Software Interface Specification

Voyager 2 Uranus
Radio Science
Raw Data Archive (Parkes)

Prepared By

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Acronyms and Abbreviations

ASCII	American Standard Code for Information Interchange
CCT	computer-compatible tape
DSN	NASA Deep Space Network
DSS	Deep Space Station (antenna and associated facilities)
GB	gigabyte
HGA	high-gain antenna
JPEG, JPG	Joint Photographic Experts Group
JPL	Jet Propulsion Laboratory
ksps	thousand samples per second
LID	logical identifier
LIDVID	versioned logical identifier
MB	megabyte
MHz	megaHertz
NASA	National Aeronautics and Space Administration
NAIF	Navigation Ancillary Information Facility
NSSDC	National Space Science Data Center (since renamed NSSDCA)
NSSDCA	National Space Science Data Coordinated Archive
OCC	occultation
PDS	Planetary Data System
PDS4	PDS Standards, version 4
PODR	Parkes Original Data Record
RCP	right circular polarization
RDA	Raw Data Archive
RMS	Ring Moon Systems (PDS discipline node)
RS	radio science
RSS	Radio Science Subsystem
RST	Radio Science Team
s/c	spacecraft
SCAT	scatter (as in ring scattering observations)
SIS	Software Interface Specification
SPICE	information system produced by the NAIF Team
VG, VGR	Voyager
VG2	Voyager 2
VG2U	Voyager 2 Uranus
VID	version identifier
XML	eXtensible Markup Language

1 Introduction

1.1 Document Overview

This Software Interface Specification (SIS) describes the format and content of the Voyager 2 Uranus (VG2U) Radio Science (RS) Raw Data Archive (RDA) (Parkes). These data were collected at Parkes Observatory in Australia, were delivered to the Voyager Radio Science Team for analysis, and have since been delivered to the Planetary Data System (PDS) [1] for archive. This document applies only to the data collected using NASA Deep Space Network (DSN) equipment temporarily installed at Parkes (DSN identifier DSS-49) during the Voyager 2 encounter with Uranus in January 1986. A different document describes data collected at the DSN station near Canberra, Australia.

1.2 Data Overview

The data are organized into one PDS4 bundle [2]. Within the bundle are several collections, summarized in Table 1.2-1 [3]. Within collections are individual products, each typically consisting of one or a few data files plus a descriptive label written in XML. The observational data are in 56 files containing Parkes Original Data Records (PODRs) in the *data_podr* collection. Binary files have been translated to ASCII. Summary data plots are in the *browse* collection.

After peer review, the bundle was posted to the PDS Ring Moon Systems (RMS) web site. Partially processed data had previously been delivered to the National Space Sciences Data Center (NSSDC) by the Voyager RS Team (RST) [4]. The original raw data had never been previously archived.

1.3 Experiment Overview

The observing geometry is illustrated in Figure 1.2-1. The spacecraft transmitted unmodulated carriers at S- and X-band referenced to the output frequency of an on-board ultra-stable oscillator (USO). As the signals passed through the atmosphere and/or rings of Uranus, they were refracted, absorbed, and/or scattered. Refraction may be interpreted in terms of the temperature and pressure in a neutral atmosphere or the electron density in an ionosphere. Changes in signal intensity may be attributed to refraction, diffraction, and/or presence of absorbing materials in the atmosphere or to size and density of particles in a ring.

The observable at Parkes was the voltage signal from an X-band receiver connected to a right-circularly polarized antenna feed. The receiver translated the original signal at approximately 8420 MHz to a baseband 0-35 kHz output. This signal was sampled by four 8-bit 20 ksps analog-to-digital converters (ADCs) operating sequentially for an effective single channel sampling rate of 80 ksps. The ADC output was recorded on computer-compatible tapes (CCTs), which were returned to NASA's Jet Propulsion Laboratory (JPL) for copying and distribution to Voyager Radio Science Team (RST) members. Dual-polarization S- and X-band signals received at NASA DSN antennas near Canberra (Australia) are being archived separately. Early processing suggested that Parkes phase instability would preclude arraying [9], an early reason for using two observatories.

Time lines for acquisition of Uranus data and acquisition of test data can be found in Appendix B.

Table 1.2-1: Collections within the Voyager 2 Uranus Radio Science (Parkes) RDA Bundle (bundle_id = *voyager2_rss_uranus_49xr_raw*)		
collection_id	**Product Contents**	**Number of Products**
data_podr	8-bit samples of radio receiver output (binary and ASCII)	56
browse	quick-look plots illustrating content of each PODR (JPEG)	56
calib_freq	estimates of USO frequency	1
context	references to descriptive materials (context products), which are maintained elsewhere	0
geometry	geometry files in non-SPICE formats, including spacecraft antenna pointing reconstruction and state vectors in the Voyager 2 frame	2
document	documents relevant to use of data files	7

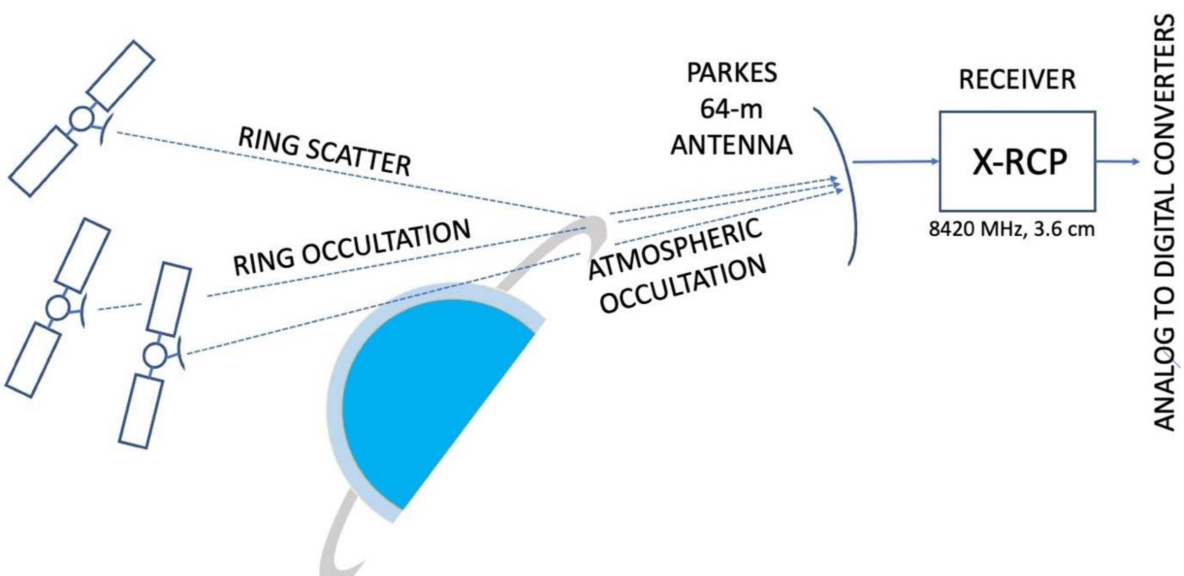

Figure 1.2-1. Observational geometry for data collection at Uranus. As the spacecraft passed behind the planet, its radio signals were refracted by the atmosphere, causing an apparent Doppler shift at the receiving station. During occultation by Uranus' rings, the signal's intensity was reduced and its frequency was spread when scattered by ring particles.

1.4 Example Data

Figure 1.2-2 is an example of partially processed data from the Uranus radio occultation ingress. There is one such four-panel plot (in the *browse* collection) for each of the 56 PODR products in the bundle. Occultations can be seen in the lower left panel of the figure; the ionospheric occultation is at 23.3 hours and the occultation by the neutral atmosphere begins shortly before 23.35 hours

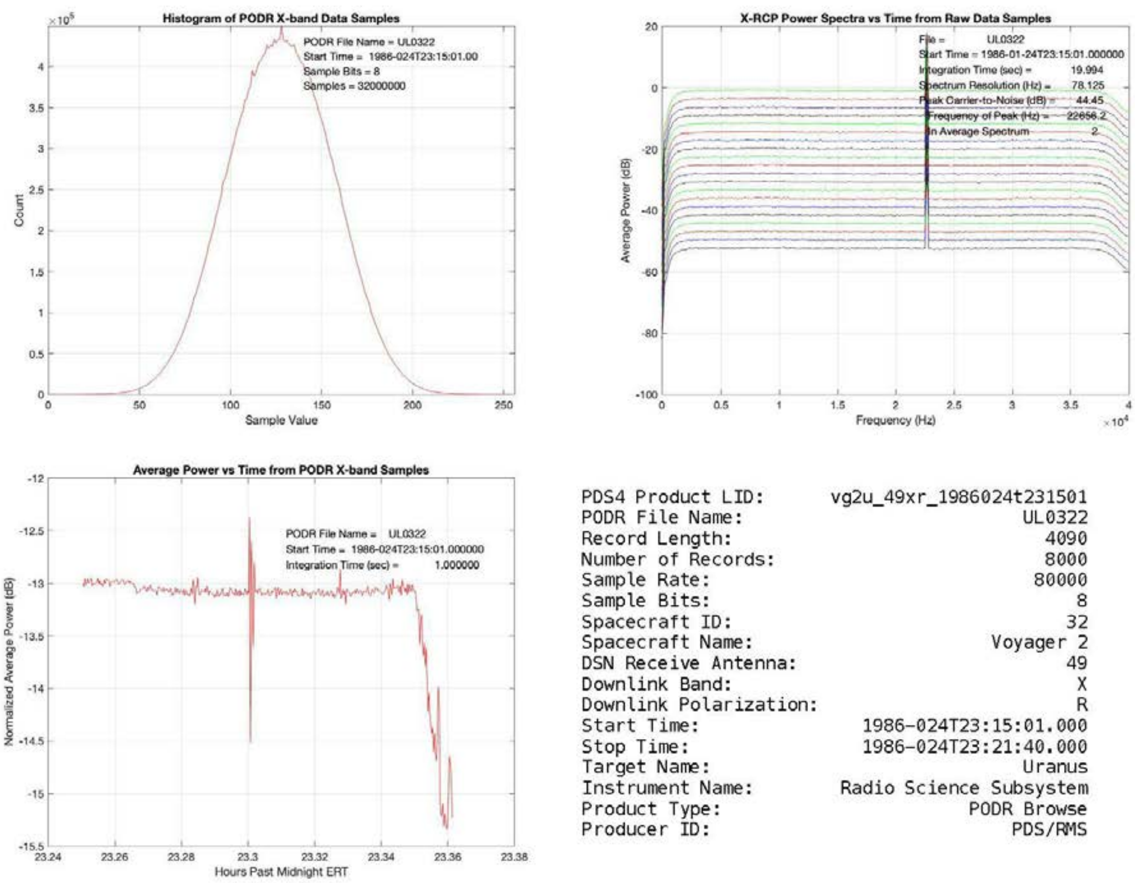

Figure 1.2-2: Example product from the Parkes *browse* collection showing the ingress ionospheric and neutral atmospheric occultations. Upper left: histogram of raw data sample values. Lower left: Power versus time in sample values — one second averages of squared sample values after removal of the mean. Upper right: Power spectra (0-40 kHz); each trace is an average over 20 seconds. Time increases from bottom to top. Lower right: an ASCII summary of the observing configuration.

Derivatives of these observations include the temperature-pressure structure of Uranus' neutral atmosphere, electron density profiles of Uranus' ionosphere, and opacities of and size distribution of particles in the Uranian rings [5]. The data in this bundle could also be used to supplement radio tracking data acquired for investigations of Uranus' mass and gravity field.

1.5 Applicable Documents

This SIS references the following URLs and documents:

[1] https://pds.nasa.gov/home/about/

[2] Planetary Data System – Data Design Working Group, “PDS4 Concepts, version 1.21.0”, doi: 10.17189/5sagaf16, October 2023 (https://pds.nasa.gov/datastandards/documents/concepts/Concepts_1.21.0.pdf)

[3] —, “Planetary Data System Standards Reference, version 1.21.0”, doi: 10.17189/j5bz-bj10, October 2023 (https://pds.nasa.gov/datastandards/documents/sr/current/StdRef_1.21.0.pdf)

[4] https://nssdc.gsfc.nasa.gov/nmc/dataset/display.action?id=PSPA-00402

[5] Tyler, G. L., D. N. Sweetnam, J. D. Anderson, J. K. Campbell, V. R. Eshleman, D. P. Hinson, G. S. Levy, G. F. Lindal, E. A. Marouf, and R. A. Simpson, "Voyager 2 Radio Science Observations of the Uranian System: Atmosphere, Rings and Satellites," *Science*, **233**, pp. 79-84, 1986.

[6] *RSC-11-9, DSN Radio Science Subsystem Interface, Original Data Record*, Document 820-013, Rev. A, DSN System Requirements, Detailed Interface Design (urn:nasa:pds:radiosci.documentation:dsn.rsc-11-9:1982-03-01). https://pds-geosciences.wustl.edu/radiosciencedocs/urn-nasa-pds-radiosci_documentation/dsn_rsc-11-9p/dsn_rsc-11-9p.1982-03-01.pdf

[7] Simpson, R. A., *Interpretation and Use of Binary RSC-11-9 (Parkes) Data*, Planetary Data System, 2024 (urn:nasa:pds:radiosci.documentation:dsn.rsc-11-9p:rsc-11-9p_unpack). https://pds-geosciences.wustl.edu/radiosciencedocs/urn-nasa-pds-radiosci_documentation/dsn_rsc-11-9p/rsc-11-9p_unpack.pdf

[8] Berman, A. L., and G. L. Tyler, *Reconstruction of Downlink Frequency from Open-Loop Data*, JPL IOM ALB-78-133, 22 November 1978. (urn:nasa:pds:radiosci.documentation:document:berman.1978)

[9] Gresh, D. L., E. A. Marouf, G. L. Tyler, P. A. Rosen, and R. A. Simpson, "Voyager Radio Occultation by Uranus' Rings. 1. Observational Results," *Icarus*, **78**, pp. 131-168, 1989.

1.6 System Siting

1.6.1 Interface Location and Medium

The storage medium, including at least two backups, is determined by the PDS RMS Node. The user interface is through the PDS RMS web site (https://pds-rings.seti.org).

1.6.2 Data Sources, Destinations, and Transfer Methods

This bundle is an aggregations of products generated by various elements of the DSN, the Voyager Project, the Voyager Radio Science Team, the Voyager Radio Science Support Team, and others. The original data were delivered on CCTs to the Voyager Radio Science Team at Stanford University. The archival products have been delivered to PDS/RMS electronically.

1.6.3 Generation Method and Frequency

This bundle has one primary observational data type — the Parkes Original Data Record (PODR), stored in the *data_podr* collection (Table 1.2-1). PODRs are binary files. They were recorded originally at Parkes Observatory, delivered to the NASA DSN station in Canberra, and forwarded to NASA JPL where they were copied and distributed to members of the Voyager Radio Science Team. Except when there were tape validation errors, the copying and delivery to end users was completed within a few weeks of the observation and was not repeated. Original binary PODrs have been converted to ASCII for easier user access; see section 3.1.2.1 for details.

Quick-look plots showing contents of the PODRs were generated as JPEG and ASCII text files, which were inserted into a Microsoft Word document. Each Word document was saved in Adobe Portable Document format (PDF), converted to JPEG, and stored in the *browse* collection.

Estimates of the USO frequency at specific times during the mission for both Voyager 1 and Voyager 2 are included in the *calib_freq* collection as a memo in ASCII format. Programmable Oscillator Control Assembly (POCA) data gave receiver tuning frequencies, which are needed to determine the exact frequency of signals in the PODR files [6]; POCA data are included in the PODR files rather than as separate files in the *calib_freq* collection. See [8] for conversion of POCA values to sky frequency at Parkes.

The *geometry* collection includes (1) a pair of files (one binary, one ASCII) with position and velocity data for selected targets with respect to the spacecraft and (2) a pair of files (one binary, one ASCII) with reconstructed high-gain antenna pointing vectors, which were used by the Voyager Radio Science Team to interpret radio occultation data in the deep neutral atmosphere. Users of this archive seeking new or improved science results should consider downloading the latest reconstructions from PDS NAIF (https://naif.jpl.nasa.gov/pub/naif/VOYAGER/).

The *document* collection includes files which describe the Voyager mission, the radio science operations plan, the archive SIS (this document), and software for generating *browse* products. DSN documents which describe radio science data formats that are mission independent — for example, [6] — are included as secondary members of this *document* collection

1.7 Assumptions and Constraints

1.7.1 Usage Constraints

Access to the Voyager 2 Uranus RS RDA (Parkes) bundle is determined by PDS.

1.7.2 Documentation Conventions

1.7.2.1 Data Format Descriptions

Since formats vary widely among data/file types, users should consult product labels for details. Receiver samples are described by [6]; example conversions of binary to ASCII formats are given in [7].

1.7.2.3 Limits of This Document

This document applies only to the PDS4 bundle containing raw radio science data in RSC-11-9 format collected at Parkes during the Voyager 2 Uranus encounter [7].

2 Interface Characteristics

2.1 Hardware Characteristics and Limitations

2.1.1 Special Equipment and Device Interfaces

The Voyager 2 Uranus RS RDA (Parkes) bundle is posted on the PDS/RMS web site (https://pds-rings.seti.org). Users of the data must have access to systems which can connect with the web site.

2.1.2 Special Set-Up Requirements

None.

2.2 Volume and Size

Most original PODR data files contain 32.72 megabytes, and their ASCII translations have 251.2 MB; other files are small by comparison. There are 56 PODRs in the bundle, making the total volume approximately 16 GB.

2.3 Labeling and Identification

2.3.1 External Labels

There is no external labeling of the bundle; these archives are stored electronically on systems managed by the PDS RMS Node.

2.3.2 Internal Labels

Voyager 2 Uranus RS RDA (Parkes) bundles, collections, and products are identified by logical and version identifiers (LIDs and VIDs, respectively) constructed in accordance with PDS4 standards. These identifiers are described further in Section 3 of this document.

2.4 Interface Medium Characteristics

The Voyager 2 Uranus RS RDA (Parkes) bundle is posted on the PDS RMS Node web site; the storage media and methods are determined by PDS/RMS.

2.5 Backup and Duplicates

The entire content of the Voyager 2 Uranus RS RDA (Parkes) bundle is backed up following procedures developed by PDS/RMS in accordance with PDS policies.

3 Structure and Organization Overview

3.1 Logical Organization

The Voyager 2 Uranus RS RDA (Parkes) is organized into one bundle as specified in Table 1.2-1. The bundle has six primary/secondary collections (Table 1.2-2). The members of collections are data products, each including its own label written in the eXtensible Markup Language (XML). The members of each collection are listed in a collection Inventory, which is accompanied by an XML label. The bundle has a label which lists the member collections, but there is no separate inventory file. Figure 3.1-1 illustrates the logical structure for the bundle.

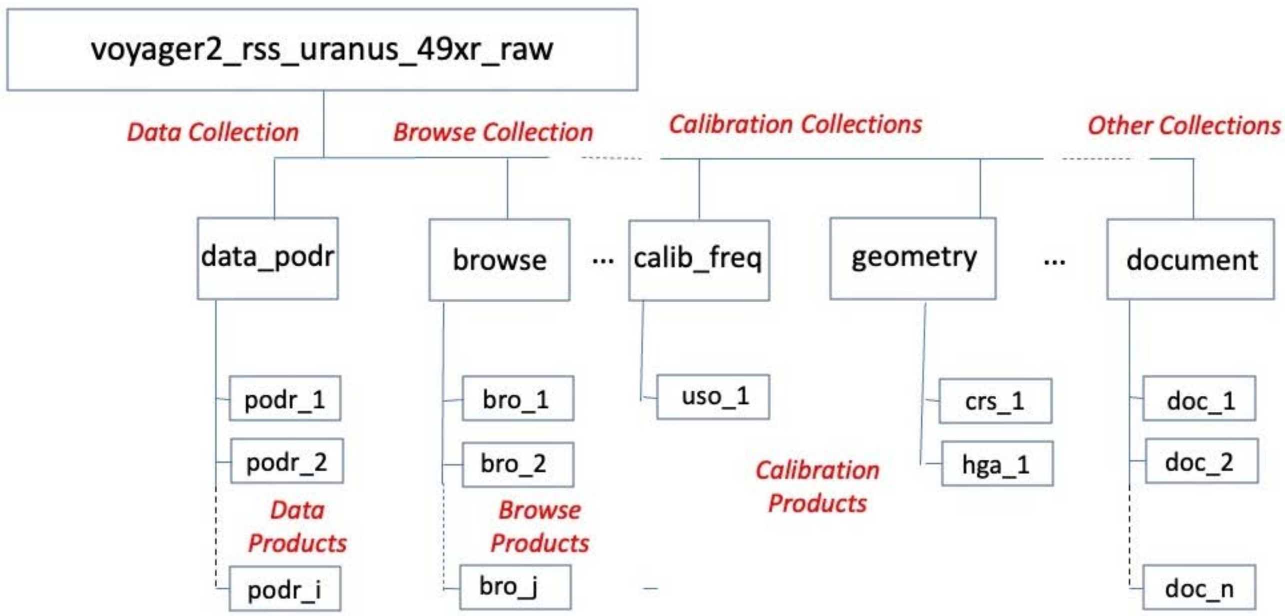

Figure 3-1.1. Logical structure of the Voyager 2 Uranus RS RDA (Parkes) bundle, which has one data collection (data_podr), one browse collection (browse), two calibration collections (calib_freq and geometry), and one document collection. The bundle also has a sixth collection —a context collection, which has only secondary members and is not shown in the figure.

3.1.1 Bundles and Collections

The Logical Identifier (LID) for a bundle is constructed by appending the <bundle_id> (Table 1.2-1) to the PDS-specific root (urn:nasa:pds). Fields within the LID are delimited by ASCII colon characters. So long as the <bundle_id> value is unique within PDS, each bundle will be uniquely identified by its LID to all users of PDS and its archiving partners.

urn:nasa:pds:<bundle_id> or urn:nasa:pds:voyager2_rss_uranus_49xr_raw

Collection LIDs are constructed by appending <collection_id> (Table 1.2-1) to the bundle LID. Because the bundle LID is unique, it follows that the collection LIDs are also unique.

urn:nasa:pds:<bundle_id>:<collection_id>

For example, the collection LIDs for the PODR and document collections in Figure 3.1-1 are:

```
urn:nasa:pds:voyager2_rss_uranus_49xr_raw:data_podr
urn:nasa:pds:voyager2_rss_uranus_49xr_raw:document
```

3.1.2 Products

A product is one or more PDS4 data objects (*e.g.*, digital files) and an associated, detached PDS4 label, which is written in XML and describes the data object(s). Product LIDs are constructed by appending <`product_id`> to the collection LID. Because the collection LID is unique, it follows that the product LIDs are also unique.

urn:nasa:pds:<bundle_id>:<collection_id>:<product_id>

3.1.2.1 PODR and Browse Products

In the *data_podr* collection, all products include the original binary file, a file containing ASCII translations of each record header, a text file containing field headers for the record header file, a file containing ASCII translations of each record's data samples, and an XML label. In the *browse* collection all products are JPEG files accompanied by a PDS4 label.

Identifiers for *data_podr* and *browse* products have the form

`vgnx_aabp_yyyydddthhmmss`

where

`n`	= spacecraft number ("2" for Voyager 2)
`x`	= target ("u" for Uranus)
`aa`	= antenna number ("49" for Parkes)
`b`	= band ("x" for X-band)
`p`	= polarization ("r" for right circular polarization, RCP)
`yyyy`	= year
`ddd`	= day of year
`hh`	= hour
`mm`	= minute
`ss`	= second

Examples of *data_pod*r and *browse* product LIDs derived from the same original data file are, respectively:

```
urn:nasa:pds:voyager2_rss_uranus_49xr_raw:data_podr:vg2u_49xr_1986024t174101
urn:nasa:pds:voyager2_rss_uranus_49xr_raw:browse:vg2u_49xr_1986024t174101
```

Although the <`product_id`> is the same for both products, they have different LIDs because the <`collection_id`> values are distinct.

3.1.2.2 Frequency Calibration Products

The logical identifier for the product in the *calib_freq* collection is:

`urn:nasa:pds:voyager1_rss_uranus_49xr_raw:calib_freq:vgr_uso` (ASCII text)

3.1.2.4 Geometry Products

Examples of logical identifiers for products in the *geometry* collection are:

`urn:nasa:pds:voyager1_rss_uranus_49xr_raw:geometry:uk0015b` (binary ephemerides)
`urn:nasa:pds:voyager1_rss_uranus_49xr_raw:geometry:uh0003a` (ASCII HGA pointing)

3.1.2.5 Document Products

Example logical identifiers for products in the *document* collection are:

`urn:nasa:pds:voyager2_rss_uranus_49xr_raw:document:ops_plan` (operations plan)
`urn:nasa:pds:voyager2_rss_uranus_49xr_raw:document:sis_vgr_rs` (this document)

3.1.3 Versioning

A version identifier (VID) may be appended to a logical identifier to specify one of several versions of the same bundle, collection, or product [3]. The combination is called a versioned identifier (LIDVID). LIDVIDs are used to locate products within PDS; every version of every product within PDS has a unique LIDVID. VIDs are separated from LIDs by a double colon ("::") and have the form `M.n` where M and n are integers. All versions are 1.0 in the initial release of the Voyager 2 Uranus (Parkes) RS RDA bundle. Examples of product, collection, and bundle LIDVIDs are shown below:

```
urn:nasa:pds:voyager2_rss_uranus_49xr_raw:calib_freq:vgr_uso::1.0
urn:nasa:pds:voyager2_rss_uranus_49xr_raw:calib_freq::1.0
urn:nasa:pds:voyager2_rss_uranus_49xr_raw::1.0
```

3.1.4 Labels

Each digital data object in the Voyager 2 Uranus RS RDA (Parkes) bundle is accompanied by a PDS4 label which describes the data object and is written in XML. In a few cases (*e.g.*, the Bundle product), the label exists by itself since the data object is either 'physical' or 'conceptual' [2]. A typical label includes sections which identify the associated data file (by file name, version identifier, modification history, time and/or spatial coverage, etc.), provide references to other relevant information (journal articles, observing system, target description, etc.), and describe the format of the file at the bit level, if necessary. PDS4 labels are digital data files in their own right; their file names are the <product_id> as described above with the extension ".xml" appended.

3.2 Physical Organization

3.2.1 File Naming and Conversions

Both within this document and within the archive itself bundle, collection, and product file names (including both digital data objects and their labels) are lower case. Where names have been reused from an earlier archive, upper case characters have been converted to lower case. PDS4 itself is case insensitive.

File names are of the form "`filename.ext`" where the base "`filename`" contains up to 27 characters and "`ext`" contains 3-4 characters. The allowable characters for PDS file names are "a-z", "0-9", the period ".", and the underscore "_". Extensions are "`dat`" for binary files, "`tab`" for files with fixed-length record tables, "`txt`" for text files, "`jpg`" for browse files, and "`pdf`" for PDF/A document files. Other extensions (*e.g.,* "docx") are available for document files.

In addition to the various data files and their labels identified in the sections below, each collection has a collection Inventory file (collection*.csv) and label (collection*.xml).

3.2.1.1. ODR and Browse Product File Names

File names are constructed from <`product_id`> values (Section 3.1.2.1) by appending an ASCII period "." and a file name extension. File name extensions in these two collections are listed below. PODR and browse products are stored in different directories to prevent collisions of label file names.

`dat`	original binary PODR file
`hdr`	file containing ASCII translations of PODR record headers
`jpg`	JPEG file with 4-panel browse plots
`tab`	file containing ASCII translations of receiver sample values from one PODR
`txt`	file containing ASCII headers for the `hdr` file
`xml`	PDS4 label file

3.2.1.2 Frequency Calibration Product File Names

The product in the *calib_freq* collection is a digital data object paired with a PDS4 label. The file names for the single product in the *calib_freq* collection are:

`vgr_uso.txt`   `vgr_uso.xml`

3.2.1.4 Geometry Product File Names

Each product in the *geometry* collection is a digital data object paired with a PDS4 label. File name pairs for the four products in the geometry collection are:

```
uk0015a.tab   uk0015a.xml
uk0015b.dat   uk0015b.xml
uh0003a.tab   uh0003a.xml
uh0003b.dat   uh0003b.xml
```

Note that binary files were created on Univac computers using 36-bit integer, 72-bit floating point, most-significant-byte-first formats. It may be easier for contemporary (ca. 2025) users to work with the ASCII files.

3.2.1.5 Document Product File Names

Each product in the *document* directory is a PDS4 label plus one or more digital data objects. For example, this SIS document includes a label plus the document in two formats. The three file names are:

```
sis_vgr_rs_1.0.pdf   sis_vgr_rs_1.0.docx   sis_vgr_rs_1.0.xml
```

3.2.2 File Conversions

PODR (binary) files are difficult to read. A typical file has 8000 records. Each record includes a 56-byte header followed by 4000 8-bit samples of receiver output. The final 34 bytes in each record were reserved for future use. As part of the conversion for this archive (1) the headers were extracted and written to an ASCII file and (2) the binary data samples were converted to ASCII and written to a separate file with 20 samples per line. The original binary format of the ODR is described in [6]. Conversion to ASCII is described in [7]; the conversion document includes an example.

Ephemerides and high-gain antenna (HGA) pointing reconstructions were delivered originally in binary format; they were converted to ASCII for this archive. Both versions of each file have been retained in the PDS4 archive.

3.2.3 Directories

PDS4 products are stored in directory structures determined by the PDS/RMS node. The PDS4 Registry can locate bundles, collections, and products as needed by users. No further information can be provided here.

4 Support Staff and Cognizant Personnel

4.1 Planetary Data System


```
Richard A. Simpson
PDS Radio Science Advisor
radiosci@att.net
```


5 Errata

The following errors/anomalies were discovered during creation of the PDS4 archive.

5.1 Bad or Missing Data

5.1.1 Corrupted Records

On both UL0305 and UL0355 record 4 was truncated — to 1108 bytes and 1504 bytes, respectively — instead of having the expected 4090 bytes. In preparation for archiving, these records were padded to 4056 bytes by extending the data samples into whatever bytes existed in record 5, then restarting with the correct record 5 boundary. The final 34 bytes in record 4 were set to zero and the “Spares-1” field in the record header (byte 48, or word 24 in [6]) was set to “1”.

5.1.2 Incorrect Record Header Values

In all records on all tapes, the DSS ID field is set to “43” rather than “49” because the data acquisition software was written to be used at permanent stations of the DSS and it did not recognize Parkes.

In all records on all tapes, the values for the “Ones” fields in Word 28 of the record header were set to “4” rather than the expected “7”.

5.2 Buffer delays

Because of buffering in the recording process, samples may be delayed by 1-2 sample positions (a few microseconds) compared to the record time tag in RSC-11-9P files. Similarly, POCA readings are delayed 1-2 seconds compared to those time tags. No corrections for buffer delays have been applied.

Appendix A Tape Log – Voyager 2 at Uranus (Parkes)

The table which follows lists Voyager 2 Uranus radio science raw data files from Parkes in chronological order.

The columns give (left to right):

YYYY Earth receive time at start time of the file (UTC year)
DOY Earth receive time at start time of the file (UTC day of year)
HH Earth receive time at start time of the file (UTC hour)
MM Earth receive time at start time of the file (UTC minute)
SS Earth receive time at start time of the file (UTC second)
TAPE Identifier of the CCT delivered to the Voyager Radio Science Team.
LID Logical identifier for the PDS4 archive, constructed in the form
vgnx_aabp_yyyydddthhmmss
where
n = spacecraft number ("2" for Voyager 2)
x = target ("u" for Uranus)
aa = antenna number ("49" for Parkes)
b = band ("x" for X-band)
p = polarization ("r" for RCP)
yyyy = year ("1986")
ddd = day of year
hh = hour
mm = minute
ss = second

YYYY	DOY	HH	MM	SS	TAPE	LID
1986	022	18	00	06	UL0357	vg2u_49xr_1986022t180006
1986	022	18	06	11	UL0358	vg2u_49xr_1986022t180611
1986	023	17	55	09	UL0359	vg2u_49xr_1986023t175509
1986	024	03	35	01	UL0356	vg2u_49xr_1986024t033501
1986	024	16	18	01	UL0354	vg2u_49xr_1986024t161801
1986	024	17	41	01	UL0355	vg2u_49xr_1986024t174101
1986	024	21	15	01	UL0304	vg2u_49xr_1986024t211501
1986	024	21	21	41	UL0305	vg2u_49xr_1986024t212141

Appendix A (continued) (page 2 of 3)

YYYY	DOY	HH	MM	SS	TAPE	LID
1986	024	21	28	21	UL0306	vg2u_49xr_1986024t212821
1986	024	21	35	01	UL0307	vg2u_49xr_1986024t213501
1986	024	21	41	41	UL0308	vg2u_49xr_1986024t214141
1986	024	21	48	21	UL0309	vg2u_49xr_1986024t214821
1986	024	21	55	01	UL0310	vg2u_49xr_1986024t215501
1986	024	22	01	41	UL0311	vg2u_49xr_1986024t220141
1986	024	22	08	21	UL0312	vg2u_49xr_1986024t220821
1986	024	22	15	01	UL0313	vg2u_49xr_1986024t221501
1986	024	22	21	41	UL0314	vg2u_49xr_1986024t222141
1986	024	22	28	21	UL0315	vg2u_49xr_1986024t222821
1986	024	22	35	01	UL0316	vg2u_49xr_1986024t223501
1986	024	22	41	41	UL0317	vg2u_49xr_1986024t224141
1986	024	22	48	21	UL0318	vg2u_49xr_1986024t224821
1986	024	22	55	01	UL0319	vg2u_49xr_1986024t225501
1986	024	23	01	41	UL0320	vg2u_49xr_1986024t230141
1986	024	23	08	21	UL0321	vg2u_49xr_1986024t230821
1986	024	23	15	01	UL0322	vg2u_49xr_1986024t231501
1986	024	23	21	41	UL0323	vg2u_49xr_1986024t232141
1986	024	23	28	21	UL0324	vg2u_49xr_1986024t232821
1986	024	23	35	01	UL0325	vg2u_49xr_1986024t233501
1986	024	23	42	10	UL0326	vg2u_49xr_1986024t234210
1986	024	23	48	50	UL0327	vg2u_49xr_1986024t234850
1986	024	23	55	30	UL0328	vg2u_49xr_1986024t235530
1986	025	00	02	10	UL0329	vg2u_49xr_1986025t000210

Appendix A (continued) (page 3 of 3)

YYYY	DOY	HH	MM	SS	TAPE	LID
1986	025	00	08	50	UL0330	vg2u_49xr_1986025t000850
1986	025	00	15	30	UL0331	vg2u_49xr_1986025t001530
1986	025	00	22	10	UL0332	vg2u_49xr_1986025t002210
1986	025	00	28	50	UL0333	vg2u_49xr_1986025t002850
1986	025	00	35	30	UL0334	vg2u_49xr_1986025t003530
1986	025	00	42	10	UL0335	vg2u_49xr_1986025t004210
1986	025	00	48	50	UL0336	vg2u_49xr_1986025t004850
1986	025	00	55	30	UL0337	vg2u_49xr_1986025t005530
1986	025	01	02	10	UL0338	vg2u_49xr_1986025t010210
1986	025	01	08	50	UL0339	vg2u_49xr_1986025t010850
1986	025	01	15	30	UL0340	vg2u_49xr_1986025t011530
1986	025	01	22	10	UL0341	vg2u_49xr_1986025t012210
1986	025	01	28	50	UL0342	vg2u_49xr_1986025t012850
1986	025	01	35	30	UL0343	vg2u_49xr_1986025t013530
1986	025	01	42	10	UL0344	vg2u_49xr_1986025t014210
1986	025	01	48	50	UL0345	vg2u_49xr_1986025t014850
1986	025	01	55	30	UL0346	vg2u_49xr_1986025t015530
1986	025	02	02	10	UL0347	vg2u_49xr_1986025t020210
1986	025	02	08	50	UL0348	vg2u_49xr_1986025t020850
1986	025	02	15	30	UL0349	vg2u_49xr_1986025t021530
1986	025	02	22	10	UL0350	vg2u_49xr_1986025t022210
1986	025	02	28	50	UL0351	vg2u_49xr_1986025t022850
1986	025	02	35	30	UL0352	vg2u_49xr_1986025t023530
1986	025	02	42	10	UL0353	vg2u_49xr_1986025t024210

Appendix B Time Line – Voyager 2 at Uranus (Parkes)

Open loop data from the Voyager 2 Uranus encounter. Tape start and stop times are given in columns 4 and 5 — the beginning of the first and last records, respectively. Each record is 1 second. Tapes delivered to the Voyager Radio Science Team are listed in column 6 (Parkes Tape). Note 1: Record 4 on the original tape was short; it was padded to the correct length,; a corrected version is included in the PDS4 archive with the file name vg2u_49xr_1986024t212141.dat

Ground Event Time (UTC)	Event Description	1986 DOY	Tape Start (UTC)	Tape Stop (UTC)	Parkes Tape	Notes
		024	21:15:01	21:21:40	UL0304	
21:27:13	TWNC ON	024	21:21:41	21:28:20	UL0305	1
		024	21:28:21	21:35:00	UL0306	
21:41:40	S-band ranging OFF	024	21:35:01	21:41:40	UL0307	
21:45:39	Telemetry OFF	024	21:41:41	21:48:20	UL0308	
21:52:00	Begin mini-ASCAL	024	21:48:21	21:55:00	UL0309	
		024	21:55:01	22:01:40	UL0310	
22:04:00	End mini-ASCAL	024	22:01:41	22:08:20	UL0311	
		024	22:08:21	22:15:00	UL0312	
		024	22:15:01	22:21:40	UL0313	
		024	22:21:41	22:28:20	UL0314	
22:28:30	ε-ring	024	22:28:21	22:35:00	UL0315	
		024	22:35:01	22:41:40	UL0316	
22:47	4-ring	024	22:41:41	22:48:20	UL0317	
22:55	X-band to low power	024	22:48:21	22:55:00	UL0318	
22:56:02	S-band to high power	024	22:55:01	23:01:40	UL0319	
		024	23:01:41	23:08:20	UL0320	
		024	23:08:21	23:15:00	UL0321	
23:17 23:21	ionosphere Enter atmosphere	024	23:15:01	23:21:40	UL0322	
		024	23:21:41	23:28:20	UL0323	
		024	23:28:21	23:35:00	UL0324	
23:38	Enter absorption region	024	23:35:01	23:41:40	UL0325	
23:44	Exit absorption region	024	23:42:10	23:48:49	UL0326	
		024	23:48:50	23:55:29	UL0327	
		024	23:55:30	00:02:09	UL0328	
		025	00:02:10	00:08:49	UL0329	
		025	00:08:50	00:15:29	UL0330	
00:19	Enter absorption region	025	00:15:30	00:22:09	UL0331	
00:28	Exit absorption region	025	00:22:10	00:28:49	UL0332	
		025	00:28:50	00:35:29	UL0333	
		025	00:35:30	00:42:09	UL0334	
00:44	Exit atmosphere	025	00:42:10	00:48:49	UL0335	
		025	00:48:50	00:55:29	UL0336	
		025	00:55:30	01:02:09	UL0337	
01:03:14 01:04:00	S-band to low power X-band to high power	025	01:02:10	01:08:49	UL0338	
		025	01:08:50	01:15:29	UL0339	
00:19	4-ring	025	01:15:30	01:22:09	UL0340	
		025	01:22:10	01:28:49	UL0341	
		025	01:28:50	01:35:29	UL0342	
01:37:40	ε-ring	025	01:35:30	01:42:09	UL0343	
		025	01:42:10	01:48:49	UL0344	
		025	01:48:50	01:55:29	UL0345	
		025	01:55:30	02:02:09	UL0346	
		025	02:02:10	02:08:49	UL0347	
		025	02:08:50	02:15:29	UL0348	
02:16:36	Begin mini-ASCAL	025	02:15:30	02:22:09	UL0349	
02:27:17	End mini-ASCAL	025	02:22:10	02:28:49	UL0350	
02:32:04	Telemetry ON	025	02:28:50	02:35:29	UL0351	
		025	02:35:30	02:42:09	UL0352	
02:45:00	End recording	025	02:42:10	02:45:00	UL0353	

Open loop test data collected before the Voyager 2 Uranus encounter. Tape start and stop times are given in columns 4 and 5 — the beginning of the first and last records, respectively. Each record is 1 second. Tapes delivered to the Voyager Radio Science Team are listed in column 6 (Parkes Tape). Note 2: Record 4 on the original tape was short; it was padded to the correct length and a correct version of the binary file is included in the archive with the file name vg2u_49xr1986024t174101.dat.

Ground Event Time (UTC)	Event Description	1986 DOY	Tape Start (UTC)	Tape Stop (UTC)	Parkes Tape	Notes
	sinusoid at -12 kHz	024	16:18:01	16:24:40	UL0354	
	11 frequency steps of 3.5 kHz, starting at -17.5 kHz	024	17:41:01	17:47:40	UL0355	2
	3 kHz sinusoid with decreasing amplitude	024	03:35:01	03:41:40	UL0356	
	sweep?	022	18:00:06	18:02:12	UL0357	
	sweep?	022	18:06:11	18:11:05	UL0358	
	sweep?	023	17:55:09	18:01:48	UL0359	