Dione Scatterometry Rev 177

R. West

September 19, 2013

- Sequence: s76
- Rev: 177
- Observation Id: di_177_1
- Target Body: Dione

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.
177OT_WU4DISCAT001_RIDER	2012-357T21:45:00	2012-358T04:00:00	06:15:0.0	Warmup for scatterometry/radiometry of Dione in rev 177.
177DI_SCATTRAD001_PRIME	2012-358T04:00:00	2012-358T06:00:00	02:00:0.0	Scatterometry/Radiometry of Dione in Rev 177.

Table 1: di_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

Division	Name	Start	Duration	Data Vol	Comments
a	distant_warmup	00:00:0.0	06:20:0.0	22.6	Warmup
b	distant_radiometer	06:20:0.0	00:06:42.0	0.4	Radiometer quick steps
c	distant_scatterometer	06:26:42.0	00:00:18.0	3.7	Scatterometer to force power on early
d	distant_scatterometer	06:27:0.0	00:10:0.0	4.2	Scatterometer rcv only off to on-Dione 9 dB cal
e	distant_scatterometer	06:37:0.0	00:16:0.0	199.7	Scatterometer target-center (Dione) with tone
f	distant_scatterometer	06:53:0.0	00:04:0.0	49.9	Scatterometer target-center (Dione) with chirp
g	distant_radiometer	06:57:0.0	00:23:0.0	1.4	Radiometer on target
h	distant_radiometer	07:20:0.0	00:50:0.0	3.0	Radiometer raster scans
Total				284.9	

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	349952	off target	2.02	off target
b	231571	off target	1.34	off target
c	231482	off target	1.34	off target
d	231480	off target	1.34	off target
e	231504	231504	1.34	4272
f	231916	231916	1.34	4220
g	232090	232090	1.34	4205
h	233623	off target	1.35	off target

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	380.0	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: di_177_1 Div a distant_warmup block

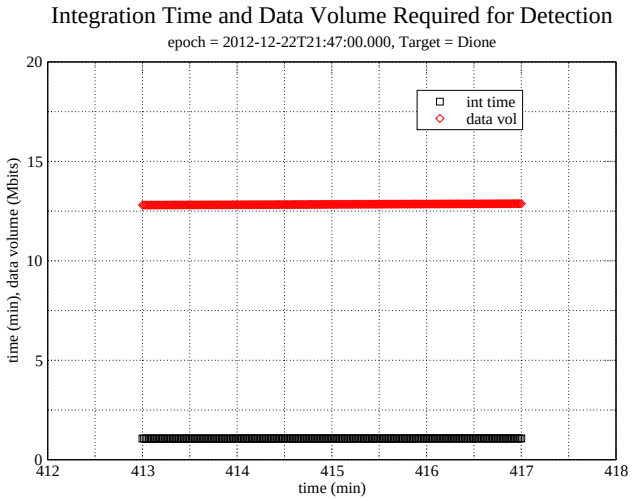

Figure 1: Scatterometry Div F: Detection integration time required for a single point detection using optimal chirp bandwidth

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.

3 Overview

This observation is a scatterometry/radiometry observation of Dione. The observation begins with the usual radiometer only warmup. Receive only scatterometry is collected while turning onto the target. Once centered on the target, disk integrated tone and chirp observations are performed, similar to prior distant icy satellite observations. Following the active observations, two radiometry raster scans of the target are performed with orthogonal polarizations.

4 Div's E,F: Dione Distant Scatterometry

The angular size of the target is about 4.8 mrad during this division. The beam 3 beamwidth is 6 mrad. The division parameters for the tone target integration are shown in table 5, and for the chirp integration in table 6.

4.1 Distant Scatterometer Performance

The detection performance is shown in figures 1, 2, and 3. The maximum doppler spread in Div f is 4220 Hz which comes from rotation and spacecraft motion. In this division, the PRF needs to be higher than the doppler spread to support potential range-doppler processing, and is set by division parameter to 4500 Hz. With this PRF, the range ambiguity spacing is 33 km while Dione is 560 km in radius. The range-spread of the beam depends on where it is pointed. For target centered pointing the cosine law can be applied to solve the geometry. At 231916 km range, the range-spread is 559 km. These numbers show that ambiguities will prevent the separation of range-doppler bins in the

Name	Nominal	Actual	Mismatch	Comments
mode	scatterometer	scatterometer	no	
start_time (min)	varies	397.0	no	
end_time (min)	varies	413.0	no	
time_step (s)	don't care	40.0	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	0.70	no	
prf (Hz)	varies	4500	no	Set to cover doppler spread
tro	6	6	no	6 - allows for some noise only data in time domain
number_of_pulses	varies	160	no	depends on PRF choice (can have more shorter pulses)
n_bursts_in_flight	varies	5	no	Used to increase PRF and data rate at long range
percent_of_BW	0.0	0.0	no	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	200.000	208.000	yes	Kbps - determines burst period
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 5: di_177_1 Div e distant_scatterometer block

Name	Nominal	Actual	Mismatch	Comments
mode	scatterometer	scatterometer	no	
start_time (min)	varies	413.0	no	
end_time (min)	varies	417.0	no	
time_step (s)	don't care	40.0	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	0.70	no	
prf (Hz)	varies	4500	no	Set to cover doppler spread and allow CSF*PRI = integer
tro	6	6	no	6 - allows for some noise only data in time domain
number_of_pulses	varies	160	no	depends on PRF choice (can have more shorter pulses)
n_bursts_in_flight	varies	5	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	208.000	yes	Kbps - determines burst period
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 6: di_177_1 Div f distant_scatterometer block

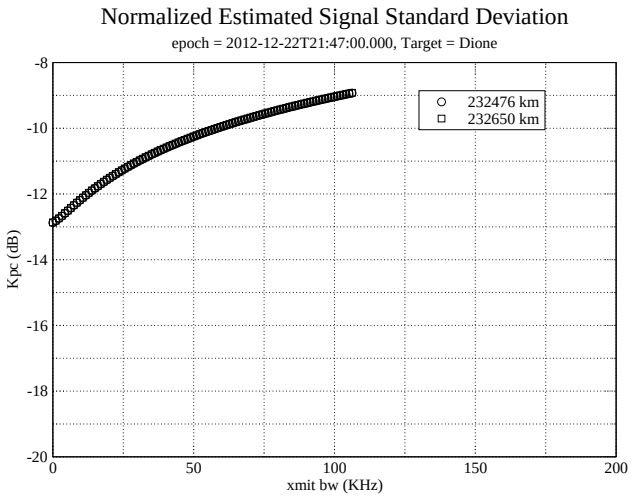

Figure 2: Div F: Normalized estimated signal standard deviation for a disk integrated observation using optimal chirp bandwidth and assuming all the bursts occur at minimum range, and 15 minutes away from minimum range.

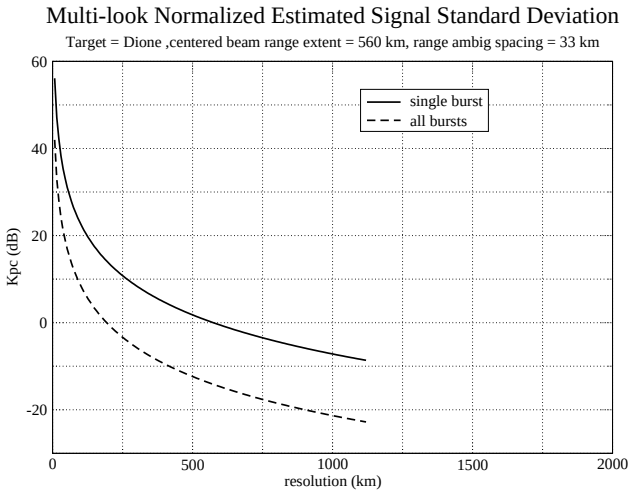

Figure 3: Div F: Normalized estimated signal standard deviation for a range/doppler cell as a function of resolution. Range/doppler resolution elements are both set equal to the specified resolution. Results are shown for a single burst, and for all the bursts in this division. Calculations are performed using the geometry at the start of the division. The presence of ambiguities are not shown.

chirp observation. Figure 3 also shows that range processing is marginal due to low SNR. Disk integrated results from the tone division should be very stable.

5 Receive Only Calibration

Div D collects compressed receive only data in the scatterometer mode with the 9 dB attenuator setting used by the target center observations, and by the subsequent imaging collection. The data are obtained during a turn from off to on-target. These data along with knowledge of Dione'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. These data are collected in compressed mode to get more integration time. The PRF and number of pulses are chosen to fill the science data buffer. These parameters give the best performance possible from the compressed mode.

6 Revision History

1. Sep 19, 2013: 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

Name	Nominal	Actual	Mismatch	Comments
mode	scatterometer	scatterometer	no	csr
start_time (min)	varies	387.0	no	
end_time (min)	varies	397.0	no	
time_step (s)	don't care	60.0	no	Used when BIF > 1, otherwise set by valid time calculation
bem	00100	00100	no	
baq	5	3	yes	3 - compressed mode
csr	0	1	yes	1 - receive only mode
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	120	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	don't care - no xmit in rcv only mode
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	200.000	3.000	yes	Kbps - determines burst period
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 7: di_177_1 Div d distant_scatterometer block