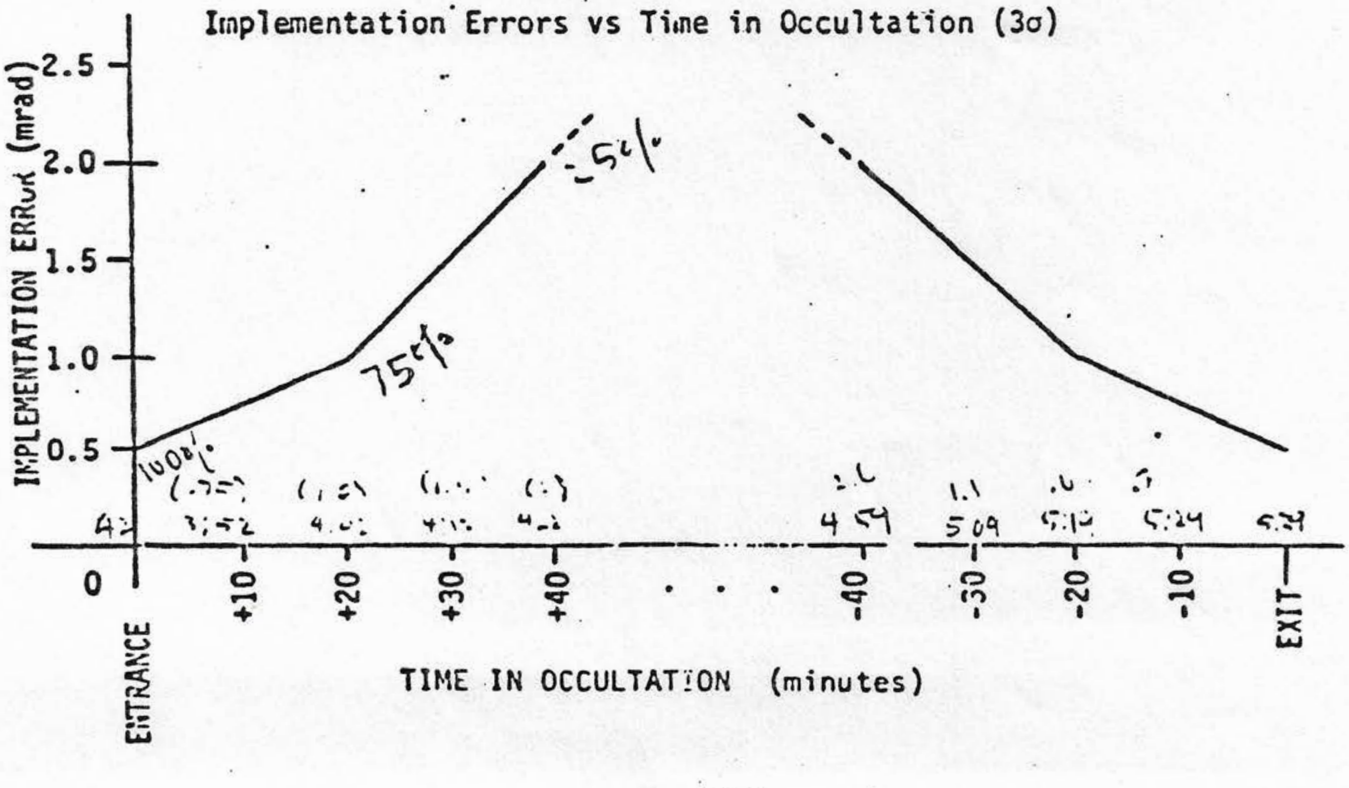
The above requirements for control and knowledge are separate from the algorithm employed to program the maneuvers. Construction of that algorithm will incur additional errors due to imperfect curve fitting and maneuver step size. The complexity of the algorithm is dependent on the actual trajectory and the amount of CCS memory used (and "cleverness" of the program).

Since the most important periods during occultations are the first and last 20 minutes, the following guidelines are offered for maneuver implementation.

It is desired to maintain the maneuver step size and curve fitting errors as small as possible at the beginning and end of occultations. During the remainder of the occultation period it will be acceptable if the step size and/or curve fitting errors are allowed to increase. This may be necessary to conserve CCS memory or attitude control gas. However, it is desired to limit such errors to values at or below those of Figure 1.

FIGURE 1.

Implementation Errors vs Time in Occultation (3σ)



ACCURACY IMPROVEMENT

The most troublesome error source in the execution of occultation maneuvers is the drift rate of the gyros. As time progresses these errors integrate and are extremely degrading at exit. In order to improve this situation it is desirable to perform in-flight calibrations of gyro drifts shortly before the close encounter periods in hope of reducing the gyro drift uncertainties.

There is also another way to greatly reduce the execution errors at exit. Since, on some trajectories, the sun exits before the earth it is therefore possible to use steps on the sun sensor bias to implement the exit maneuvers rather than using gyro control. Only the roll axis need be on inertial control for this strategy in order to avoid stray light problems. Any error remaining on the roll axis will not degrade the antenna pointing becuase this axis is aligned with the antenna boresight.

TITAN

During the past year there has been considerable discussion about implementing an occultation maneuver at Titan. The determination of the actual science value of such a maneuver is impeded by the large uncertainties that exist about Titan's atmosphere. It is important to note that, regardless of the atmosphere's characteristics, the occultation signal is optimized at the near limb. Since the diameter of Titan (as viewed from a spacecraft in occultation) is several antenna beam widths, the power loss without a maneuver is very great. The question that remains is whether or not the atmosphere of Titan is sufficiently dense to make a maneuver valuable. This question will not be conclusively answered before the arrival of the MJS77 spacecraft. However, the current uncertainty band includes a range where limb tracking maneuvers are valuable. Therefore, in order to avoid the needless loss of science data at Titan it is necessary to perform a limb tracking maneuver.

Desirable

GEW:gj

Distribution:
MJS77 Radio Science Team
Experiment Reps
T. Assefi
G. Cunningham
R. Draper
V. Evanchuk
J. Hunter
J. Long
J. Randolph
R. Riggs
E. Stone
F. Surber

SIS Number: 4-8003-19

Date: Jan. 9, 1979

SOFTWARE INTERFACE SPECIFICATION

GENERATING PROGRAM: RASMA	USER PROGRAM:
COMPUTER SYSTEM: UNIVAC 1108	COMPUTER SYSTEM:

PURPOSE OF INTERFACE/SUMMARY:

To provide a magnetic tape containing records of pointing vectors and angles for the Radio Science Maneuver.

INTERFACE DEVICE:

Magnetic Tape [X]

Disk File [ ]

File Name/Convention:

Punched Cards [ ]

Manual [ ]

Other:

DATE CODE:

(BCD, EBCDIC, Etc.)

RECORDING METHOD (e. g., FORTRAN unformatted, NTRAN, common 1/O program -- name and call sequence, etc.)

See attached

4-8003-19

RASMA SOFTWARE INTERFACE SPECIFICATION

1.0 Detailed Interface Definition/FORMAT.

The Mission Build Rasma Program Package consists of four absolute elements. The Data file described in this SIS is an output of one of these. In brief, the "rasma" absolute writes a file 84 which contains SCE time, certain pointing vectors (referenced to EME 50) and certain pointing angles. The data file 84 is reformatted by absolute "READ84" into a data file 22 which contains one record for each time increment. It is this data file 22 which is delivered to the RSDT, and which is described below. Delivery will be made via 7 track magnetic tape.

2.0 Organization.

2.1 Header

The data file has no header.

2.2 The records of the data file consist of a parameter set of 18 parameters, in the following order:

1. SCE Time
2. Angle between HGA Boresite and virtual image
3. Angle between Earth and virtual image
4. Angle between Jupiter and virtual image
5. Angle between HGA Boresite and Earth
6. Angle between Jupiter and Earth
7. Virtual image x-component
8. Virtual image y-component
9. Virtual image z-component
10. HGA Boresite pointing vector x-component
11. HGA Boresite pointing vector y-component
12. HGA Boresite pointing vector z-component
13. Earth x-component
14. Earth y-component
15. Earth z-component
16. Jupiter x-component
17. Jupiter y-component
18. Jupiter z-component

On UH0003 each record contains 252 bytes. The first 36 bytes is some sort of header/label. Then these 18 values (72 bits each) follow.

3.0 PARAMETER SET RULES

3.1 Time

The "time" is the spacecraft event time (UTC) for the parameters in the record. Its format is double precision in seconds past 1950.0

3.2 Pointing vectors

The pointing vectors are the X,Y, and Z components for the unit pointing vectors, in the EME 50 spacecraft centered coordinate system.

3.3 Angles

Each of the 5 angles are in degrees, and are obtained by taking the arc-cosine of the dot product of the appropriate pointing vectors in the record.

4.0 Precision

All pointing vectors and angles are computed in double precision.

5.0 File Release Form

A copy of the file release form for the file 22 is attached.

6.0 Time Increment

The time increment (time between records) will generally be one second for the design file (from which the M&E file is generated) and six seconds for the reconstruction file.

RASMA FILE RELEASE FORM

Released To: ______________________________

Released By: ______________________________

Released via Tape No: ______________________________

Date of Release: ______________________________

CRS Tape Used: ______________________________

File # on Tape	Corresponding Event	Corresponding Manpar File #
1. ____________	____________	____________
2. ____________	____________	____________
3. ____________	____________	____________

Preparer: ______________________________

S/C Sequence: ______________________________

Special Instructions: ______________________________

____

____

____

____

____

____

Released By ____________________ ____________________
Date

Concurrence ____________________ ____________________
SCT Date

Concurrence ____________________ ____________________
RSDT Date

The interface defined is acceptable in format and content to accomplish MOS program requirements and is described in sufficient detail to allow program design and coding to be accomplished.

SCT Cognizant Engineer Robert V. Frampton

SCT Cognizant Programmer [illegible]

RSDT Cognizant Engineer [illegible]

RSDT Cognizant Programmer [illegible]

Concurrence:

Spacecraft Analysis System Cognizant Engineer Jack W. Rhoads

Radio Science System Cognizant Engineer [illegible]

Ground Data System Engineer Robert D. Polansky

Software System Engineer [illegible] 5/18/77