Saturn Scatterometry Rev 282

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April 23, 2018

- Sequence: s100
- Rev: 282
- Observation Id: ri_282_1
- Target Body: Saturn

1 Introduction

This memo describes one of the Cassini RADAR activities for the s100 sequence of the Saturn Tour. A sequence design memo provides the science context of the scheduled observations, an overview of the pointing design, and guidelines for preparing the RADAR IEB. A 3-hour warmup occurs first using the parameters shown in table 3.

2 CIMS and Division Summary

CIMS ID	Start	End	Duration	Comments
282RI_WARMUP003_RIDER	2017-187T03:28:00	2017-187T09:35:00	06:07:0.0	
282RI_OUTBHIRES003_PIE	2017-187T09:35:00	2017-187T11:41:00	02:06:0.0	

Table 1: ri_282_1 CIMS Request Sequence

Each RADAR observation is represented to the project by a set of requests in the Cassini Information Management System (CIMS). The CIMS database contains requests for pointing control, time, and data volume. The CIMS requests show a high-level view of the sequence design.

The CIMS requests form the basis of a pointing design built using the project pointing design tool (PDT). The details of the pointing design are shown by the PDT plots on the corresponding tour sequence web page. (See https://cassini.jpl.nasa.gov/radar.) The RADAR pointing sequence is ultimately combined with pointing sequences from other instruments to make a large merged c-kernel. C-kernels are files containing spacecraft attitude data.

A RADAR tool called RADAR Mapping and Sequencing Software (RMSS) reads the merged c-kernel along with other navigation data files, and uses these data to produce a set of instructions for the RADAR observation. The RADAR instructions are called an Instrument Execution Block (IEB). The IEB is produced by running RMSS with a radar config file that controls the process of generating IEB instructions for different segments of time. These segments of time are called divisions with a particular behavior defined by a set of division keywords in the config file. Table 2 shows a summary of the divisions used in this observation. Subsequent sections will show and discuss the keyword selections made for each division. Each division table shows a set of nominal parameters that are determined by the operating mode (eg., distant scatterometry, SAR low-res inbound). The actual division parameters from the config file are also shown, and any meaningful mismatches are flagged.

Division	Name	Start	Duration	Data Vol	Comments
a	distant_warmup	-6:10:0.0	06:08:48.0	5.5	Warmup
b	distant_radiometer	-0:01:12.0	00:02:24.0	0.1	Radimeter division replaced by custom dust probe
c	distant_radiometer	00:01:12.0	00:04:48.0	0.3	radiometer while off target
d	distant_scatterometer	00:06:0.0	00:00:30.0	1.2	scatt to force power on
e	distant_radiometer	00:06:30.0	00:15:30.0	0.9	Radiometer division replaced with cal collection
f	sar_lo_rings	00:22:0.0	00:00:24.0	2.4	sarl off target - forces cal cycles
g	scat_rings	00:22:24.0	00:03:36.0	27.0	scatt off target, still turning on track
h	scat_rings	00:26:0.0	00:02:0.0	15.0	scatt off target, still turning on track
i	scat_rings	00:28:0.0	00:12:0.0	90.0	scatt on A-ring
j	scat_rings	00:40:0.0	00:20:0.0	150.0	scatt on A-ring
k	scat_rings	01:00:0.0	00:07:0.0	52.5	scatt on B-ring
l	scat_rings	01:07:0.0	00:06:0.0	45.0	scatt on B-ring
m	scat_rings	01:13:0.0	00:05:0.0	37.5	scatt on B-ring
n	scat_rings	01:18:0.0	00:04:0.0	30.0	scatt on B-ring
o	scat_rings	01:22:0.0	00:04:0.0	28.8	scatt on B-ring
p	scat_rings	01:26:0.0	00:03:0.0	21.6	scatt on B-ring
q	scat_rings	01:29:0.0	00:04:0.0	30.7	scatt on B-ring
r	scat_rings	01:33:0.0	00:04:0.0	30.7	scatt on B-ring
s	scat_rings	01:37:0.0	00:03:0.0	23.0	scatt on C-ring
t	scat_rings	01:40:0.0	00:05:0.0	60.0	scatt on C-ring
u	scat_rings	01:45:0.0	00:05:0.0	60.0	scatt on C-ring
v	scat_rings	01:50:0.0	00:04:32.0	54.4	scatt near normal incidence
w	sar_lo_rings	01:54:32.0	00:00:13.0	2.6	sarl crossing normal incidence
x	scat_rings	01:54:45.0	00:01:51.0	22.2	scatt near normal incidence
y	scat_rings	01:56:36.0	00:07:24.0	88.8	scatt on C-ring
z	scat_rings	02:04:0.0	00:01:0.0	12.0	scatt on C-ring
lbrace	scat_rings	02:05:0.0	00:04:30.0	54.0	scatt on C-ring
Total				946.3	

Table 2: Division summary. Data volumes (Mbits) are estimated from maximum data rate and division duration.

Name	Nominal	Actual	Mismatch	Comments
mode	radiometer	radiometer	no	
start_time (min)	varies	-370.0	no	
end_time (min)	varies	-1.2	no	
time_step (s)	varies	3600.0	no	Used by radiometer only modes - saves commands
bem	00100	00100	no	
baq	don't care	5	no	
csr	6	6	no	6 - Radiometer Only Mode
noise_bit_setting	don't care	4.0	no	
dutycycle	don't care	0.38	no	
prf (Hz)	don't care	1000	no	
tro	don't care	0	no	
number_of_pulses	don't care	8	no	
n_bursts_in_flight	don't care	1	no	
percent_of_BW	don't care	100.0	no	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	0.248	0.248	no	Kbps - set for slowest burst period
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 3: ri_282_1 Div a distant_warmup block

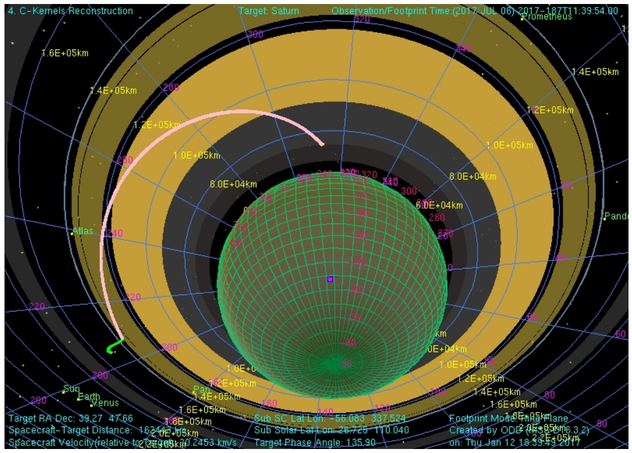

Figure 1: PDT view of RI 282 observation.

3 Overview

This observation is the fourth and last of the active ring scans. It occurs in a proximal orbit where the spacecraft passes through the ring plane just inside of the rings. The pointing design reverses the approach used in the ri 277 observation. The central beam is swept across the rings starting from the outer A-ring at high incidence after the spacecraft finishes turning onto the IVD pointing profile (See fig. 1.) The spacecraft is outbound from the ring plane when the turn to the IVD pointing profile completes and range to the beam footprint varies from around 95000 km up to about 133000 km. The projected beam footprint size which sets the real aperture resolution varies from 800 km on the C-ring to around 1300 km while looking at the A-ring. The beam footprint is moved slowly over the course of about two hours to allow many looks to accumulate. The pointing design keeps the beam aimed at a point along the line joining the sub-spacecraft point in the ring plane with the center of Saturn. This ensures that iso-range contours in the ring plane will be nearly parallel to iso-radius contours. Range compression processing can then be used to improve radius resolution from the real aperture limit. How much improvement will depend on signal strength, and ambiguity limitations. The radar mode (ie., bandwidth) is varied during this scan to allow for the best possible range resolution. The signal strength was estimated assuming a normalized backscatter of 1.0. The high spacecraft velocity leads to very high doppler shifts, so doppler ambiguities are unavoidable and doppler processing is not expected to be useful. The minimum PRF is also limited by the instrument command parameters, and range ambiguities will be present in much of the data. Since many looks are accumulated, and the rings are effectively a 1-D target, a deconvolution algorithm should be able to unravel the range ambiguities. Limitations on the number of instructions will also introduce some time domain clipping. The high range to the ring plane requires multiple bursts in flight for the more distant parts of the scan which placed further limitations on the PRF used.

This observation did not suffer from a trigger time error nor was there any data loss in the downlink. Furthermore, this observation used scatterometer mode throughout due to the high range. Scatterometer mode allowed the lowest possible PRF of 250 Hz which reduced the range ambiguity problem. The A-ring and part of the B-ring collections still have range ambiguities, but part of the B- and all of the C-ring collections are range ambiguity free.

4 Dust Detection Experiment

This observation contains a dust detection experiment during the ring plane crossing which occurred at the start of the observation time. During the ring plane crossing, the spacecraft pointed its high gain antenna into the direction of orbital motion to protect the instruments and spacecraft systems from damage due to impacting dust particles. Although these dust particles were not expected to damage the high gain antenna, they could generate electrical signals that are detectable by the radar receiver. Therefore, the radar operated across the ring plane crossing to see if such dust impact events were observable. Both active and passive modes were used here. In the configuration file, divsion B covers the nominal ring plane crossing time. The division parameters are for radiometer only mode, however, this

Name	Nominal	Actual	Mismatch	Comments
mode	scatterometer	scatterometer	no	
start_time (min)	varies	28.0	no	
end_time (min)	varies	40.0	no	
time_step (s)	don't care	12.0	no	manually set
bem	00100	00100	no	
baq	varies	6	no	6 - 8-4
csr	8	0	yes	0 - fixed attenuation
noise_bit_setting	varies	4.0	no	
dutycycle	0.70	0.55	yes	0.55 - staying within limits
prf (Hz)	don't care	250	no	
tro	don't care	0	no	
number_of_pulses	don't care	14	no	
n_bursts_in_flight	1	2	yes	accomodating longer range
percent_of_BW	100	100.0	yes	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	varies	125.000	no	
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 4: ri_282_1 Div i scat_rings block

time interval was manually replaced by a scatterometer mode collection to provide a high sample rate data set suitable for locating short strong events. Scatterometer mode provides a longer integration time than the altimeter mode used in ri 276, albeit with coarser time resolution. The radiometer mode data provides even longer time integrations and wider bandwidths that are more likely to capture dust impacts, but raw samples are not available so the dust impacts may not be visible.

5 Engineering Calibration Collection

During the turn onto the outer A-ring, a special engineering calibration data collection was performed. Division E in the configuration file is a radiometer only division which was manually overwritten with an engineering test collection similar to those acquired periodically throughout the mission. These tests consist of short segments of receive only data collection that cycle through the four bandwidth modes (scatterometer, sar-lo, sar-hi, and altimeter), and a set of attenuator settings that have been frequently used in the four bandwidth modes. Both 8-bit straight and compressed collections are included. The engineering test in this observation was placed during the initial turn so there is no visible target in view and the receive only data collected gives a reading of the noise floor level.

6 Revision History

1. Apr 6, 2017: Initial Release

7 Acronym List

ALT	Altimeter - one of the radar operating modes
BAQ	Block Adaptive Quantizer
CIMS	Cassini Information Management System - a database of observations
Ckernel	NAIF kernel file containing attitude data
DLAP	Desired Look Angle Profile - spacecraft pointing profile designed for optimal SAR performance
ESS	Energy Storage System - capacitor bank used by RADAR to store transmit energy
IEB	Instrument Execution Block - instructions for the instrument
ISS	Imaging Science Subsystem
IVD	Inertial Vector Description - attitude vector data
IVP	Inertial Vector Propagator - spacecraft software, part of attitude control system
INMS	Inertial Neutral Mass Spectrometer - one of the instruments
NAIF	Navigation and Ancillary Information Facility
ORS	Optical Remote Sensing instruments
PDT	Pointing Design Tool
PRI	Pulse Repetition Interval
PRF	Pulse Repetition Frequency
RMSS	Radar Mapping Sequencing Software - produces radar IEB's
SAR	Synthetic Aperture Radar - radar imaging mode
SNR	Signal to Noise Ratio
SOP	Science Operations Plan - detailed sequence design
SOPUD	Science Operations Plan Update - phase of sequencing when SOP is updated prior to actual sequencing
SSG	SubSequence Generation - spacecraft/instrument commands are produced
SPICE	Spacecraft, Instrument, C-kernel handling software - supplied by NAIF to use NAIF kernel files.
TRO	Transmit Receive Offset - round trip delay time in units of PRI