Rhea Scatterometry Rev 177

R. West, C.Veeramachaneni

September 18, 2013

- Sequence: s76
- Rev: 177
- Observation Id: rh_177_1
- Target Body: Rhea

1 Introduction

This memo describes one of the Cassini RADAR activities for the s76 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 4.

2 CIMS and Division Summary

CIMS ID	Start	End	Duration	Comments
177OT_WU4RHSCAT001_RIDER	2012-357T11:59:00	2012-357T19:45:00	07:46:0.0	Warmup for scatterometry/radiometry of Rhea in rev 177.
177RH_SCATTRAD001_PIE	2012-357T19:45:00	2012-357T21:45:00	02:00:0.0	Scatterometry/Radiometry of Rhea in Rev 177 - a Pie.

Table 1: rh_177_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

Division	Name	Start	Duration	Data Vol	Comments
a	distant_warmup	00:00:0.0	08:00:0.0	28.6	Warmup
b	distant_radiometer	08:00:0.0	00:05:0.0	0.3	Radiometer quick steps
c	distant_radiometer	08:05:0.0	00:53:0.0	3.2	radiometer raster
d	distant_scatterometer	08:58:0.0	00:02:0.0	12.0	Scatterometer rcv only off-Rhea
e	distant_radiometer	09:00:0.0	00:07:12.0	0.4	Radiometer during turn
f	distant_radiometer	09:07:12.0	00:00:18.0	0.0	Radiometer during turn
g	distant_scatterometer	09:07:30.0	00:02:0.0	12.0	Scatterometer rcv only during turn to target-Rhea
h	distant_scatterometer	09:09:30.0	00:04:54.0	63.2	Scatterometer target-center stare (Rhea) with chirp
i	distant_scatterometer	09:14:24.0	00:01:0.0	12.0	Scatterometry during turn
j	distant_scatterometer	09:15:24.0	00:04:12.0	54.2	Scatterometer target-center stare with chirp
k	distant_scatterometer	09:19:36.0	00:00:54.0	10.8	Scatterometry during turn
l	distant_scatterometer	09:20:30.0	00:04:12.0	54.2	Scatterometer target-center stare with chirp
m	distant_scatterometer	09:24:42.0	00:01:0.0	12.0	Scatterometry during turn
n	distant_scatterometer	09:25:42.0	00:04:18.0	55.5	Scatterometer target-center stare with chirp
o	distant_scatterometer	09:30:0.0	00:00:48.0	9.6	Scatterometry during turn
p	distant_scatterometer	09:30:48.0	00:14:12.0	170.4	Scatterometer target-center stare with chirp
q	distant_radiometer	09:45:0.0	00:05:0.0	0.3	Closing radiometry
Total				498.6	

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

Div	Alt (km)	Slant range (km)	B3 Size (target dia)	B3 Dop. Spread (Hz)
a	346090	off target	1.47	off target
b	103494	off target	0.44	off target
c	100893	off target	0.43	off target
d	73511	off target	0.31	off target
e	72490	off target	0.31	off target
f	68827	69093	0.29	1215
g	68675	68888	0.29	1218
h	67661	67748	0.29	1239
i	65185	65263	0.28	1294
j	64682	64798	0.28	1305
k	62571	62679	0.27	1355
l	62121	62227	0.27	1366
m	60023	60122	0.26	1420
n	59525	59608	0.25	1433
o	57393	57470	0.25	1493
p	56998	56998	0.24	1504
q	50081	50081	0.21	1733

Table 3: Division geometry summary. Values are computed at the start of each division. B3 Doppler spread is for two-way 3-dB pattern. B3 size is the one-way 3-dB beamwidth

Name	Nominal	Actual	Mismatch	Comments
mode	radiometer	radiometer	no	
start_time (min)	varies	0.0	no	
end_time (min)	varies	480.0	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	0.992	yes	Kbps - set for slowest burst period
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 4: rh_177_1 Div a distant_warmup block

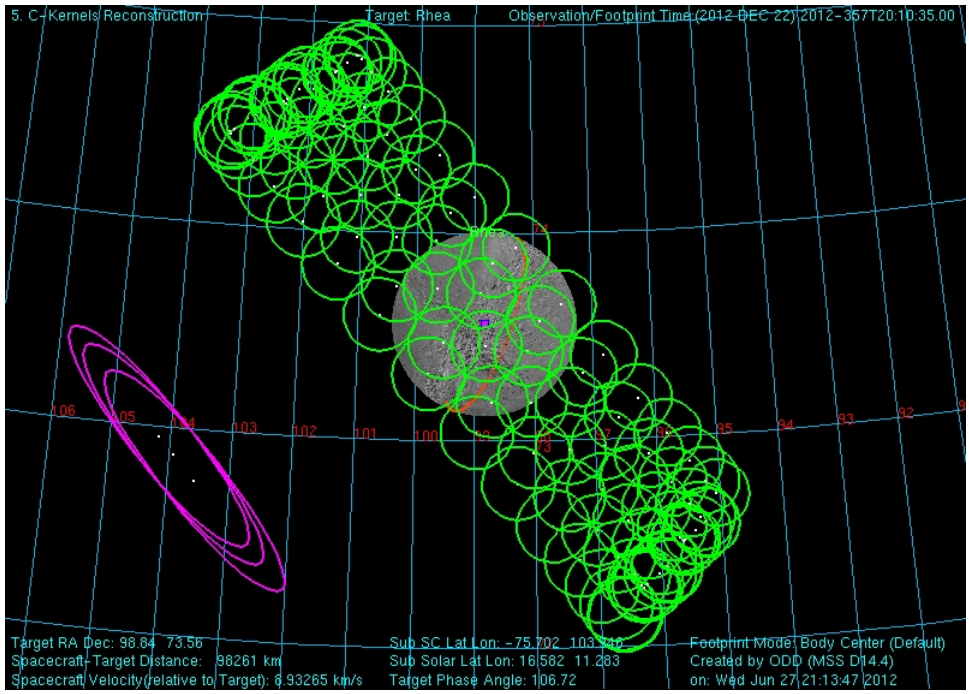

Figure 1: Div C: Radiometer raster scan 1

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.

3 Overview

The observation begins with the usual radiometer only warmup. Then the radar central beam is turned to Rhea for two standard inbound Radiometry raster scans at moderate range (80,000 km). Following these segments, the spacecraft turns the central beam off-target for calibration, and then back on-target for five chirp stare observations.

4 Radiometry scans

Div's A,B and C supplies IEB parameters for the warmup and raster-scanning radiometry. The scan layouts are shown in Figs. 1 and 2.

5 Receive Only Calibration

Div G collects receive only data in the scatterometer mode with the 9 dB attenuator setting used by the target center stare observations. The data are obtained during a turn from off to on-target. These data along with knowledge of Rhea's brightness temperature provided by the radiometry can then be processed into gain and noise temperature data for the instrument and later used to adjust calibration settings if needed.

Name	Nominal	Actual	Mismatch	Comments
mode	scatterometer	scatterometer	no	
start_time (min)	varies	547.5	no	
end_time (min)	varies	549.5	no	
time_step (s)	don't care	30.0	no	Used when BIF > 1, otherwise set by valid time calculation
bem	00100	00100	no	
baq	5	5	no	
csr	0	1	yes	1 - rcv only with fixed attenuator
noise_bit_setting	4.0	4.0	no	Scat signal set higher than ALT/SAR
dutycycle	0.70	0.70	no	
prf (Hz)	varies	1200	no	Set to cover target doppler bandwidth
tro	6	6	no	6 - allows for some noise only data in time domain
number_of_pulses	varies	8	no	depends on PRF choice (can have more shorter pulses)
n_bursts_in_flight	varies	1	no	Used to increase PRF and data rate at long range
percent_of_BW	0.0	100.0	yes	100.0 - n/a in rcv only operation
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	200.000	100.000	yes	Kbps - determines burst period
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 5: rh_177_1 Div g distant_scatterometer block

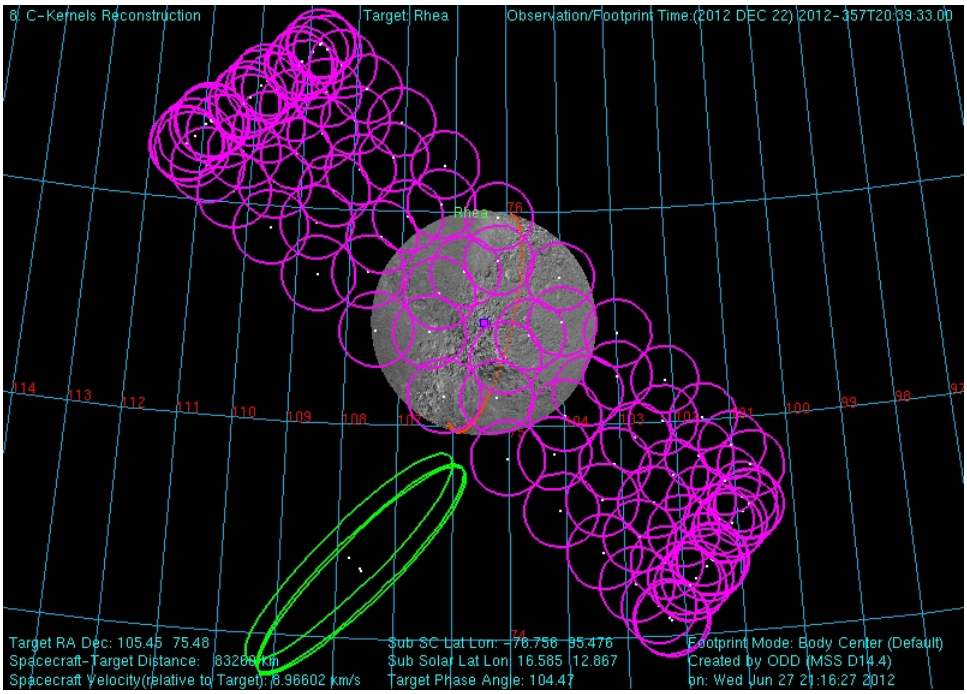

Figure 2: Div C: Radiometer raster scan 2

6 Div's H,J,L,N: Rhea Distant Scatterometry

The target is larger than the beam so a multi-point stare is used to collect scatterometry data. The range is close enough to use a full chirp, so range processing will be possible. Figure 3 show the pointing design for the 5-point scatterometry stares from the merged ckernel. The division parameters for the chirp scatterometer observations are shown in table 6. With a range around 60000 km, SNR is adequate for normal scatterometer processing.

7 Revision History

1. Sep 19, 2013: Initial Release

Name	Nominal	Actual	Mismatch	Comments
mode	scatterometer	scatterometer	no	
start_time (min)	varies	549.5	no	
end_time (min)	varies	554.4	no	
time_step (s)	don't care	10.0	no	Used when BIF > 1, otherwise set by valid time calculation
bem	00100	00100	no	
baq	5	5	no	
csr	0	0	no	0 - normal operation with fixed attenuator set to match Phoebe for easier cross-calibration
noise_bit_setting	4.0	4.0	no	Scat signal set higher than ALT/SAR
dutycycle	0.70	0.40	yes	0.4 - avoids draining ESS with many transmitted pulses
prf (Hz)	varies	1552	no	Set to cover doppler spread
tro	6	6	no	6 - allows for some noise only data in time domain
number_of_pulses	varies	0	no	depends on PRF choice (can have more shorter pulses)
n_bursts_in_flight	varies	1	no	Used to increase PRF and data rate at long range
percent_of_BW	0.0	100.0	yes	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	200.000	215.000	yes	Kbps - determines burst period
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 6: rh_177_1 Div h distant_scatterometer block

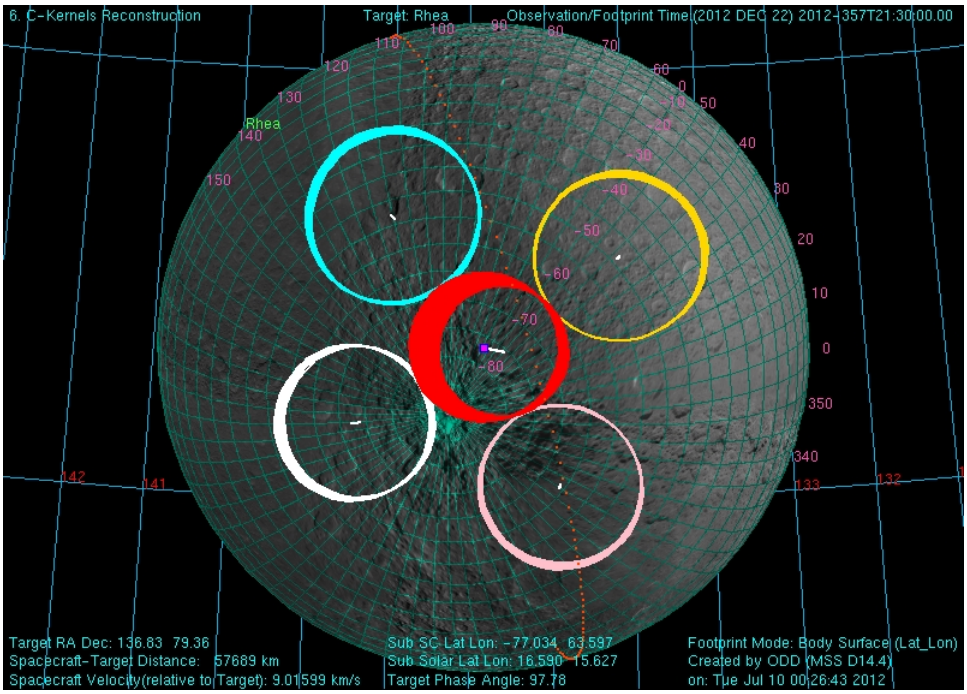

Figure 3: Div's H,J,L,N: Scatterometer stares

8 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